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Embodied Creativity: A process continuum from artistic creation to creative participation

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Declaration

I hereby declare that this thesis has not been submitted, either in the same or different form, to this or any other university for a degree.

Signature:

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Summary

This thesis breaks new ground by attending to two contemporary developments in art and science. In art, computer-mediated interactive artworks comprise creative engagement between collaborating practitioners and a creatively participating audience, erasing all notions of a dividing line between them. The procedural character of this type of communicative real-time interaction replaces the concept of a finished artwork with a 'field of artistic communication'. In science, the field of creativity research investigates creative thought as mental operations that combine and re-organise extant knowledge structures. A recent paradigm shift in cognition research acknowledges that cognition is embodied. Neither embodiment in cognition nor the 'field of artistic communication' in interactive art have been assimilated by creativity research.

This thesis takes an interdisciplinary approach to examine the embodied cognitive processes in a 'field of artistic communication' using a media artwork called Sim-Suite as a case study research strategy. This interactive installation, created and exhibited in an authentic real-world context, engages three people to play on wobble-boards. The thesis argues that creative processes related to Sim-Suite operate within a continuum, encompassing collaborative artistic creation and cooperative creative participation. This continuum is investigated via mixed methods, conducting studies with qualitative and quantitative analysis. These are interpreted through a theoretical lens of embodied cognition principles, the 4E approaches.

The results obtained demonstrate that embodied cognitive processes in Sim-Suite's 'field of artistic communication' function on a continuum. We give an account of the creative process continuum relating our findings to the 'embedded-extended-enactive lens', empirical studies in embodied cognition and creativity research. Within this context a number of topics and sub-themes are identified. We discuss embodied communication, aspects of agency, forms of coordination, levels of evaluative processes and empathetic foundation. The thesis makes conceptual, empirical and methodological contributions to creativity research.

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Chapter 1

Introduction to this thesis and cultural starting point

1.1 Introduction

Couched between contemporary art, cognitive science and creativity research, this thesis constructs a unique perspective that brings together these disciplines and suggests methodologies that can be shared between them. As an interdisciplinary thesis, it combines concept, design and implementation of proprietary technologies developed in the creation of a media artwork, which is used as platform for empirical studies in a real-world context. It is a broad and varied thesis that begins its journey by attending to contemporary cultural advancements observed by scholars in the humanities. From this vantage point, it launches investigations into contemporary applied creativity and proffers an expansive perspective to creativity research on aspects of embodied cognition by incorporating present-day understandings of artistic processes in real-world settings.

Process and social interaction, artistic or otherwise, constitute human physical expressions. Collected and concerted, they are the momentary movements of society that are poised on the apex of an evolutionary path while comprising and revealing cultural conceptions of worldviews on one hand, and technological tools as vehicle for implementation on the other. Culture is made up of these ever changing, fleeting, and collective human movements that in their essence are physical bodies acting and moving in space. This is also encompassed in a new understanding of the body, which has shifted cognition research to contemplate the cognitive role of the body as equal to the mind.

Moreover, human physical expression constitutes art. Artistic creation synthesises experiences and observations of living in the world. It is adaptive and flexible, and shifts with cultural conceptions impelled through technological pursuits by utilising these to create new reflections, different angles, and stir and shape directions that amalgamate perceptions of the material world. In the process of doing so, it steps across boundaries and dismantles the neatly established disciplinary categories, keeping society on its toes and away from becoming stagnant. Media art is such an example of artistic creativity in a contemporary world where previously formed categorial understandings of art-making are now unsuitable. Medosch (2003) offered these words when defining media art:

"As a genre, media art stumbles as much as it innovates. Because it crosses over into areas of science and technology, it is considered a complex matter. By definition interdisciplinary, it has connections with the information and communication technology (ICT), industry, science, the art world and the creative industries, but is in not really a full member of any of these clubs. Rather than having a core identity, its connections with the different parts of society give it a composite character. Hybrid identities, fluid realities, and constant readjustment have become part of the routine".

It is important for creativity research to respond to these developments because human physical expression, art and technology are held together by creativity. In this thesis, we query accustomed mindsets in creativity research by proposing explorations that unite art form, technological tools, and artistic process underpinned by developments in cognition research.

In the next section, a detailed background is given of developments that have shaped contemporary engagement between artists and audience. We draw on scholars from the humanities to demonstrate the evolution and dimensionality of media art. This account of contemporary artistic creativity undergirds this thesis. We then turn to chapter two, where we review creativity research which has not yet acknowledged that these advancements are formative to artistic creativity.

1.2   Digital technology, media arts, and the creative process continuum

A decade ago in an article in the New York Times, art critic Kimmelman (1998) suggested that "the barriers among art forms have radically dissolved during the last few decades, among other things causing a freer flow of ideas, materials and techniques". This, in essence, has been largely the influence of digital culture with its ubiquitous computing via new tools, new communication channels, Internet, wireless connectivity, and the hybridisation (Couchot, 2005) of the old with the new in terms of tools, materials and techniques. But the art & technology trajectory is not new in the sense that the formative years for the use of electronic and digital technology in artistic creativity emerged fifty years ago from the cultural activities of the 1960's. During this decade, John McHale, a 60's pioneer with a background in fine art and sociology commented presciently on computers and their social role. In his view the creation of masterworks was to be replaced with "alternative cultural strategies, through a series of communicative gestures in multi-media forms", where "the artist defines art less through any intrinsic value of art object than by furnishing new conceptualities of life style and orientation" (quoted in Gere, 2006).

Throughout the era of the 1960's, the cultural activity that surrounded computers, video and telecommunication technologies gained momentum, producing artistic collaborations and exhibitions in art & technology in Europe and the United States. E.A.T.(which stands for Experiments in Art and Technology), for example was one of the earliest and prominent formations with collaborating artists and engineers in New York (Shanken, 2005). Historical exhibitions such as *Cybernetic Serendipity* at the ICA in London in 1968 celebrated technology with less emphasis on artistic expression. This changed in 1970 with John Burnham's New York exhibition *Software, Information Technology: Its New Meaning for Art*. The exhibition presented an important turning point because for the first time conceptual artists experimented with technology in the critical

analysis of culturally-infused ideas that often flourish in conceptual art.

1.2.1   Interactivity, a changeling in the arts

Besides art & technology and conceptual art, the 1960's also birthed op art and kinetic art, happening and Fluxus as art movements. Although art history has categorised these art forms as separate from each other, contemporary views perceive them to be commonly underpinned by 'algorithm'. Weibel (2007) states that these art forms developed in parallel with progress in computing machines, machine languages, and associated algorithmic procedures. From analogue art forms such as painting and sculpture, artists developed intuitive algorithms in the form of *instructions for use and action* in natural language where the artistic object was replaced with *instructions to act*, morphing old art forms into new ones.

Algorithms, or *instructions for use and action* in the form of sequences of signs have been used in art and culture throughout the centuries. The have been used as rules of play, plans in architecture, musical scores, and in the fine arts as support devices in the creative process. In analogue art forms, algorithms are used in an intuitive application, comprising the creative process of Fluxus, happening, op and kinetic art, and as exact application in art & technology and digital art.

Instructions for use and action can be directed towards machines or humans. Weibel (2007) distinguishes between two forms of interactivity depending on whether *instructions to act* are propagated via manual, mechanical tools or electronic and digital tools. *Instructions to act* via the former encompasses hands, buttons, keys and so forth, of which op and kinetic art are an instance, and the latter designates interaction with digital tools which is defined as new media art[1], or simply media art.

From this vantage point, interactivity in the arts is not a new phenomenon. It has been evolving from the culture of the 1960's where it originally carried a vibrant ideological current (Daniels, 2000). Interaction between artist, artwork and audience brought a new context into cultural activity aimed at an aspiring ideal for art and its new expressions. Daniels (2000) explains that "inter-media" was aimed at creating art works that invited the public to an egalitarian status, offering interaction with the artwork through the creative process of a self-determined experience. The many forms of interaction in natural language and emergent technologies brought into the cultural arena during this era were intended to repudiate the establishment, breaking away from artistic genres, categories and institutions. After the 1960's, natural language interaction developed further, often into large-scale public projects to widen the social base of art, and foster participatory interrelations between cultural and political milieus (Stiles & Shanken, 2010, in press).

Interaction coupled to art & technology shifted into a different direction. Between the 1970's and 1980's interactivity in the context of art & technology waned for several reasons. Easily destabilised software in an exhibition context, general skepticism towards the industrial military complex[2] associated with technology, and the habitual consumption of art as aesthetic commodity

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[1]The term was mostly used during the 1990's.

[2]Related to the Vietnam War.

in the form of objects gave way to a dominance of conceptual and minimal art during the 1970's and 1980's, minimising the inclusion of interactive, technological components as part of artistic creativity (Shanken, 2002; Daniels, 2000).

Furthermore, the experimental nature of artistic creativity during the 1960's paved the ground for what developed in the coming decades into interactive art, incorporating performance, installation, video, and environmental art among others. With the digital explosion in Western society (led by the US and followed by Europe) during the 1990's, interactivity in the context of art & technology resurfaced, this time prioritising the use of the newest technologies such as laser disc, VR, and telematics in the creation of interactive experiences over the social-critical dimension that had spurned artistic creativity of the 1960's. This tendency gave impetus to the manufacturing industries of technological products, to use artistic creativity in the popularisation of their products (Stiles & Shanken, 2010, in press).

In the 1990's, against the political backdrop of a society marked by massive technological surveillance and general social inertia, the promise of personal agency resulting in a sense of empowerment through interactivity in the engagement with technology-driven products was perceived to be a new social paradigm (Stiles & Shanken, 2010; Daniels, 2000). Stiles and Shanken (2010) state that "in the 1990's and 2000's, the appropriation of the concept of interactivity as a novel feature of specific technologies falsely implied that interactivity did not exist before or without those technologies" (p.84).

1.2.1.1 Interactivity not without agency

Interactivity is a feature of contemporary culture contributing to the evolving communication paradigm of the digital era (Hung, 2009). Evidently, general ubiquitous computing devices, the Internet and mobile applications, are enabled by some form of interactivity as input. Within contemporary media arts, interactivity redefines our understanding of what constitutes a work of art.

Kluszczynski (2007a) suggests that when engaging with an interactive artwork, the participant establishes a bridge between the object as artefact and the work of art through his or her receptive-creative actions, and this joint endeavour becomes the final product. Hence the concept of an artistic product in the traditional sense, a finalised, durable and permanent object, is now replaced by the procedural character of a communicative real-time situation; the creation of context via artistic activity versus the construction of a subjective structure with physical artistic materials. In essence, this becomes the internal principle of the work with the recipient who "must undertake actions that will result in forming the object of his or her perception" (p.216).

Kluszczynski further suggests that the final artwork more accurately constitutes a field of interactive, artistic communication. Similarly, Eco (1989) mentions a "field of possibilities"[3] in what he understands to be "the open work" or "work of movement". Echoing Kluszcynski's description of interactive media artworks, Eco's thesis focusses on artworks from the visual arts and the musical genre created prior to the digital age. He thus lends his support to the idea that creative actions with artworks by participants are not necessarily predicated upon technology or a particular era. Eco adds that the "field of possibilities" in the "open work" encompasses an explicit intention by

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[3]Eco appropriates the concept of "field of possibilities" from Henri Pousseur's "La nuova sensibilit musicale".

the artist to encourage inexhaustible interpretations in the absence of an optimal resolution of the artwork. This "field of possibilities" creates an openness of artistic communication which may vary when interpreted but it always maintains a "coherent identity of its own and which displays the personal imprint that makes it a specific, vital, and significant act of communication" (p.20).

1.2.1.2 *The field of artistic communication*

If the interpretation of an interactive artwork lies within a communicative field or within a field of possibilities, then how is this communication understood, how is meaning conveyed? Kluszczynski (2007a) posits two models that establish the relation between communication and meaning in the context of interactive artworks. The first model, preserving modernist tradition, communicates by relying on representation, expression and conviction. Conviction in as far as it relates to the dominance of the artist as author over the artwork and its meaning, as well as the perceptive-interpretive process of the participant. Kluszczynski (2007a) builds this model on Derrida's theory of logophonocentrism, which states that communication is understood, in the modernist sense, as conveying ready-made meanings. Meaning that is to be conveyed is encoded, it needs to be abstracted from extraneous elements by various methods. For example in a text, the message and its meaning are static elements that need to be uncovered by the reader.

In the second model, in accordance with the post-modernist tradition, the artist is transformed into a designer of contexts. The artist abandons the concept of authorship and gives up the usage of representations. The created work requires an active reception by the participant where meaning is emergent from the process of interaction. This active interpretation relies on the creativity of the participant. The reading of sense, as in the first model, is replaced by creational reception of the work in the second model. Kluszczynski defines creative reception as communication which is "a process of creating meaning, a significantly creative activity" (p.220).

In this thesis, we build on Kluszcynski's concept that meaning in an artwork is constructed from active audience participation through the engagement with the field of artistic communication, and also on Eco's point that in interactive artworks participants create their own interpretation of the artwork within the field of artistic communication. From this perspective, we postulate that interactive artworks involve creative action by the artist's as designer of contexts through a creative process which prepares the field of artistic communication, and the participant's receptive-creative actions within this prepared field of artistic communication.

1.2.2 New forms of collaboration and creative processes

In a recent article, Kluszczynski (2007b) speaks of a transformation of the cognitive paradigm that is surfacing in media art. Central to this transformation is communication in the context of "network order". This "network order" is composed of collaborative and participative efforts by individuals, forming an interconnected community in the production of artworks. Historically, the avant-garde of the early part in the 20th century formed collaborative movements such as Dada, Futurism and Surrealism, but these types of collaborations cannot be compared to the contemporary phenomenon of artistic collaboration.

The concept of 20th century artistic collaboration emerged from socio-political situations,

they included "a strategic-programmatic nature" to shield avant-garde artists from traditional understandings of art held up and perpetuated by institutions, and unite artists through shared programmes and art practices (Kluszczynski, 2007b; Roberts & Wright, 2004). Although the anti-establisment ideology of these movements broadened the scope of artistic tools and materials, with the exception of shared creative process by some cinematic artistic endeavours, the influence on collaborative artistic productivity was minimal.

Kluszczynski's point is that the new form of artistic collaborative activity has reached a new "plane of creation". He illustrates this point with two seemingly different examples from digital media that show the profound paradigm shift of communication that has taken place out of concurrent development of tools and practices. His first example are the artist/developers of the open source programming tool for artists called *Processing*[4]. The two developers consider themselves primarily initiators that have launched a large network of users of the software, they consider this network of users co-authors, cultivating the development of the tool and inspiring new art practices. The influence of the multi-media character produces a collective creative process that hosts a diversity of artistic practices and their attendant competences.

The second example is the interactive artwork, *Intimate Transactions*, where two participants evolve their immersive experience via their bodies by interacting with each other in different locations. The artists state that through an increasing sense of intimacy, this work promotes an indirect and subtle collaboration between the participants. Here, interactivity produces a new dimension of creative collaboration between both recipients, or active participants. In essence, this "new plane of creation" is a new form of artistic collaboration in the collective history of Western art, it expands the artistic domain as we know it by including the domain of creative recipients, which has brought forth new types of artworks where both parties, the artist and the recipient, are designers of their own experience.

1.3 Research questions and structure of this thesis

Since the 1960's, art & technology has unleashed a change in artistic creation. Today, parallel to cultural developments of the information age as global society, art & technology has found its place in media art. Within this genre, interactive technologies have attained a firm foothold in artistic creation, transcending the concept of a finished art object. These types of artworks have empowered members of the audience by putting the responsibility of creating an artistic experience into the hands of each member via creative participation. We now speak of procedural engagement with a 'field of artistic communication' by the participants, and also by the artists in the creative preparation of this field. This creative co-production has generated new forms of collaboration, forming networks between people, tools, and expertise in the collective creative process.

So far creativity research has not taken these developments into account when studying artistic creativity. For most of the sixty years the field has been actively investigating creativity, it has done so separately from cultural developments. Up until today the bulk of studies conducted into artistic creativity have focussed on idea generation in controlled environments devoid of attention

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[4]This is programming tool used in the early stages in the game development of Sim-Suite.

to the procedural aspects of creative engagement in real-world settings. In the same vein, forms of artistic expression, for example in the visual arts, have equally been disregarded whereby the evolution from analogue to digital tools has gone unnoticed by those studying artistic creativity.

Moreover, the majority of creativity researchers consider creative cognition as rooted in cognitive processes that build on extant knowledge structures. Creative cognition researchers orient themselves on research evidence in cognitive science. In recent years, cognitive science has gained a new understanding in that cognitive processes are developed and determined through the real-time and goal-directed interaction of an organism's sensorimotor capacities, body and environment. Similar to developments in contemporary artistic creativity, these advancements have not yet entered into creativity research.

1.3.1 Defining the creative process continuum

This thesis breaks new ground in creativity research by attending to artistic creativity and embodied cognition. We focus on computer-mediated interactive media art by proposing that the 'field of artistic communication' engenders procedural creative processes defining the multi-dimensionality of a continuum. Creative processes involved in collaborative preparation of the 'field of artistic communication', and creative processes involved in cooperative and creative participation in the 'field of artistic communication' operate cognitively on a continuum via embodiment.

To research the creative process continuum we ask the overarching question:

How are related cognitive processes expressed in two instances in the creative process continuum?

To answer this question, we use a case study research strategy for empirical investigations. This strategy encompasses the interactive media artwork 'Sim-Suite' which informs investigation conducted as 'cognition in the wild'. We examine the collaborative creative processes that constructed the artwork, and cooperative creative processes by members of the public who participated in the artwork. For methodological considerations, we break down the main question into two subquestions each addressing one part of this thesis' overall investigation:

- *What are the embodied cognitive processes that are expressed as creative preparation of the field of artistic communication in a long-term, collaborative engagement?*

- *What are the embodied cognitive processes that are expressed as creative participation in the field of artistic communication in a short-term, immersive engagement with others?*

Drawing on embodied cognition for this investigation, we have to acknowledge that we are faced with early stages of a new outlook and comprehension of cognition, where higher cognitive processes are not uniformly mapped out so that these could serve as a framework for this thesis. We therefore use embodied cognition approaches in the construction of a lens, a theoretical lens on conducting our research. The literature reviewed for this lens is further supplemented with empirical research that supports the contextualisation of our findings.

In the next subsection we layout the eight chapters of this thesis to provide an overview of how we go about the investigation of the creative process continuum.

1.3.2   Outline of chapters

Chapter One

In the first chapter we present this thesis' starting point, established in the humanities and investigated in creativity research. We explain changes that have taken place in the creation of artworks with digital tools, how these changes pertain to artistic expression, social interaction and process. We focus on digitally-enhanced interactivity as the feature enabling creation of the 'field of artistic communication' between artist and audience. Both types of creative engagement are procedural, and the self-constructed and created experience of the artwork is the final product. At the same time, the creation of digital artworks has fostered new forms of collaboration with networks between artist, non-artists and tools. Bestowed with these advancements in artistic creativity, we postulate that the creative process is a continuum which can be probed scientifically. We end this chapter by stating research questions and outlining this thesis' contributions.

Chapter Two

In chapter two we review literature in creativity research where this thesis aims to contribute. We learn that creative cognitive processes exploit extant knowledge structures, however the understanding that cognition is embodied, has not yet been considered or included. We point out that creativity research has a narrow view of creativity in general and visual artistic creativity in specific. This stems mostly from historical developments, the concern with quantification of creative thought at the expense of understanding process and applied creativity. We position this thesis' interdisciplinary approach among the main approaches, and review particular research topics relevant to this thesis. We then hone in on artistic creativity in the visual arts and discuss problem-finding, creative process, embodiment, art forms and artistic collaborations.

Chapter three

In chapter three we introduce the media artwork "Sim-Suite", an interactive installation created collaboratively in a real-world, authentic setting. The installation represents the case study used as research strategy to launch investigations into the creative process continuum in pursuit of questions asked in chapter one. Sim-Suite is played by three participants, who interact with each other competitively while stepping and balancing on wobble-boards. We explain artistic intention, list exhibitions, and give background to the three team members, who created the installation in two separate collaborations. We then detail construction and materials, and layout game-play, rules, and approaches to measuring creative participation.

Chapter four

Chapter four is divided into two main sections. In the first main section we introduce the theoretical lens made up of two approaches under the embodied cognition paradigm, the embodied-embedded

approach and the enactive approach, and we then outline and review basic principles of embodied cognition for each approach. This serves to create the appropriate mindset which we shall use in the analysis of the creative process continuum pertaining to the creation and engagement with Sim-Suite. The second main section gives background on two investigations we have conducted with Sim-Suite, adopting a mixed method approach of qualitative and quantitative analysis. In the first investigation we collected data on Sim-Suite's team members' collaborative creative process via dialogic reflection sessions, using Grounded Theory for the analysis. For the second investigation, we collected data via Sim-Suite's logfile from participants' interactions with the installation during exhibitions at cultural festivals. We give background to the extraction of variables and the tabulated data sets based on the creative participations concepts established in chapter three.

Chapter five

In chapter five we lay out the findings of the qualitative analysis through the theoretical lens of enactive cognition principles. In the first part of the chapter we explain how the lead artist, who is also the author of this thesis, generated the artwork's thematic selection, and discuss working styles of both, interdisciplinary collaborations. We then introduce findings of both collaborations by modelling the commonalities of the process in four stages. We then present in greater detail findings on the elements of the second collaboration, and model from the enactive perspective how these findings are related to each other, as networks of interactions that collaboratively created Sim-Suite's game. We then conclude this chapter by contextualising our findings with embodied cognition research and some aspects of creativity research.

Chapter six

In chapter six we introduce the statistical analysis in four stages conducted with data sets from Sim-Suite's logfile. Firstly, we list variables and their pictograms for data visualisation purposes and look at central tendencies. We generate a correlation matrix of all variables and notice a high number of correlations with defensive behaviour variables, which are indicators of sophisticated creative participation. Secondly, we split defensive behaviour scores into one group of games with low defensive behaviour scores, and another with games of high defensive behaviour scores. We conduct cluster analysis for each group of games to identify shared characteristics or patterns between games. To better highlight these shared characteristics, we produce correlation matrices for each recognised cluster grouping in the cluster analysis. Thirdly, we look at average difference of variables in games of low and high defensive behaviour scores. Fourthly, we concentrate on variables within games, and analyse how variables pertaining to bodily activity unfold over time. We then conclude the chapter by contextualising our findings with embodied cognition research.

Chapter seven

In chapter seven we enter into a general discussion by placing related findings (in the sense that findings are related to the same embodied cognitive process in the creative process continuum) from chapters five and six alongside each other. We give an account of the creative process con-

tinuum via four major themes and a number of sub-themes. To do so, we contextualise findings together with empirical results from studies in embodied cognition, the thesis' theoretical lens, and creativity research. In the first theme we establish a foundation for this chapter by drawing on research that has produced an embodied communication model that we use in support of artistic communication. In the second theme, we review related findings with research on intrinsic motivation in creativity and agency research in embodied cognition. The third theme centres on forms of coordination. Here we first explain a view of affordances from the embodied perspective, and then discuss triads in Sim-Suite's creative and participatory process. We contextualise aspects from the creative cognition agenda, and then expound linguistic entrainment and interactional synchrony as these relate to our findings. In the fourth theme we discuss three levels of evaluative processes we have identified in the creative process continuum and establish links to empathy in embodied cognition. Throughout this chapter, we base our findings on empirical research and topics in embodied cognition and illustrate in discussion the corresponding characteristics. We conclude this chapter by contextualising reviewed topics in creativity research with the overall conclusions from our research.

Chapter eight

In chapter eight we first state our motivation for this research, and then summarise our main contributions. We then explain a number of limitations of this thesis. These are the trade offs between an investigation of real-world artistic creativity and traditional research approaches. We would have compromised the authenticity of a real-world context by introducing observational techniques. Limitations of our approach are due to data being collected retrospectively on the collaborative creative process by Sim-Suite's team members which does not convey a real-time situational perspective. Other limitations arise from conducting two separate exploratory and uncoordinated investigations where not all findings had relational matches across both investigations. This resulted from our approach rather than from technical limitation. In addition, data on age groups of Sim-Suite players could have been useful to see possible connections with playing styles. This chapter ends with a brief discussion on future work.

1.3.3   Summary of contributions

In this subsection we provide an overview of the thesis' contributions. This thesis breaks new ground in creativity research, it does so conceptually, methodologically and empirically. The contributions are derived from an interdisciplinary, mixed method approach that investigates through a theoretical lens of embodied cognition the current developments in interactive computer-mediated artworks by using a case study research strategy via the artwork 'Sim-Suite'.

Conceptually, the thesis contributes to creativity research by *reconceptualising the creative process with input from the humanities as a creative process continuum; reconceptualising and redefining artistic achievement as preparatory act for shared communication; conceptualising audience engagement as creative participation and redefining the role of the audience as participatory actors in shared artistic communication in interactive media artworks.*

Methodological contributions to the study of artistic creativity are the case study research strategy of *Sim-Suite as authentic, real-world performance of an artistic creative process by interdisciplinary collaboration for data collection; and authentic, real-world performance by the public as Sim-Suite participants for data collection.* Moreover, methodological contributions extend to the *conception of the artwork Sim-Suite devised to measure human interaction; the development of a meta analysis of the creative process continuum via a mixed method approach; and the translation of the concept 'creative participation' into a functional approach with Sim-Suite for data collection.*

Specific embodied cognition contributions supporting this thesis are *the recapitulation and non-compartmentalisation of embodied cognition research by integrating disparate theoretical approaches and drawing on empirical results as an underpinning to creative cognition investigations; and the empirical demonstration of multifocal accounts of specific research topics in embodied cognition as part and parcel of the creative process continuum.*

Empirical results are:

- *The use of three-dimensional forms as preinventive forms (wobble-board) for collaboration and shared perception of affordances and creative invention*

- *Identification of relational systems components in collaborative idea implementation of Sim-Suite's game*

- *A form of epistemic action in the collaborative creation of the Sim-Suite game*

- *The discovery of playing 'styles' by Sim-Suite participants due to spatial orientation to each other in the installation*

- *The discovery of interactional synchrony among high-defensively playing Sim-Suite participants*

Related publications by the author:

Jungmann, M., & Fitzpatrick, G. (2009) Sim-Suite. In *Proceeding of the seventh ACM conference on Creativity and Cognition* doi 10.1145/1640233.1640334

Sim-Suite received the prize for *Best Demonstration* at Creativity and Cognition '09 (http://www.creativityandcognition09.org/)

Jungmann, M., Lutz, R., Villar N., Husbands. P., & Fitzpatrick, G. (2006) Exploring the Boundaries between Perception and Action in an Interactive System. In B. Bardy and D. Mottet (Eds.) *Proceedings of the 3rd International Conference on Enactive Interfaces*, University of Montpellier: Montpellier, p. 165.

Chapter 2

Background to creativity research

2.1 Introduction

In this chapter we introduce background literature from creativity research and build up a case in support of the gap where this thesis aims to make a contribution. This chapter contributes the main literature reviewed for this thesis. However, in chapter four we review additional literature as part of the theoretical lens on embodied cognition.

In the first chapter we explained that cultural observations have revealed that contemporary art has transformed creative processes, in that these no longer make a distinction between artist as the active creator and audience as the passive perceiver. Instead, these art forms are led by technologies of the information age, which primarily focus on communication and procedural aspects of experience rather than a final object as the artwork. These contemporary artworks provide a 'field of artistic communication' that is shared by artistic preparation and creative participation without separation because one constitutes the other. Originating in the humanities, this describes the core of the gap this thesis' research is addressing. We are now turning to creativity research where creative processes have been studied. We map out an equivalent theoretical, conceptual and empirical research landscape emphasising applied and situated artistic creativity, art forms, and embodiment.

In this chapter we lay out how these foundational aspects have been investigated in the past. We have done so in three main sections, each consisting of a number of subsections. We start out by continuing this section, 2.1, outlining the scientific definition of creativity and the scientific view of how creative contributions are understood in the context of the cultural evolution. In addition, we set the stage for our theoretical lens by explaining that creativity research is mostly conducted from the premise that creative thinking and behaviour is derived from combining and re-organisation of extant knowledge structures.

In the second section 2.2, we first explain the six approaches to creativity research. Here we concentrate on the first three, the 'big three', to depict the dominant research positions investigating the creativity complex. We explain how this thesis' interdisciplinary approach is couched

between these six approaches, while drawing upon them in terms of conceptual placement and methodologies.

In the subsection that follows, 2.2.1, we discuss several research topics concerning divergent thinking and problem solving; problem-finding in art; intrinsic motivation and assessment of creativity; evaluation of creative thought; creative cognition; and experiments in support of the Geneplore model. The idea behind this subsection is to show on specific research topics the limitations imposed by the field, as well as topics with investigations that aim to expand the field towards situated and social aspects of creativity. We conclude that foundational aspects needed for this thesis, that take into consideration real-world and domain-related artistic production and contingencies, are not addressed by the field.

The final section, 2.3, focusses explicitly on applied visual artistic creativity. The disregard in creativity research towards the differentiation of contemporary forms of art-making, proposes the general research conducted within the visual arts as the closest relative to the media arts genre that can be discussed in respect to this thesis' contributions. In the first subsection, we look at problematic issues surrounding problem-finding and failed attempts to categorise and generalise artistic creative processes pertaining to the visual arts. In the following subsection we concentrate on and highlight research pertaining to artistic creative processes in the visual arts that mention embodiment. We show here that although some research has produced findings on embodiment, these are not contextualised with the contemporary outlook of cognition, such as embodied cognition principles. We close this section by profiting from research on the cultural evolution of human cognition with a focus on the arts, hence coming full circle with the beginning of this chapter where we reviewed creativity research's view of culture. Here, we show the significance of art forms from the higher perspective of cognition as an instrumental component in the evolving distributed cognitive network of society.

The concluding section 2.4, summarises the previous sections and points out the missing links in creativity research pertinent to real-world creativity, process, embodiment and art forms. We now continue this section by looking at general definitions of creativity and understanding of creative contributions with a cultural context.

2.1.1 Scientific understanding of creativity

In psychology and cognitive science research into creativity has been traditionally the study of mental operations underlying creative thought. Creative potential is understood as being a latent faculty that can be accessed via various kinds of tests in cognitive task analysis. Some research also looks at applied creativity, specifically in the arts and sciences. Defining and understanding creativity is a challenging endeavour because of its wide-ranging aspects permeating several spheres: the individual, the process, the product, and the culture. This issue is foregrounded, for example, by computational creativity, which seeks to formulate an algorithmic perspective on creative behaviour in humans. A major theoretical issue from the computational perspective is that creativity is difficult to define in objective terms. Creativity researchers have stated that those working in the field are unable to agree upon a singular definition of creativity that would unite

the field (Barron & Harrington, 1981; Torrance, 1988; Conrad, 1990; Plucker, Beghetto, & Dow, 2004; Ivcevic, 2009).

There are two main converging axes that can be identified in various definitions of creativity in research. One axis describes creativity as novelty, surprise, originality and unpredictability; the other axis defines creativity as production of useful, appropriated and socially valued products. Definitions of creativity have been inherently centred on an observable product. The *Encyclopedia of Creativity* states that creativity is "the production of something new or rare that has value in the world" (Runco & Pritzker, 1999, p.11) and this definition is particular to Western culture (Lubart, 1999). Criticism within the field states that too much emphasis is being placed on the creative product while overlooking the more general existential dimensions of creative behaviour (Rhodes, 1990; Smith & Amnér, 1997).

2.1.1.1   Cognitive traits of extant knowledge structures underpin creativity

Simonton (1999) uses historical reports as case studies to develop a historiometric approach to creativity. His method draws on data which is almost exclusively obtained through historical records of creative individuals, "whose status as creators is unquestionable" (p.455). His approach excludes individuals whose creative achievements do not live up to historical impact. Simonton further compiles these case studies to be analysed in order to discover "general laws and statistical relationships that transcend the particulars of the historic record" (p.455). Others, who have created a similar line of research, investigating creative achievements by eminent creators via historical records, have conducted qualitative analyses on these case studies to develop a developmental evolving-systems approach (Gruber & Davis, 1988; Gruber & Wallace, 1999).

Weisberg (1993), who traces a long career of studying historical records of outstanding creative individuals states that society's view of creativity endowed with genius is a considerable myth. The majority of researchers agree that creativity is derived from ordinary, cognitive processes which are involved in every day thought and action (Finke, Ward, & Smith, 1992; Hayes, 1989; Langly & Jones, 1988; Mandler, 1995; Newell, Shaw, & Simon, 1962; Schrank & Clearly, 1995; T. B. Ward, Smith, & Vaid, 1997). Here the question arises, how else can a distinction be made between everyday creativity and creativity that becomes a historical achievement, if not for extraordinarily talented people? Boden (2004) suggests that the distinction can be made between 'psychological' creativity which she calls P-creativity, and 'historical' creativity or H-creativity. P-creativity produces a new, surprising and valuable idea that is new to the person who is having the idea no matter how many others have had the idea before. H-creativity is therefore a special case of P-creativity where the idea is new, surprising and valuable and no one else has had the idea before as far as we know.

H-creative people have a better sense of domain-relevance than others, on which Boden (2004) elaborates using the example of Mozart's musical ability. Mozart's ordinary thinking process that led to great musical achievements was not the result of exceptional memory but his ability (along with everyone else's ability to do the same) to conceive a conceptual space in its entirety. We might be able to plan a trip to a city nearby and all details involved in getting there may appear in their entirety in our minds. Mozart's capability was to conceptualise symphonies in their entirety,

belonging to the domain of music. Memory stores items in conceptual spaces within the mind, and the more richly structured these spaces are the greater the possibility of enhancing access to these stored items and their relevant characteristics. To richly structure conceptual spaces of a domain may take many years and we know from Mozart's life that he spent a long time studying music before he delivered a successful composition. Mozart knew the musical domain of his time and had extensive knowledge of conceptual structures involved in that domain. In Boden's (2004) view, the notion of P-creativity is imperative to the understanding of creativity in humans and that should be the path of creativity research. On the contrary, H-creativity should be left for the historians of art, technology and science.

2.1.1.2 Culture and creativity

Creativity is intrinsically tied to the cultural evolution which enables creative ideas to be organised so that they are generated and socially valued in relation to what has preceded them. Creative ideas build on previously established conceptual understandings. Often ground breaking artistic or scientific ideas are not easily accepted because they require perceivers, or society, to instigate a fundamental conceptual shift. The ground that is being broken by these ideas lies outside of the conceptual domain that has already been explored, delineated and established with regulating mechanisms as a conceptual map of the mind (Boden, 2004).

Research into the cognitive origins of culture supports this view of creative advances dovetailing within the cultural framework, defining it as *collaborative inventiveness* (Tomasello, 1999). There are two viewpoints from this perspective. In the first, an individual encounters an artefact or cultural practice together with a novel situation where this artefact is not entirely suitable. After understanding the intention behind the artefact and assessing the need for the current situation, the individual successfully modifies the artefact to fit the current situation. In this case the artefact is inherited, and the modification to the artefact was collaborative across historical time. Secondly, the collaboration is simultaneous when several individuals create something new through social and cooperative interaction, allowing for dialogic feedback loops that an individual may receive on creative suggestions. Recently this understanding, that creativity is embedded in a social context, has been recognised by creativity researchers (Amabile, 1983b; Csikszentmihalyi, 1988; Harrington, 1990).

The propulsion theory in creativity research entails a similar approach to the afore-mentioned theoretical stance on cognitive origins, regarding the cultural adaptation of creative production. Sternberg's (1999) propulsion theory categorises individual creative contributions in the social context of a domain. Here, creative contributions preserve and extend current paradigms of a domain through *replication, redefinition, forward incrementation* and *advance forward incrementation*; or they reject paradigms and replace these with contributions that change the field via *redirection, reconstruction*; or *reinitiation*, or existing paradigms can be integrated into a new one via *synthesis*.

Let us return to an earlier example to illustrate the rationalisation of individual creative contributions from this viewpoint. During Mozart's time, Salieri's work was popular and pivotal to the development of 18th century opera. Mozart on the other hand was struggling to gain popularity

with his compositions. Salieri's work was welcomed and accepted, it was a paradigm-perserving contribution in that Salieri's work was an *advanced forward incrementation* of the domain. By contrast, Mozart's contributions were paradigm-rejecting, in that his contributions moved the domain into a new direction from the existing starting point, therefore his work was unpopular. Today Mozart's creative contributions are acknowledged and valued, while Salieri's fame has diminished to just another composer of that time. The model proposed here is primarily a conceptual aid. In actuality creative products may combine several of the afore-mentioned categorical elements in their contribution.

Consider Tomasello's (1999) *collaborative inventiveness* from the perspective of propulsion theory in relation to the example of Mozart. His creative contribution in the domain of opera was not socially valued because his ideas were ahead of his time, lining him up historically with many others who endured the same fate in other domains. As mentioned earlier, ideas ahead of their time are either rejected or discovered later, as it was the case with Mozart. Sternberg (1999) explains that these creators' ideas skip a step which cannot be followed by others in the domain. Therefore the creative contribution does not become part of the chain of *collaborative inventiveness* at that time. These contributions may be inserted at a later stage when the field has collectively moved on.

In these theoretical formulations, it has to be noted that the evolving cultural perspective linked to creativity through physical expressions predicates numerous forms within domains which may not connect to other domains. In the domain of art all forms of art are influenced by cultural evolution. Art forms are dynamic entities with evolving tools, enabling artists to break into new contexts and concepts that change aesthetic and social understandings of the constituting elements of art and art-making. These may be entirely integrated in a certain cultural milieu but not accepted in another, not because of the type of artistic contribution they are but because of other social, economic, and political factors that threaten the status quo of a different cultural milieu. A perfect example is the exclusion of digital art creation from scientific analysis as developing forms of artistic creativity despite the fact art made with digital tools has been culturally accepted for the past twenty-five years as forms of contemporary art. In general, digital art forms do not generate a creative product in the conventional sense, therefore these art forms do not adhere to static definitions of creativity as advocated in creativity research which may be one reason for this exclusion.

In the next section we review approaches in the study of creativity. The intention is to show dominant research approaches and the resulting narrow perspectives of creativity. Here, we explain how this thesis is couched between established categories of approaches and methodologies to construct an interdisciplinary approach. We then highlight specific concepts as they support the thesis' interdisciplinary approach with a view to embodied cognition.

2.2 Approaches to the study of creativity

In creativity research, Mayer (1999) differentiates between six approaches, psychometric, experimental, biographical, biological, computational and contextual, to the research of creative thought
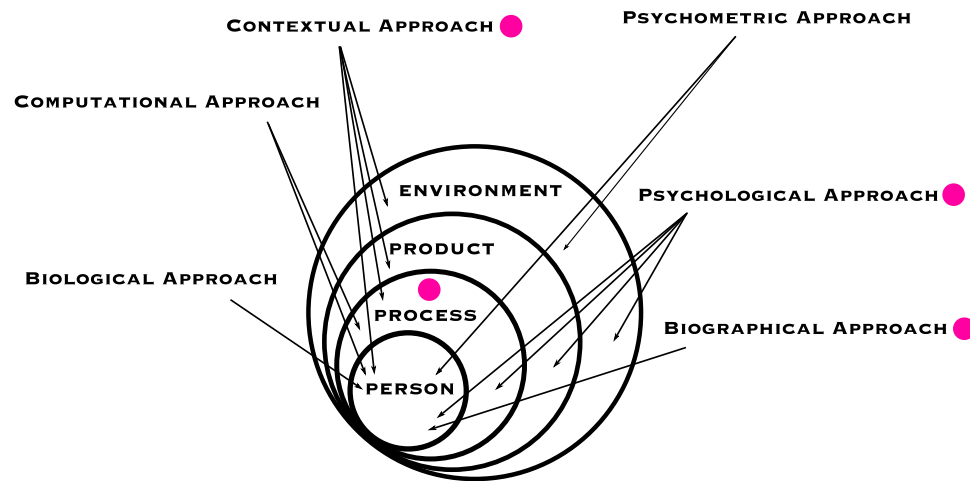
Figure 2.1: Diagram showing the positioning of this thesis in creativity research. Pink dots indicate influences from the research field on this thesis' interdisciplinary research approach. This thesis' overall approach is *contextual* by investigating the creative process continuum from cultural observations emergent in the domain of media art. We investigate the *process* of creative preparation and participation, or creative process continuum, of this art form by using a case study research strategy. Methodologically, we achieve this via qualitative methods adapted from *biographical* approaches and statistical methods adapted from *experimental, psychological* approaches.

and behaviour. Of those six approaches three have been labelled the 'big three', they are the main research paradigms that have shaped the field and today's understanding of creativity. The approach that has dominated since the field's inception in the 1950's is the psychometric study of creative mental traits (Guilford, 1950; Plucker & Runco, 1998). It was initiated by researchers who previously studied intelligence. The methodological background of intelligence research presupposes intelligence and creativity to be mental traits which are quantifiable by appropriate measurement instruments, assessing differences between individuals. In intelligence research the approach is centred on quantification of mental traits via standardisation of IQ scores and factor analysis. This was the starting point in the research of understanding creativity as quantifiable trait that can be studied for example through divergent and convergent thinking tests (Guilford, 1957, 1975, 1988).

Also situated among the 'big three' are approaches to creativity in experimental psychology. Likewise, these approaches are conducted with psychometrics in a controlled environment but with manipulated variables, and "these dependent variables are the components, traits or indicators of creativity" (Runco & Sakamoto, 1999, p.62). The experimental psychology approach is differentiated from psychometrics through the design of experimental research set ups, where in the context of cognitive task analysis changes in the individual's performance are investigated. Strategies used by this approach cover open-ended tasks and often implement realistic tasks, and investigations of analytical and exploratory problem-solving.

Biographical approaches are included as part of the main three approaches to creativity. We mentioned earlier Simonton's (1999) historiometric study, aiming to understand creativity through

case studies. Biographical approaches generally focus on case studies with historical records and self-reported accounts, using qualitative analysis in their investigations. Biographical creativity researchers centre their efforts on eminent creators with historical recognition and mostly regard creativity to be a special trait.

There are three remaining approaches left to mention in a total of six approaches to creativity research. Among them is the contextual approach, which is a collection of views that are underpinned by the distinguishing characteristic that creativity is context-based, operating beyond the cognitive traits of the individual. This approach looks at the reciprocal dynamic between individual and social interaction taking place within cultural relationships. The contextual approach is the home of social, cultural and evolutionary studies of creativity.

An example for the contextual approach is Csikszentmihalyi's (1988) work on developing a systems view of creativity. This systems view of creativity holds firm that "we cannot study creativity by isolating individuals and their works from their social and historical milieu in which their actions are carried out" (p.325). Csikszentmihalyi has shown that the locus of creativity can be conceptualised as three interrelated systems, which centre on the creative *person*, the *culture* or *domain*, and the *social system* or *field*. Creativity arises from the interaction of these three interrelated systems. This systems view of creativity aims to capture the main cycles of cultural evolution via *variation, selection* and *transmission*. New ideas produce creative work through *variation* and change, which is retained by the field, or the social institution, through a *selection* process. The culture or domain is then responsible for passing on these creative achievements to the next generation through *transmission*. The field is the social organisation of the cultural domain, where *gatekeepers* operate in managing the evaluation and preservation of creative contributions. Csikszentmihalyi's systems view argues for an overall dynamic of socially situated and embedded creative ideas, but falls short in illustrating local, immediate, physical and interpersonal aspects affecting the production of creative ideas (Kurtzberg & Amabile, 2001).

The other two remaining approaches to the study of creativity are the biological or neuroscience approach and the computational or artificial intelligence approach. Each of the six approaches to creativity research follows additional divisions centering to varying degrees on aspects related to person, process, product and environment, as seen in figure 2.1.

When aiming to situate this interdisciplinary thesis among the six approaches, we draw on multiple approaches to create a complete picture. In figure 2.1 we demonstrate the various approaches this thesis touches upon, indicated by pink dots. Contemporary cultural observations in the production of artistic works led to the understanding that creative processes in interactive media art operate on a continuum. This is indicated by the pink dot on 'process'. The creative process continuum emerges from cultural developments as they take place collaboratively and via participation as part of the greater technological and cognitive evolution. This is indicated with a pink dot on the contextual approach. To study this creative process continuum in a real-world instance with multiple methodologies we deploy a case study research strategy. We draw on qualitative analysis from biographical approaches and more recently also deployed in experimental psychology. For a quantitative analysis we use statistical tools from experimental psychology. Overall this the-

sis is underpinned by the understanding that creative mental operations exploit extant knowledge structures, which involve the body as extended, situated and coupled in its cognitive operation and embedded in the social and material environment. Therefore this thesis conducts investigations from the mindset of embodied cognition which will be elaborated upon in chapter four.

2.2.1 Research topics and experiments in the main approaches to creativity

Previously we outlined the main approaches in the research of creativity. In this subsection we demonstrate in more detail psychometric methodologies, and important developments in experimental psychology in support of this thesis' research. With the former focus, we aim to shed light on narrow understandings of creativity from previous decades that are still pursued in contemporary research on creativity, operating from the standpoint of individual differences via psychometrics. With the latter, we reveal more recent developments in experimental and social psychology. Here, lab studies are beginning to take a direction that recognises the importance of social and subjective aspects in real-world creativity.

2.2.1.1 Divergent thinking and problem-solving

In the first approach mentioned earlier, psychometric researcher Guilford (1975) developed an approach to creativity by extending the divergent thinking component in his Structure-of-Intellect model (SOI) of intelligence.

The *encyclopaedia of creativity* states: "Divergent thinking is cognition that leads in various directions. Some of these are conventional, and some of these are original. Because some of the resulting ideas are original, divergent thinking represents the potential for creative thinking and problem solving. Originality is not synonymous with creative thinking, but originality is most undoubtedly the most commonly recognized facet of creativity" (Runco & Pritzker, 1999, p.577).

Guilford defined creativity as a form of problem-solving, characterised by sensitivity to problems, fluency in the production of ideas, flexibility and novelty of ideas, and ability to synthesise and reorganise information (Guilford, 1950). Specifically, the classification still in use today describes problem-solving ability as:

Fluency is defined as the number of meaningful and relevant ideas generated in response to the stimulus.

Flexibility is defined as the number of relevant responses for different categories.

Originality is defined as the statistical frequency of the responses.

Elaboration is defined by the amount of detail in the responses.

Kaufman (2009) suggests a more memorable way to define these four scales: "Lets say that your significant other wants to go out to eat and asks you to come up with different restaurants that might be a good choice. You might come up with a huge list of restaurants (high fluency), you might come up with a wide range of food styles (high flexibility), you might think up a few restaurants that most people would not have known (high originality), or you might focus on one type of food and rattle off every single place nearby (high elaboration)".

These four factors to problem-solving are then applied to a typical test question in divergent thinking, such as: name all things that you can think of that are both white and edible? In con-

vergent thinking the question might be something like this: what object is black, hard, found underground, and is used for heating? (Guilford, 1988). Creativity researchers speak of Guilford's divergent thinking tests as a battery because it consists of a number of tests in different subject areas corresponding to the various divergent-thinking components of Guilford's SOI model (Plucker & Renzulli, 1999). Criticism of Guilford's psychometric approach aiming to understand creativity has been directed towards his indifference to the social relevance of his research, and the fact that divergent thinking tests do not correspond to the kind of thinking required by serious creative activity. It has therefore had little to say about adult creativity in actual work domains (Sternberg & Grigorenko, 2001). Plucker and Renzulli (1999) and other researchers suggest that as far as the primary use of psychometric methods in quantifying creativity is concerned, it relates to the fact that researchers, who were interested in creativity, were already investigating other cognitive phenomena from the psychometric perspective. These researchers were continuing to pursue their methodological habits when they shifted their research to the investigation of creativity.

Research into creative thinking is fundamentally understood as originating from problem-solving. Individuals solve problems by producing and selecting discretionary actions that accomplish a goal state. The divergent thinking and convergent thinking components, which characterise the nature of ideas to be generated, are also closely related to what kind of problem has to be solved. For instance, divergent thinking is related to problems that require the person to engage in tasks that are open-ended. Generally the problem is ill defined. Convergent thinking on the other hand involves problem-solving with tasks that are closed-ended with well-defined problems. From this perspective divergent thinking and convergent thinking comprise opposite thinking processes but research has shown that both processes occur naturally on a continuum (Eysenck, 2003).

Creative endeavours in the natural environment do not pose problems that separate the processes of divergent or convergent thinking. This indicates that findings in convergent and divergent thinking research, as separated research strands, produce an incomplete picture of creativity. This is because these findings do not uncover how each spectrum of divergent and convergent thinking processes interact with each other. Divergent thinking tests developed by Guilford and later pursued by his successor Torrance (Torrance, 1988) are often criticised for being too narrow, and are unable to capture the broad spectrum of creative ability.

2.2.1.2   *Problem-finding in art*

In creativity research problem-finding is understood as a component in problem-solving. Problem-finding and problem-solving involve skills and cognitive tendencies that belong to the general creativity complex (Runco, 1994). Problem-finding is considered a preparatory stage, which defines the problem that is being solved in the course of the creative process in a series of succeeding stages. Previously we mentioned that Guildford's model recognised aspects of problem-finding by acknowledging *sensitivity to problems*.

Problem-finding has been developed as a research topic with a taxonomy of three different types (Dillon, 1982): (a) presented problems, where the problem and its apparent characteristic are pre-defined; (b) discovered problems, where the problem is derived from presented information; and (c) created problems, where the individual defines the nature of the problem and pertinent

information, creating a problem where none existed before.

Closely linked to problem-finding is problem representation. Changing the representation of a problem to be solved or restructuring the problem can affect memory load and also lead to developing insight (Sternberg & Lubart, 1996). Different positions have been taken up by researchers when explaining insight as a mental operation that is involved in solving presented problems. Weisberg and Alba (1981) suggest that cognitive processes are rooted in experience, memory and retrieval. However, the dominant accepted position is that insight occurs from mentally "restructuring" the problem, which takes place without awareness through swift cognitive restructuring processes (Metcalfe, 1986a, 1986b). In applied creativity, problems are generally open-ended without one correct solution. The position of the creative cognition agenda and its approach to research discussed later in this section, is that "insight may occur, for example, when novel properties emerge unexpectedly from combinations of elements drawn from memory, when retrieved information is transformed or modified, or when a coherence or systematic reclassification is discovered among pieces of information retrieved from memory" (Finke et al., 1992, p.149). Furthermore, Finke et al write that analogical transfer can also be useful in solving problems, and that studies have shown analogical transfer is encouraged through contextual cues.

Artists have notoriously been subjects of investigations in studies on problem-finding (Runco & Chand, 1994). In an influential empirical study, researchers investigated art students to better understand the applied creative process, as well as the concept of problem-finding (Csikszentmihalyi & Getzels, 1971; Getzels & Csikszentmihalyi, 1976). Thirty-one male art students who had been studying for at least three years in a well-established art school took part in an experiment that simulated free-creative conditions (when students were asked, 71% agreed with labelling the conditions as free-creative). These students were asked to make selections of their choice from twenty-seven still-life objects, such as a book, a lens, a bunch of grapes and a velvet hat. Objects had been set up on one table, and the student's individual composition was placed on another table inside their studio. Students were then asked to draw the composition, using a variety of dry media, until they felt it was complete while they were being observed and photographed during the process. Upon completion, artworks were assessed by five experts in the field on the basis of subjective ratings on craftsmanship, originality and aesthetic value. Researchers found that discovery-oriented behaviour (which corresponds to (c) in the taxonomy of problems), such as the length of time spent in the problem-finding stage, was predictive of the artwork's originality. Similarly, studies conducted with children and adolescents in the context of divergent thinking tasks found that discovered problems contributed significantly to the prediction of creative accomplishments (Wakefield, 1985; Runco & Okuda, 1988).

A completely different research take connects problem-finding and artistic, creative thought to the creator's emotional involvement. Wakefield (1986, 1992) studied problem-finding in relation to empathy for the self in conflict. The concept of 'empathy with oneself' is rooted in the observation (Margulies, 1989) that artists create from their experiences, and empathetic understanding of the artist's feeling of the self in conflict provides a useful tool for understanding artistic problems (Wakefield, 1994). He tested this hypothesis in a qualitative study that inves-

tigated problem-finding in creative thinking in relation to empathy for oneself. The study was conducted with creatively inclined college students using a Thematic Apperception Test (TAT), where a set of ten stories is told in response to nine ambiguous black and white pictures and to one blank white card. Wakefield (1994) reported that the "statistical correlations of the length of response to the blank card with scores on tests of creative thinking supported the conclusion that the blank card (as opposed to picture cards) tended to evoke creative responses" (p.110). Furthermore, a creativity index was generated which showed that education students majoring in the fine arts were more creative in response to the blank card than any other group. Wakefield further concludes that 'empathy with oneself' can help identify how problems are found in art, and that logic and intuition may play a role in problem-finding.

Wakefield's research findings have not been probed further, there is little additional research that extends the concept of 'empathy with oneself' into the realm of real-world artistic creativity. Empathy is also a component when creating artistic experiences for others that involve active participation with the 'field of artistic communication'. Enactive cognitive science, one of the directions within embodied cognition which we shall be discussing in chapter four, attributes empathy to the innate understanding of intersubjectivity. Rather than empathy with oneself, artists must find ways to understand empathically the consequences of their creative preparations for others to experience creative participation.

2.2.1.3 Intrinsic motivation and assessment of creativity

During the 1980's, due to the acknowledgment that creativity is socially embedded, an approach from social psychology began investigating the contextualising aspects of creativity (Amabile, 1983b, 1996). Conceptual and operational understandings of creativity were harnessed and brought together in a component model. The model is comprised of three components: *domain-relevant skills, creativity relevant skills*, and investigations of creative behaviour in relation to motivation, summarised in a third component as *task motivation*. Creativity is differentiated between intrinsically and extrinsically motivated behaviour. Intrinsic motivation stems from internally and personally generated aspects that promote interest in creative explorations. Extrinsic motivation is creative engagement on the premise of receiving a reward or other conditions that are placed from the environment upon the individual to elicit creative behaviour.

After hundreds of studies, Amabile and colleagues gathered unequivocal research evidence that led to the development of the *Intrinsic Motivation Principle of Creativity* which simply states that intrinsic motivation is conducive to creative behaviour and extrinsic motivation, such as an expected award, is almost always detrimental (Amabile, 1983a, 1996; Hennessey, 2003). Researchers state further that without intrinsic motivation, creative behaviour is most unlikely (Hennessey, 2003). From this body of evidence, researchers have gone on to uncover the equally detrimental impact of deadlines, surveillance and competition. Recent research data shows that the evaluation of an individual's creative work is the most baneful extrinsic constraint of all (Amabile et al., 1990; Hennessey, 2003). A suggested explanation for the impact of extrinsic motivation is that the individual discounts his or her internal motivation in favour of the external cause. Discounting intrinsic interests in favour of attending to external motivation for task engagement has

been found to be age independent.

Over the years this topic has produced a new understanding of motivation in contemporary research. This new perspective aims to conceptualise motivation no longer as a transitory and situation specific influence on creative behaviour. Instead, research into motivation should be conducted from the perspective that creativity is environmentally induced and that creative individuals exhibit enduring motivational traits. These findings on the role of motivation as propagated through environmental and social factors project serious criticism onto psychometrically measured creativity. For example, in the administration of Torrance tests a variety of social and environmental factors have been known to influence test results, and thus questions the construct validity of these tests as giving an objective account of creative behaviour (Hennessey, 2003) .

In addition, social psychology research has contributed to the assessment of creativity via the consensual assessment technique (CAT) developed by Amabile and her colleagues (Amabile, 1982, 1983a; Amabile, Hennessey, & Grossman, 1986; Hennessey, 1994). The development of CAT in the assessment of creativity was inspired by Getzels and Csikszentmihalyi's (1976) seminal research on problem-finding in the fine arts discussed earlier. In a longitudinal study researchers used subjective judgement when evaluating the results produced by art students. In the consensual assessment technique, judges evaluate creative output generated by subjects. The tests are always open-ended and the judges evaluate subjectively. The four main requirements for the judges are (1) judges have adequate experience in the domain; (2) judges assess the products independently and are not furnished with a definition of creativity, or any other instructions; (3) judges rate the creative products relative to one another, there are no absolute standards involved in the rating; and (4) each judge views the creative products in random order. Over the last two decades numerous researchers have deployed CAT successfully, making dependable judgements in product creativity by solely relying on the subjective gauge that people know creativity when they see it. CAT serves as an outstanding example (maybe the only one thus far) for the integration of subjectivity into the research field, overcoming the difficulty of having to specify an absolute objective criterion for creative assessment.

2.2.1.4   Evaluation in creative thought

Guilford (1975) identified five cognitive operations in creative thinking in his SOI model. Divergent thinking as one of the five cognitive operations is the production of many ideas as a solution to a problem. The counterweight to divergent thinking is the ability to evaluate ideas. Guilford narrowly defined evaluation as involving logical and conscious criteria in discriminating and judging ideas. Ideas cannot be evaluated by themselves, evaluation occurs in the context in which the idea is created. Idea evaluation in creative thinking, like many other "late cycle"[1] capacities, has received much less attention than cognitive processes that support idea generation. Contrary to some researchers' argumentation, idea evaluation is an active process and critical to creative achievement (Runco & Chand, 1994; Mumford et al., 2002).

At this stage in creativity research, there are two main views on evaluative thinking. Firstly, the understanding on evaluation of ideas refers to deferred judgement which encompasses a dis-

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[1]Late cycle pertains to the applied creative process and will be discussed later in this chapter

tinct set of cognitive processes operating after the initial idea has been formulated. Many studies conducted within this understanding are based on divergent thinking tests. Baer (1993, 1994) conducted experiments together with training programs in divergent thinking, and test results showed evaluation in divergent thinking is task-specific. He concluded that evaluative skills from this perspective are task-specific but that without further research it is unknown what these evaluative skills might be (Baer, 2003). Wallas (1926), who formulated the creative process in four stages (*1. preparation, 2. incubation, 3. illumination, 4. verification*), saw that *verification* of an idea took place after *illumination* and *idea generation*. Earlier, we mentioned Amabile's (1996) componential framework, where she describes *response validation* as the last step before achieving the goal of producing a solution to a creative problem. The majority of research on evaluative thinking understands it to be a separate step in cognitive processing.

Secondly, evaluation in creative thinking is coupled to idea generation and happens 'online'. Evaluative thinking occurs during the execution of idea generation processes. Online evaluative thinking is a generative-interpretive dynamic which, as Johnson-Laird (1988) illustrated, is one of the three relationships of constraint bearing on creative performance, typical for interpretive artists in improvisation, music and dance performances. Here, generation of ideas has to be spontaneous and arbitrary without an opportunity for revision, this process is aided by having had previous experiences in a similar context (Johnson-Laird, 1993). In less time constraining activities such as creative writing the same dynamic can occur when ideas are under revision. Mumford et al. (2003) were able to show that in an organisational setting, where individuals are presented with tasks that required creative solutions involving information gathering and concept evaluation, early evaluation led to higher quality and more original solutions. Finke et al. (1992) bases the Geneplore model (to be discussed later in this section) on a similar dynamic. On the meta-level of the model, the cycling through generative and interpretative cognitive processes inherently contains evaluative thinking.

It is important to note that researchers who are have conducted research in organisational arenas in commercial settings have advanced understanding on evaluation in creative thinking because these researchers are investigating the implementation of ideas. Mumford and colleagues (Mumford et al., 1991, 2002; Vincent et al., 2002) found that evaluative processes follow idea generation while actively involved in the implementation process, during this time even more creativity comes into play in the appraisal, impact and popularity of the idea. Mumford et al. (2002) argue that ideas might be produced against a set of criteria but once in the process of implementation, especially under revision, they are judged against different criteria than used during the idea generation process.

Welling (2007) reviews the main four mental operations in creative thought and raises the issue of relevancy in selection criteria. He refers to Damásio's 'somatic markers' (Damásio, 1995), an emotionally-based selection tool, as evidence that this "selection device actually exists on a neurological level" governing all mental operations (p.174). Welling proposes that relevancy of information should give some clues as to how the selection mechanism functions, maintaining that in every task implicit selection criteria are present that determine the best solution.

Evaluation of creative ideas is paramount to the actual process of creation. Evaluation here means the artist evaluates an incremental idea that builds up the artwork against a set of criteria that he or she has chosen to be expressed in the artwork. What is evaluated is whether this incremental idea contributes to the overall artwork or whether the idea needs to be revised. Therefore, criteria for idea evaluation are completely context dependent because each incremental idea builds one what has been achieved so far. Many other factors may contribute to the evaluation of each idea, which lie beyond the previously established conceptual criteria for the making of the artwork. External factors, such time pressure, may impose limitations, or material concerns may constrain an artistic endeavour. All of this is taken into consideration during the evaluation of creative ideas in the process of creation. Types of evaluation and selection decisions are critical to creativity because they show resourcefulness and adaptability. These evaluation procedures have an accumulative effect, forging the direction of an artwork. From this perspective, it would seem more significant to understand idea evaluation in the face of several contingencies rather than locating the categorical placement of idea evaluation with creative thinking processes. Such research would entail studies in 'real-world' artistic creativity with 'real-world' forms of art. In this thesis we pursue the study of interdisciplinary 'real-world' collaborative creativity in media art, where evaluation is a multi-facetted cognitive process contingent on the generation of ideas but also on communication and forms of artistic expression.

2.2.1.5 *Creative Cognition and the Geneplore model*

In the early 1990's a broader psychological perspective was developed into the creative cognition agenda by Finke, Smith and Ward (Finke et al., 1992; T. B. Ward et al., 1997; T. B. Ward, Smith, & Finke, 1999). These researchers have created a research agenda, creative cognition, that approaches creative thinking from the standpoint of cognitive continuity. In contrast to conventional approaches to the study of creative thinking, creative cognition acknowledges that creative thinking embraces a multitude of cognitive processes that produce creative insights across domains. The researchers are not focussed on testing creative thinking instigated by a particular task but are looking to understand the interrelationship between cognition and perception in creative thinking. The underlying idea for the creative cognition agenda is that creative thinking is composed of cognitive processes that are open to investigation. Based on the significant body of research in cognitive science that looks at cognitive functioning, these researchers link their development of formal experimental methods investigating creative thinking to concepts in cognitive science. They have found that cognitive functioning in creative behaviour covers the range from mundane to extraordinary creative performance via generative processes (Finke et al., 1992). Fundamentally this generative cognitive ability can be seen from the fact that humans "readily construct a vast array of concrete and abstract concepts from an ongoing stream of otherwise discrete experiences" (T. B. Ward et al., 1999, p.190). In creativity, the output of these generative abilities must then be processed in an evaluative capacity to fulfil, as discussed earlier, the dual axis of novelty and utility.

In 1992 Finke et al. (1992) developed the heuristic model of creative cognition, called the Geneplore model. The model is a conceptual framework that captures the cyclic dynamic of gen-

erative processes on one hand, and structures that explore and interpret output on the other. In an attempt to validate their model, creative cognition researchers proceeded in designing a series of experiments that build on extant knowledge structures. The generative processes of extant knowledge structures are responsible for the continuum of creative and non-creative thought encompassing substantial overlap between both. In creative cognition, creative thinking is characterised by how these generative cognitive processes are employed or combined. Therefore, it is one of the goals of creative cognition to determine the precise ways in which generative processes and factors influence creative functioning. In this sense, individual differences in creative ability are understood as variations in the use of "specifiable processes or combination of processes, the intensity of application of such processes, the richness of flexibility of stored cognitive structures to which the processes are applied, the capacity of memory systems, and other known and observable fundamental cognitive principles" (T. B. Ward et al., 1999, p.191). The idea of continuity in creative ability makes creative cognition devoid of the search for any absolute definition of creativity, or the focus on selected specific cognitive processes. Although creative cognition is centred on mental operations, it acknowledges other factors contributing to creative performance, such as motivation, environment and cultural definitions of innovation.

From the perspective of embodied cognition and creativity, the creative cognition agenda and the resulting Geneplore model offer a platform where advancements from embodied cognition could be integrated to evolve this heuristic model. This possibility arises from the intrinsic adaptive modular approach and cyclic dynamic between generative processes and structural exploration of creative and non-creative thought as a continuum of cognitive traits. But as far as the author is aware there have been no attempts made in this direction.

2.2.1.6   *Experiments in support of the Geneplore model*

To illustrate adaptability of this model, we will summarise the most significant aspects of experiments and research findings. Experiments in creative visualisation were centred on mental synthesis and image scanning, where researchers placed an emphasis on novelty, ambiguity and emergence. With the aim of investigating creative visual discovery in two-dimensional forms and alphanumeric characters, creative cognition researchers stepped beyond limitations of demand characteristics (such as tasks can either be right or wrong) and designed procedures that are in their nature more explorative. Similarly, open-ended task evaluation led researchers to incorporate self-reports to access individuals' strategies when performing tasks. Researchers did not separate experimentally an individual's mental construction of patterns from the process of creatively interpreting them. These studies demonstrated the importance of combinational play in generating creative ideas with results attesting to structured qualities in that the patterns imagined were not randomly assembled but exhibited beauty and elegance (Finke et al., 1992).

When developing experiments to investigate creative mental synthesis utilising real-world objects, the researchers provided drawn three-dimensional geometric object parts, or preinventive forms, that can be formed into solid shapes and interpreted as novel ideas for creative inventions. Experiments varied in condition with restrictions on object parts and/or categories, and random versus chosen object parts and/or categories. After generating these creative inventions, or prein-

ventive forms, individuals were prompted to interpret their meaning and use. These inventions were mainly generated in a utilitarian context, for example a contact lens remover was developed by a subject. In correspondence to previous experiments, researchers were able to confirm that an invention is more likely to be creative when preinventive forms are generated by individuals before knowing what the interpretive category would be. In sum, an individual's creativity was enhanced when preinventive forms (or the product) were generated without goal. Only after that step had been completed, creative insights brought forth meaning and use for these preinventive forms. Finke et al. (1992) clearly state that these studies only represent the initial phase of the creative process and are not indicative of the development of a prototype.

Similar findings were confirmed with experiments conducted in conceptual synthesis, using preinventive object forms (for example a hook) in terms of mental blend, such as conceptual combination and metaphors. The discovery of a creative concept was more likely when the interpretive object forms were interpreted after forms were already generated. Conceptual combination is the merging of previously separate concepts into units that express new thoughts, ideas, and meaning, which have shown to engender emergent properties that were not previously present in the separate concepts (Wilkenfeld & Ward, 2001). In conceptual combination Finke et al. (1992) suggest that incongruous separate components which form conceptual combination, as well as the property of ambiguity, may result in increased creative cognition in the absence of an obvious interpretation. In other words, when readily available interpretations are a given because of the similarity of the concepts in disposition, efforts to produce alternate interpretations are minimised. These studies on conceptual combination and metaphors test for comprehension through the interpretation of visual stimuli, they do not investigate the production of ideas using conceptual combination and metaphors, as it would occur in real-world performance of creative work.

In section 2.2.1.2 we briefly mentioned the creative cognition stance on the insight problem, which is the investigation into the underlying mechanisms of insight production. Creative cognition researchers acknowledge that memory has a role in providing useful clues and critical information in solving a problem. Memory retrieval constitutes one aspect of insight which grants the basis from which the information is transformed or modified so that novel properties can emerge unexpectedly from the combinations of elements drawn from memory.

Creative cognition experiments are likely to be the most realistic simulations exploring the concept of creative discovery in a controlled environment with qualitative flexibility, such as the use of self-reports for data collection. The nature of this approach encompasses random, novel, complex and incongruous stimuli. From the perspective of this thesis, the creative cognition agenda represents perhaps the only approach in creativity research studying in controlled environments with prerequisites flexible enough to include embodied cognition principles in the design of experiments, and tasks that closely mimic those of existing art forms in real-world artistic creativity.

In section 2.2.1, we have given an overview of research topics and typical experiments conducted in creativity research. Although the approaches range from paper and pencil tests in the quantification of creative thinking processes to studies in creative discovery that use preinven-

tive forms in the production of ideas for three-dimensional inventions - the research emphasis is strongly focussed on cognitive traits that probe for idea generation without considering the temporal dimension of the creative thinking. In real-world creativity implementation of ideas takes considerable time and a transformation of preconceived conceptual notions to be expressed through materials in the world. To construct an artistic idea with worldly materials so that it can be perceived by others is an emergent process that makes extensive use of the body's sensorimotor capacities. The temporal dimension of artistic creativity is largely overlooked although it is a well-known fact that those working professionally in artistic domains can spend years on a single project. In the next section, we review how creativity research has investigated aspects of the creative process in artistic creativity.

2.3   Creativity research and the creative process

In this section, we focus on the study of applied artistic creativity in the visual arts by originating artists[2]. As we mention in this section at a later stage, creativity research has paid little attention to forms of art-making, therefore the visual arts present the closest relative in this genre that can be discussed from the perspective of this thesis. The media artwork Sim-Suite, central to this thesis' investigations, is composed from visual and sculptural elements and both are considered visual art.

We start out by connecting back to an earlier subsection on problem-finding. There, we described a landmark experiment where researchers learned that discovery-oriented behaviour, indicative of the time spent in the problem-finding stage during artistic creation, was predictive of degrees in the artwork's originality (Csikszentmihalyi & Getzels, 1971; Getzels & Csikszentmihalyi, 1976). Since then, few experiments have been conducted that investigate whether problem-finding occurs in actual real-world creativity. Those who have made it part of their research to observe professional visual artists at work have done so from different perspectives, each addressing a particular issue. Barron (1972) investigated art school students to draw up a general profile of budding artists; Mace and Ward (2002) interviewed sixteen professional visual artists during their creative process to understand influences and interactions with the environment; and more recently Yokochi and Okada (2005) contributed a detailed cognitive analysis of the creative production by a traditional Chinese ink painter, and Edmonds et al. (2006) investigated types of interactivity with artworks that focus on human-computer interaction. Others have gathered data retrospectively via interviews and self-reports. Israeli's (1981) hybrid approach investigated artist's decision-making via observation of the actual process of painting and sculpture together with retrospective data such as notebooks, interviews, and the finished artwork. Okada et al. (2009) conducted a series of interviews with two visual artists, investigating how the themes of their work evolved through analogical modification. D. T. Marsh and Vollmer (1991) used interview techniques to focus on the multi-dimensionality of the creative process, and paid attention to the assumptions that visual artists and writers make about the creative process. Cawelti et al. (1992) expanded Marsh

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[2]Originating artists produce artworks that originate an object of some kind. In contrast, interpretive artists are interpreting an existing object.

and Vollmer's (1991) work via interpretive structural modelling. Mace (1997) interviewed professional artists to determine if there are patterns in creative production while recognising that multiple variables influence the process.

2.3.1 Problems with problem-finding and process definitions

One study in particular revisited problem-finding defined by Getzels and Csikszentmihalyi (1976) as being a central component of the creative process distinct from problem-solving. Dudek and Côté (1994) conducted an experiment akin to Getzels and Csikszentmihalyi's experiment in the attempt to validate their results on problem-finding in the artistic process. In addition, Dudek and Côté's experiment included divergent thinking measures to assess the relationship between divergent thinking and problem-finding in artistic activities. For their experiment, researchers shifted to a different artistic medium as well as a different observational technique. To avoid confounding craftsmanship with aesthetic quality they chose photographic collage as the artistic medium which helped in controlling for drawing skills. In the modification of the observational technique, Dudek and Côté opted to videotape the duration of the experiment instead of recording it by direct observation. This eliminated possible disturbances of the subjects through the physical presence of an observer and allowed for more flexibility in the analysis.

Other elements were directly referenced from Getzels and Csikszentmihalyi's experiment, such as subjects were art students, and the use of a studio as location for the experiment. Similarly, subjects were able to access a table with twenty-three still-life objects of the kind that Getzels and Csikszentmihalyi used for their experiment. The subjects also accessed another table where they could select photographs of the same twenty-three objects. Dudek and Côté divided the experiment into two timed phases, a preparatory phase (or the problem-finding stage) where subjects selected and arranged the objects, and a solution phase (or the problem-solving stage) where they constructed the collage by cutting out photographs and pasting them on cardboard. The divergent thinking test was the TTCT, figural forms test, it was administered at the end of the collage-making activity.

Dudek and Côté were not able to confirm Getzels and Csikszentmihalyi's findings. Exploratory behaviours in the preparation phase, or problem-finding stage did not correlate significantly with aesthetic or original qualities. The results uncovered that the sum of behavioural acts during the problem-solving stage correlated significantly with aesthetic and original quality of collages, and subjects who performed more behavioural acts during the problem-solving stage scored higher on the originality scale of the TTCT. Dudek and Côté concluded that this difference stems from the change in medium which required the subjects to re-orient themselves to an unaccustomed task of cutting and pasting photographs as a creative activity. Furthermore, they explained that this difference does not indicate problem-finding as an index of greater creativity. Rather it questions the sequence which could mean that problem-finding takes place in more than one phase.

Problem-finding is attributed to the preparation phase in Wallas' (1926) classic four-stage model of the creative process. The model identifies four components: (a) preparation, (b) incu-

bation, (c) illumination, and (d) verification. Lubart (2001) compiled a comprehensive review of research that has been conducted on the modelling of the creative process. He noted that Wallas formulated his model based on introspective accounts of creative acts by highly creative people. A closer look into Wallas' sources shows that creative people whose accounts where taken into consideration for the model were mostly scientists, such as Hermann von Helmholz and Poincaré[3]. Creative behaviour in the arts differs from creative behaviour in the sciences and this includes problem-finding and problem-solving (Cawelti et al., 1992; Mace & Ward, 2002; Wakefield, 1988). Dudek and Côté explain that the concept of problem-finding originated in the field of science, where this concept is appropriate because in science "problems can be formulated and answers can be found, tested, verified, or rejected". They further state: *"Science, unlike art, is a shared body of intertwined theoretical and methodological beliefs, concepts, laws, and theories held together by a dominant paradigm which attempts to offer a coherent explanation of the functioning of the physical universe"* (p.141).

On the other hand, Dudek and Côté observe that artistic creation is underpinned by a creative search for a personal format from the beginning to the end of the creative process. The search is guided by an intrinsic and personal understanding of form and quality, and grounded in an inner system that is flexible and affective, composed of idiosyncratic rules and procedures. This system is sensitive to its surroundings, adapting and fluctuating moment to moment in response to both, the inner and outer stimuli throughout the process of creation. This search stops when equivalence is reached between both states, and has manifested the personal format. Dudek and Côté further mention that this interaction between inner and outer realm during the creative process can impose psychic tension on the artist, or disequilibrium, which is partial to transcending the "censoring eye of mere expertise" to arrive at the state where the creative product *feels* right. We are reminded of Wakefield's (1986, 1992) research cited earlier in section 2.2.1.2. Wakefield found that artists react emphatically, they use their experiences engendered from the self in conflict in the process of creation. Mace (1997) studying the creative process of professional visual artists observed that the creative process includes "the awareness of a perceptual or conceptual conflict" and the "physical rendering of that problem" (p.273).

The main message that Dudek and Côté advocate is that the creative process is a journey of *discovery*, and this is still the case even if the 'problem' has already been defined. They are unable to agree with Getzels and Csikszentmihalyi's definition of problem-finding as indicator of creative thought, and label it rather as trial and error pursuit, common to all problem-solving. Dudek and Côté see the artistic process as "a search for more meaningful, more satisfactory and thus more original ways of expressing the artist's vision through the vocabulary of his or her own time" (p.142).

2.3.1.1   *The one-size-fits-all definition of the artistic process by visual artists*

In an experiment conducted by Cawelti et al. (1992), artists worked together with researchers in modelling the creative process which showed that artistic experience engenders a high degree

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[3]In chapter five on "Thought and Emotion", Wallas also looks at artists, but mostly to quote excerpts from poems by poets such as Dante, Blake, and Shelley.

of simultaneity between artists. Cawelti et al. (1992) state that classifying the creative process into four stages is an oversimplification which obliterates the importance of this simultaneity. Lubart (2001) in his review cites a substantial amount of research which does not support the four stages formulated by Wallas (1926). He highlights a study conducted by Eindhoven and Vinacke (1952) who investigated artists as well as non-artists in the creation of paintings over several sessions, which included the recording of thoughts and sketches into notebooks in-between sessions. Eindhoven and Vinacke (1952) found no evidence that support the four stages but described the creative process as being dynamic and recursive. Mace (1997) reports that in her study on the creative process with professional visual artists problem-finding and problem-solving as defined by Getzels and Csikszentmihalyi (1976), occur recursively throughout the entire creative process, at any given moment without particular sequence. Mace defines both stages together as *problem manipulation* and concluded that avoiding a separation of the creative process into problem-finding and problem-solving would yield greater theoretical value because from her research the creative process is a process of responsive and flexible development.

These results are also mirrored in lab studies with professional artists. For example, Kay (1991) conducted a study investigating problem-finding and problem-solving behaviour by posing open-ended tasks in conjunction with two puzzle games to sixty professional artists, semi-professional artists and non-artists. Her results are unable to confirm problem-solving behaviour by professional artists, instead her study shows that "professional artists used a personal aesthetic that guided their ideas in art as an organizing principle" (p.250). Only semi-professional artists offered elements of problem-finding behaviour as suggested by Getzels and Csikszentmihalyi (1976). Evidently, there are more complex issues at stake with problem-finding behaviour, including factors related to experience and development of a personal perceptual language.

A recent study by Simonton (2007) argues that Picasso's sketches for the painting of *Guernica* were derived from blind-variation & selective-retention (i.e. nonmonotonic variants), rather than a more systematic, expertise-driven process. Although this thesis' research is not concerned with creative cognition as special trait nor with the distinction of a pro- or anti-Darwinian viewpoint, however it is important to flag that Simonton demonstrates in his analysis of Picasso's sketches as they lead up to a final painting a chaotic, exploratory and unpredictable trajectory that conveys the artist's intent on *searching*. This stands in contrast to a straightforward progression of orderly sketches which would be expected if the artistic process was neatly distinguishable as a series of consecutive stages suggested by Wallas (1926) and others. The concept of *searching* may well be in line with Dudek and Côté's (1994) understanding of the artist's 'inner' system which is sensitive to and incorporates experiences from the environment in a quest for a personal format. In the previous section when discussing the creative cognition agenda and the Geneplore model, findings on creative visualisation, mental and conceptual synthesis, are consistent in confirming that creative output is more likely when individuals engage in a task as a form of *discovery*, where the interpretation of the creative product's meaning and use takes place *after* the task has been completed.

In summary, from creativity research we learn that the visual artistic process is complex. The

general consensus is that the creation of artworks is approached in an individualistic manner, through a process that is determined and shaped by interactions with the social and material environment and the experiential accumulation of acts in art-making. It is important to note that the research reviewed here is from studies with a focus on single artists rather than on artistic collaborations. This research evidence shows that it might not be possible to prescribe a generic classification of steps or procedures to the creative process by visual artists. Mostly we have seen that this type of creativity engenders processes that are cyclic and recursive while referencing the artist's reflexive engagement with the physical rendition of the artwork-in-progress. The artistic product emerges through the developmental process because visual artists are not working to resolve a preordained idea. Throughout the remainder of this thesis, we shall demonstrate on Sim-Suite as case study that this approach is also maintained in collaborative artistic creativity. The essence of the process is formed from and by perceptual engagement with tools and materials while unfolding a journey of personal communication between self and immediate surroundings, grounded in the artist's contingent social and cultural experiences from which the artistic product emerges as 'track record'.

In this thesis, we aim to convey that 'real-world' creativity with 'real-word' contingencies is not linear or categorical, and specific to the type of artwork that is being created. We shall illustrate that creative cognition by Sim-Suite's collaborators and participants consists of web of cognitive processes that are situation-dependent, orchestrated by the conscious mind, non-conscious neurological processes, and the body. The current scientific view of cognition is that cognition is embodied in the development and determination of cognitive processes through real-time and goal-directed interaction of an organism's sensorimotor capacities, body and environment.

2.3.2   A process without a body?

Previously discussed research results by Dudek and Côtè (1994) showed that artists who were more engaged and physically active scored highest in producing aesthetic and original collages. Moreover, this correlation carried over to divergent thinking tests, focussing on requisite mental skill. The body's role in the creative process is possibly more than that of a facilitator, physically executing pre-conceived thoughts and ideas to manifest objects in a three-dimensional world. In this subsection we review studies in visual artistic creativity that have either mentioned or focussed on aspects of embodiment. Although these studies are scarce, their findings show how the body's role is not subordinate to creative thought processes.

Although Mace (1997) expressed the need for researchers to broaden their conceptual horizon about where determinants of creative behaviour lie and how these interact with each other, there is little knowledge on how and why aspects of the creative process are influenced by embodiment. Smith and Amnèr's (1997) literature overview and survey of research on creative perception sees the concentration on visual perception in creativity research as potentially one-sided. In justifying this position, Smith and Amnèr mention that other researchers such as Arnheim (1954, p.154 ff.) had similar observations in that "the tactile channel has a greater and more penetrative power than the visual one" (p.78). This is to say that physical engagement is at least as meaningful as is visual

perception. Furthermore, Getzels and Csikszentmihalyi (1976, p.247) consent to the importance of physical engagement in artistic creation. They state "that a creative problem cannot be fully visualized in the "mind's eye"; it must be discovered in the interaction with the elements that constitute it".

Many investigations into the artistic creative process have reported findings related to physical engagement. In the context of embodiment, these findings are subordinate because they are reported and discussed only in relation and connection with overarching concepts such as problem-finding or problem-solving, or other aspects pertaining to the artistic creative process as systematic engagement. Separated from the main objective, the signification of these findings is inconsequential. In the previous section we saw that Dudek and Côtè's (1994) research results demonstrated a close relationship between physicality and creative output. Moreover, Kay (1991) found in her study that professional artists were expressing their thought process through visual-spatial strategies. In comparison to the other two groups (semi-professional artists and non-artists), professional artists showed a more continuous and varied physical interaction with the study's materials. Professional artists considered more variables of the puzzle pieces, they were picking up individual pieces and analysing colour and shape and reflecting on work-in-progress, such as moving to obtain different viewpoints or rotating the creative product. Mace (1997) who conducted an investigation into real-world art-making using a multivariate analysis was particularly interested in how creative processes physically manifest over time. She concluded that the creative process is centred on awareness of a cycle that allows conceptual and perceptual understanding to be rendered into physical form, which then feeds back an extended comprehension, starting the cycle all over again. Therefore, the physical manifestation of the creative process realised by and through the acting body is not only a feedback loop to the artist's thought processes but also the 'engine' to instigate more thought patterns that evolves the creative product. In a subsequent study, Mace and Ward (2002) confirm that the process of physically creating artworks influences concept development of the artwork and that content and form are interdependent in advancing "negotiations" between artist and artwork.

Yokochi and Okada (2005) conducted a study on the real-time creative process while explicitly focussing on the relationship between body movements and cognition. They investigated a case study of a Suibokuga painter, or traditional Chinese ink painter. The Suibokuga painter was observed and interviewed in two instances. In the first instance, he was videotaped while working on his commission, painting Fusuma doors of a Japanese temple, and interviewed upon completion of the work. The second instance was a field experiment designed by the researchers to take advantage of the painter's fondness of improvising on lines drawn by members of the audience. The painter was asked to produce eight images created from fifteen random lines drawn by two experimenters and eight images created on blank paper. Both sets were on the theme of 'the four seasons' with two images of each season in each condition of the experiment. The entire production took five days while he averaged creating three to four images a day in his studio, and upon completion he was interviewed.

Yokochi and Okada found that the painter started out without a clear picture in mind of what

he was going to paint onto the temple doors. He first filled in larger areas with approximately twenty-minute painting sessions, alternating painting with stepping back from the doors to survey his work. He frequently paused his paintbrush between concentrated stretches of painting. As he was getting closer to finishing his work, he moved back and forth in front of the temple doors adding a few lines here and there. A similar pattern of behaviour was observed when he drew on paper. From interviews and observations, researchers concluded that the painter gradually evolves his painting during the process, and that pausing is indicative of the painter forming his plans.

Yokochi and Okada further investigated why the painter moved his brush in the air before drawing lines on paper. The researchers had identified three sections in each drawing cycle. The beginning section was marked from when the painter soaked his brush in the Chinese ink plate until just before putting it on paper. Hand movements with the paintbrush in the air were accumulative in the beginning sections of the drawing cycle in both conditions of the field experiment. The researchers' conjecture is that hand movements are supporting the painter's decision where to sit down the brush on the paper, and also supporting rehearsal of smooth brush movements while generating a mental image of what he is planning to draw. Yokochi and Okada preliminarily concluded that the function of these body movements is to manage two essential activities in creative drawing, they assist in bridging the production of mental images with the physical production of images on paper.

The benefit of studying artists in the field is that these studies can supply researchers with information that is inaccessible to lab-generated studies (Mace & Ward, 2002). Yokochi and Okada (2005) comment that field studies in particular have the advantage to propose new hypotheses and insights with high ecological validity although they are difficult to conduct in terms of controlling variables. In an insightful review, Mumford (2003b) took stock of the latest developments in creativity research. In his review he devoted a section to "late cycle skills"[4] where he pointed out that traditionally creativity research has been centred on "early cycle" activities, and this includes capacities and dispositional characteristics that facilitate idea generation. According to Mumford, the field has neglected studying the late cycle, or the implementation of ideas that he claims is not, as some researchers think, just a matter of implementation issues. In a rebuttal, Mumford (2003a, p.150) emphasised that during the late cycle *the activities involved in turning an idea into a useful new product, a host of other new cognitive and social processes comes into play*. Furthermore, he stated that the research potential of the late cycle was already pointed out to the research community fifty years ago.

In summary, we see that a small number of creativity researchers investigating the creative process by visual artists recognise the importance and signification of their observations in relation to the body. Although the field is aware of the necessity to understand late cycle cognitive processes, little has been done to contextualise these findings beyond their description in reported research results. This is a gap that can be filled by embodied cognition principles.

The late cycle is a prominent part of real-world creativity which is closely linked to tool use, traditional as well as technological tools, it is where the body moves into a vivacious role engen-

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[4]As far as the author of this thesis knows the term has been coined by Mumford but is not widely in use.

dering cognitive niches that integrate cognitive processes through physicality. When 'engineering' the artistic artefact, through shaping and changing materials with tools and objects, artists actively look for opportunities in their cognitive activity of problem-solving and decision-making. This is a process of niche construction through creative performance, and while doing so artists exhibit a wide range of cognitive behaviours in which they extend their minds in the environment as they utilise available external resources. Emergent from this activity is an interplay between the individual and the environment that builds up a network of creative interactions characteristic of the art form in which the artist is working.

In this thesis we explore the actual collaborative creative process from the vantage point of embodied cognition. We achieve this by using theoretical stances by embodied cognitive scientists and also by building on the empirical research produced in recent years in various areas in the field. In this way, the thesis contributes an embodied cognitive perspective on 'real-world' artistic creativity which has been, until now, not considered by creativity research.

2.3.3   Art without contemporary forms?

A similar notion of a 'missed opportunity' is that artistic creations are rarely studied in relation to contemporary cultural currents. In subsection 2.3.1, Dudek and Côté (1994) indicated that the artist's vision is expressed through the vocabulary of his or her own time. Those who study the creative process in the visual arts have mostly turned to artworks in classical traditions while omitting contemporary developments of artistic vocabulary.

Empirical investigations of artistic creativity that authentically capture circumstances, contingencies and social interactions surrounding the artistic process are not easy to realise, which has been confirmed by those who have studied real-world creativity (Mace, 1997; Mace & Ward, 2002; Yokochi & Okada, 2005). In addition, laboratory tests are insufficient, they only procure a feeble approximation of what takes place in the real world. Gardner (1994) spoke about the inadequacy of testing artistic creativity via divergent and convergent thinking tests. He explained that these kinds of tests barely suggest the complex behaviour involved in the "knowledge of a medium". This should be self-evident to most researchers because of the 'relative ease' involved in achieving improved performance on divergent and convergent thinking tests through brief training sessions, therefore making these tests inadequate for understanding artistic creative skill in a particular medium. He concluded that the field has "little concern with the perspectives of various art forms, or with patterns of individual and critical development, interest, skill and understanding" (p.18).

Gardner's keen observations are indeed neglected exigencies of creativity research investigating artistic creation. In particular, recognising that art forms, cognition and creation are inseparable to the understanding of artistic creativity, this thesis attends to this issue which, in part, frames the gap of this research. To get a perspective on the significance of art forms we look to others who research cognitive evolution. Donald's (2006) starting point across all artistic domains is that "art is always created in context of distributed cognition" (p.4). In his research he is concerned with the origins and functions of artistic forms and media, and what cognitive principles govern art.

Although his concern is not directed to creativity, his research findings on evolutionary cognitive aspects of art provide a platform for clarification of how art forms are intrinsically tied to creativity.

Donald states that art constitutes cognitive engineering where the artist deliberately engineers audiences' experiences by using foundational mechanisms of human social communication: joint and reciprocal control of attention. To do so the artist must anticipate audiences' reactions which can only happen up to a certain extent because the perceiver's brain does not have identical ways of deconstructing a world. Engineering a state of mind in an audience, the outcome is always cognitive and is judged by how effectively this state of mind change was achieved[5]. Art cognitively engineers major social functions via special kinds of cognitive machines that "influence memory, shape public behaviour, set social norms, and modify the experience of life in their audiences" (p.7).

Artists operate in human cultures and these cultures can be seen as massive distributed cognitive networks where worldviews and mental models are constructed and shared by members of a society. Traditionally, artists operate at the forefront of the process of large scale integration, which is a uniquely human characteristic to integrate many sources of experiences into a single abstract model or precept [6], linking minds together through the flow of ideas, memories and knowledge. In creativity research there is some understanding of a larger network in which art functions, recall section 2.2 where we discussed Csikszentmihalyi's (1988) contextual approach to creativity via a systems view, defining artistic work as emergent from networks of individuals, ideas, actions and objects in a particular domain. Artists not only derive their most basic ideas and techniques and inspiration from the network but must also function within its limitations.

Artists' minds emerge from society, obtaining their material from culture itself. The artistic object reflects the process that created it through predominant mental models and worldviews that surround it. Therefore art emanates from "the innate human capacity of self-reflection" where artists influence cognitive activity of a society by deliberately refining, changing, elaborating mental models and worldviews through symbols, allegory, images, and other expressive forms, creating a "collective vehicle for self-reflection" and shaping identity of cultural periods (Donald, 2006, p.5).

Donald claims that "art is a technology-driven aspect of cognition" (p.6). Technology, a driving factor in the properties of the distributed cognitive system and network of society, alters the nature of how cognitive work is performed. Symbolic technologies, or art-making technologies in general, are forms of carriers for artistic expression of ideas and representations. The role of the artists as component in the distributed cognitive system evolves parallel to the system's use of technologies. The media or technology of artistic expression affect directly what can be represented. It affects the kinds of cognitive networks that artists can construct, therefore expanding or limiting ideas, and furthermore, the range of worldviews. For example, the development of symbolic technologies enabled Rodin to conceive and cast his bronze sculptures but also limited what he was able to represent.

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[5]Donald points out this is so even in cases of extreme narcissism, where the only intended audience is the artist.
[6]The raw materials of experience and also memory constituents.

Technology influences architecture of cognition both inside and outside the head. Through the vehicle of a particular technology, or a technology that serves as an external memory system, art forms are changed and shaped, together with the worldviews they can represent, influencing collective memory itself, through "media of storage and pathways of retrieval" (p.6). Donald states that "this point has largely been missed in cognitive theories of art. When one is dealing with a distributed network of many individuals linked together, rather than an isolated individual, as a major source of creativity, the properties of the network, particularly those of network memory, become highly relevant. These are typically affected much more by technology than by the properties of biological defined memory in the individual, which are largely fixed in the genome" (p.7).

To set this thesis' stage, in the first chapter we provided input from scholars in the humanities describing how technology changed the definition of artistic engagement between artist and audience. This change was instigated through the use of symbolic technologies that allow the engineering of intimate, cultural experiences which direct audience members' agency to interactive participation within the devised 'field of artistic communication', while stimulating new aspects of self-reflection, and physical and mental experiences. The absence of contemporary art forms using new symbolic technologies, such as digital media art, from creativity research presents a gap in understanding how artistic endeavours have changed creative engagements in regard to the collective distributed cognitive network they function within. Cultural theorists can make statements about the digital impact on cultural governance but at this time creativity research is unable to report how these changes have affected artistic creativity in the larger distributed cognitive creative system.

This thesis aims to explore new grounds that could be further developed by investigating creativity in conjunction with developing forms of artistic expression. Media art is a diverse art form where activities from one project to the next can vary depending on the conceptual content that is being tackled. Naturally, our methodological approach is specific but could be refined in future work, and hopefully can encourage similar types of investigations. Over time this would render a collective picture of the relationship between creative processes, new symbolic technologies and social interaction.

2.3.3.1 *Digital materials as building blocks in contemporary art*

New symbolic technologies are made from digital materials[7] that are electronically driven and are not three-dimensional like conventional materials. Digital materials have shaped new perceptions on the global scale, they have been integrated in all facets of life, including contemporary art forms. Prior to the rise of digital materials in society, humans were adapted to conventional physical materials and from these coalesced artefacts that related spatial dimension to internal complexity. The spatial dimension of the artefact signifies the complexity of the artefact in its use (Maeda, 2000). Typically, small objects have simpler functions bigger objects have more complex functions. This size-complexity relationship further extends to what kinds of interactions are developed between the artefact and human, and what kinds of skill sets are required in the interaction.

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[7]Digital material is used as an umbrella term for software, hardware, analogue technologies operating in virtual space.

When the first digital materials became prevalent in society new types of interactions were created. They were simplistic and did not depend upon a coupling with bodily skill during the engagement. Keyboards and buttons on a screen induced cognitive responses together with a series of monotonous and minor actions (Burr & Djajadiningrat, 2004). This general change of artefacts and the interactions they propose lies within the nature of the digital material itself. Manzini (1992) suggests that the miniaturisation of digital technology has disconnected this relationship of spatial appearance and internal complexity. This is the reason why humans can no longer relate with direct experience, through sensory perception, to the level of manipulative capacity of digital materials and components. This disruption between direct experience and projected manipulatable capacity, evokes a phenomenon in humans that lets the interaction with a digital or electronic artefact emerge mysteriously from inexpressive materials (Manzini, 1992). To compensate for these issues, humans learn to grasp the new temporal dimension that accompanies digital materials. A digital artefact may be small in size but virtual space is a dynamic surface that allows transcending the artefact's physical size through the axis of time. This axis recompenses the lost expression of internal complexity by adding the value of ceaseless operation (Maeda, 2000).

During the early days when information technology was restricted to keyboard, mouse and screen, before the arrival of ubiquitous computing in the 1990s, concerns about the engagement with technology were based on *what* technology could carry out in the interaction with humans. With the maturation process supplanting the confines of the desktop and enhancing the scope for interaction these concerns have shifted, and creators of human-computer interactions are now concerned with *how* we engage with technology. At the same time, the maturation process of information technology is opening up new possibilities for structurally coupled relationships between the human and the digital environment.

In recent years as the development of digital materials has progressed, the issue of inaccessible spatial-internal complexity in the interaction with digital materials is being tackled by incorporating conventional materials to mediate the relationship. Through physical computing, the amalgamation of digital with conventional materials, bodily skill and the role of the body have been better integrated in artefacts with human-computer interactions.

Information technology plays a big part in contemporary art-making and has expanded the field of art tremendously. The media artwork used as platform for investigation in this thesis could not have been created a decade ago because the concept of the artwork makes use of a variety of existing cultural concepts that are appropriated, recombined and reconfigured and assembled into a new system and innovative interface that combines conventional materials such as timber, wooden wobble-boards, bedsprings with analogue and digital sensor technology which have been developed in recent years.

2.3.3.2   *Collaborating originating artists and media art*

The use of new symbolic technologies in the visual arts has further changed patterns of collaboration between artists, and also between artists and non-artists. From the research perspective of group creativity, Kurtzberg and Amabile (2001) conducted a survey and found it to be an inchoate research area. Group-creativity has been researched from the standpoint of team-level creative pro-

cesses that focus on group problem-solving and brainstorming. Group problem-solving has been shown to carry potential risks and benefits, and study results seem to suggest that team interactions prevent creative achievement. Conducted primarily in lab settings, test participants are brought together only for the purpose of these studies. They shared no history, or any established patterns of interactions, or even an authentic incentive to collaborate and cooperate that would encourage mutual understanding. Only a limited number of studies have been conducted in natural settings but those were in managerial and organisational contexts. Kurtzberg and Amabile (2001, p.289) pointed out that research needs to understand how the individual mind generates ideas within the group and further, how creative ideas arise from creative synergy. Creative synergy is defined as ideas "formed, shared, adapted and inspired simultaneously by more than one person". Moreover, "central to the notion of creative synergy is the idea that a group of people has produced something that no one would have been able to do alone".

Artistic efforts in collaboration are conventionally attributed to the interpretive arts such as theatre and performance, which is to say that the collaborative factor is more visible to others because the artistic nature of interpretive arts is "fundamentally public, interactional, and social" (Sawyer, 1998). On the other hand, the creative process by originating artists is often concealed and the outcome, the final artwork, does not necessarily make the process apparent whereas the final product in the interpretive arts is the process itself (Sawyer, 2006). More significantly, media art created by originating artists is likely to follow a creative process that is indeterminate, where elements that create the final product vary depending on the artistic intention and materials, including a specific, immature technology.

In comparison to filmmaking which is also a highly collaborative endeavour and produced by originating artists, elements that contribute to film-making are predetermined, such as the script and actors, and the process entails the combining of creative clusters that are categorised into dramatic, visual, technical and musical clusters (Simonton, 2004). In contrast, the synergetic effect that the process of media art aims to achieve is based on the model of artistic collaboration where not only the sum of its parts is something more or different, but where "the parts are not removable or replaceable because they do not combine so much as change" (Green, 2004, p.596). Film-making on the other hand follows the model of artistic collaboration where the sum of its parts really does add up to create the cinematic product (Simonton, 2004).

In contrast to traditional approaches by originating artists, the interdisciplinary nature of media arts encompasses relationship-based interaction patterns that determine how the creative process of a project evolves, and how the project development is maintained over time. It is the potential high level of complexity caused by interdisciplinarity that is followed by a demand for diverse forms of expertise which figures into an increasingly collaborative practice approach in the media arts. Hence, the quality of the creative process is shaped by how these different forms of expert knowledge are brought together and are integrated to result in a synergetic effect, which is ideally as a whole something different from the sum of its parts (Steinheider & Legrady, 2004).

Expert knowledge in the context of a media art project is relative to the project. A person's expert knowledge in a field or discipline arises from having had experience in a variety of situations

that are seen from the same perspective, the one that originates from within the field (Dreyfus, 2002). Experience in a particular task, which is inevitably predicated on expertise, can produce less original ideas because people tend to rely on their experience (Runco, Illies, & Eisenman, 2005). In media art production, expert knowledge is put into a new situation from the perspective of innovation in context of the project, which lies outside of each contributing expert's field. This requires the expert to reconfigure expert knowledge to rise to the challenging demands of the project, including the work with novel technologies. However, to utilise this reconfigured expert knowledge effectively, communication patterns between collaborating parties are equally necessary which we shall demonstrate with our investigations.

2.4 Conclusion

In this chapter we have presented an overview of creativity research as it pertains to this thesis' research of applied artistic creativity. We aimed to portray the narrow research focus that creativity research has pursued over the past fifty years. To do so we introduced the common ground definition of creativity as, mostly restricted to a socially valued product. We explained that theoretically, researchers have a firm understanding of the reciprocal cultural significance of artistic contributions, but this is not reflected in empirical investigations. This is seen in the predominant approach to the research of creative behaviour, which relies on quantification with psychometric instruments and divergent thinking pen and paper tests. A similarly notorious approach, the biographical approach conducts research from the standpoint that creativity comprises special traits, when the majority of researchers in the field agree that the constituents of creativity evince cognitive processes of extant knowledge structures. Although here the understanding is not comprehensive either because recent developments in cognition research have identified that embodiment plays a significant role in cognition, which has yet to be included in the research on creative thought and behaviour.

The field's disposition is that creative behaviour is a form of problem-solving. This is also the starting stage in the definition of the creative process. In artistic creativity, this stage is thought to be preceded by problem-finding or a preparatory stage. Historically, the understanding of stages in the creative process has been mostly formed from biographical records and self-reports. However, an empirical investigation's consensus cannot be reached on categorical stages of the artistic creative process, including the concept of problem-finding. An in-depth analysis that concerns the complex issues of artistic creativity is needed, but directions that have begun to forge new grounds, for example empathetic aspects in problem-solving, have not been further explored.

Some broadening of the field has taken place with social psychology contributing research on the importance of intrinsic motivation and the subjective assessment of creative outcomes. This can also be said about the creative cognition agenda with the Geneplore model. Despite the fact that the creative cognition agenda is supported by experimental research within controlled environments, more progress is made with realistic simulation of creativity via open-ended tasks, self-reports, and catering to a variety of aspects that build on the understanding that creativity is part of a cognitive continuum. On the other hand, connections to recent developments in cognition

have not been made because embodiment has not been included in the creative cognition agenda.

As with the categorical stages of the creative process there is much concern to systematise creative thinking. This was illustrated within the two main approaches to idea evaluation, which are mostly concerned with the relative positioning to idea generation. This tendency to schematise and systemise creative behaviour may result from the cultural and real-world divorce that this field is experiencing for historical reasons. Among these reasons are the onset of creativity research from the point of quantification, and the appropriated social mystification of creativity via historical figures.

In recent years more researchers, who are interested in understanding visual artists' ways of working, have conducted field studies to probe the late cycle of creativity. Notably, creativity research has ignored temporal qualities of process and sought to isolate and reduce creative behaviour to creative thinking, hence the flourishing of creative thinking tests. Results of these investigations conducted within the late cycle show that individual creative processes may contain elements that show similarities among artists, but these cannot be classified or generalised. The reason for this is that the creative process is dependent on forms of artistic expression and environment. Moreover, these investigations demonstrate that creative behaviour is dependent on the physical, and that both thinking and acting are providing the underlying mechanism to creativity. Separating the two is not only artificial but it also falsifies the scope of creativity.

In the same vein, separating the physical from forms of visual artistic expression is denying the cognitive evolution that humanity undergoes in a persistent pursuit of cognitive niches with ever new technologies. In other words, the physical is tied to forms of expressions in the world that are dynamically linked and are evolving in parallel with culture. Forms of art-making are therefore a crucial factor in understanding how creative behaviour progresses alongside cognition. So far creativity research has paid little attention to this evolution because it has not understood the role of process and its components as they are realised in real-world creative behaviour.

Moreover, the evolving cognitive culture engenders an equally living, evolving social conception of art, which may be best described as enhanced worldviews (Donald, 2006). This social conception of art is in turn linked to a physical expression of social interaction, whereby this linkage articulates and progresses types of social interaction by creators and audience. On the creation side, this can be seen in new types of artistic collaborations, and on the side of the audience this can be seen with new types of engagement, such as the interactive participation with artworks.

The issues laid out in this section are not unknown to researchers in the field as confirmed by the annual review of creativity 2010. Hennessey and Amabile (2010) state:

> The underlying theme of this review is the need for a systems view of creativity. We believe that more progress will be made when more researchers recognize that creativity arises through a system of interrelated forces operating at multiple levels, often requiring interdisciplinary investigation.

The research proposed by this thesis is interdisciplinary from a number of perspectives. This thesis builds in various ways on existing approaches in creativity research. It takes its overall cues from the contextual approach to creativity, specifically so by investigating creative processes as

continuum with real-world authentic artistic creation on one end of the continuum, and real-world authentic audience participation on the other. Putting it differently, the research conducted for this thesis looks at the culture surrounding the artwork as an equal factor in the study of creative processes. This is the core in the gap where this thesis contributes, to show via research that media art creations are produced by a process continuum between artists and audience. The previously explained aspects, such as contemporary art forms transpiring in the cultural landscape, are the research scaffolding upon which this gap can be filled.

Within the contextual approach to creativity, this thesis' research strategy is that of a case study which might be comparable with strategies used in biographical approaches. The central component of this case study strategy is the artwork Sim-Suite. We investigate the creative process continuum in two ways: The creation of the artwork stretching over many months and involving two teams in two locations through collective retrospective introspection, as well as data collected via numeric logfiles from creative audience participation during exhibitions with Sim-Suite. For the former investigation we turn to quantitative analysis which is used in the biographical approach of creativity research and recently in experimental psychology. For the latter we utilise statistical tools, the instruments of experimental psychology in creativity research.

Authenticity in this thesis' research serves in two ways. The first one we have already mentioned in the preceding paragraphs. Secondly, this thesis' theoretical lens is focussed on 'cognition in the wild' (Hutchins, 1995). From the standpoint that creative behaviour is based on cognitive processes that build on extant knowledge structures, we must heed the current research advancements in cognition and direct our research efforts from the perspective of embodied cognition. Thus, this thesis' analyses are conducted from the starting point of embodied cognition in recognition of the gap in creativity research we mentioned in the previous paragraphs. Process and embodiment are closely related and underpin cognition in general, one is not possible without the other. In our earlier review on creative process investigations with professional artists, we saw that several researchers have stated that the role of the body is not one of subordination, by being relegated to the execution of thought processes, but that it is on par with thinking processes in creative achievements. To this day these findings have not been contextualised with embodied cognition and creativity. We are breaking new territory with this interdisciplinary approach and therefore our investigations are exploratory.

The literature review of creativity research provides the background for motivating and positioning the overall research of this thesis and its contribution. There are other strands of research that are central to the thesis and will be addressed in more detail as they become relevant. One strand is the theoretical conceptions of embodied cognition developed from two perspectives which we shall take to the analysis of the data. This is discussed in chapter four as part of our methodological approach. Another strand is looking in more detail at empirical research and topics in embodied cognition, specifically as they relate to our findings. We draw on this empirical research in chapter seven to reflect against our findings and contextualise these to highlight specific contributions. In the next chapter we introduce the interactive installation artwork Sim-Suite.

Chapter 3

The interactive installation "Sim-Suite"

3.1 Introduction

In this chapter we introduce the interactive installation artwork Sim-Suite. The artwork forms the basis for investigation of the creative continuum, which we introduced in the previous chapters. Sim-Suite has been created to investigate the 'field of artistic communication' where both creators and audience are contributing in creating experiences while forming their object of perception. We use Sim-Suite as a cultural platform to investigate both sides of this engagement, that of the team members whose creative effort made the physical instance of the artwork and that of the public who share the artwork as 'field of artistic communication' by actively and creatively engaging with it.

Sim-Suite is a media artwork that appropriates game-play to create artistic expression. This chapter is divided into three sections. In this section, 3.1, we contextualise games made with code and give a brief cultural perspective on games and their development into artistic expression. We briefly mention typical artistic methods stemming from modernist movements that artists use in the creation of games and mention some examples of games as art. In the same section the lead artist, who is the author of this thesis, contributes her artistic perspective on the concepts behind Sim-Suite in an artist statement. We then list exhibitions with Sim-Suite where we collected data from the participating public to be analysed as Sim-Suite's creative participation in chapter six.

In the second section, 3.2, we introduce the team members who took part in the collaborative creative process of Sim-Suite in the form of two separate collaborations. In the first collaboration the lead artist Manuela Jungmann (MJ) collaborated with Michael Ferguson (MF), an artisan furniture maker, to create Sim-Suite's timber encasements and platform. In the second collaboration MJ collaborated with John Revill (JR), an academic engineer, to create Sim-Suite's game. We move on by detailing the project and provide background on construction and technical aspects.

In the third section, 3.3, we describe Sim-Suite's game-play and interaction mechanics. We explain the function of virtual objects such as game-board and tokens and illustrate how complexity emerges from Sim-Suite's game rules. Here we detail explicit and implicit aspects of game-play.

In the same section we describe Sim-Suite's creative participation in the 'field of artistic communication' and define a theoretical working definition for 'creative participation' as part of the creative process continuum. We then conclude this chapter in section 3.4 by briefly summarising important points.

3.1.1 Games as art in culture

In an attempt to briefly map out the position of games in the greater context of contemporary artistic pursuits, we have to lay the foundation at the entrance of new media technologies into culture, and its wide ranging and deep-seated effects on the contemporary art scene. The metamorphosis of games from entertainment to artistic commentary can no longer be seen from the typical art historical perspective. Today, media theorists rather than art historians would agree that the notion of new media technologies has changed society's conception of art-making and art appreciation, and this includes games.

The digitalisation of society has impacted culture to the extent that old models of art historical study are no longer suitable to explain contemporary artistic expression, but art history has not been able to grasp these changes effectively. Conferences like CHArt, the British society of art and design historians, whose interest centres on art created with computers, demonstrate that discussions on this theme are ongoing. The 2010 conference of CHArt focusses on "the death of Art History", where it "wishes to explore the role of digital technologies in the disruption of Art History and the profound changes in the way that we display, consume and study art" (CHArt-British society of art and design historians, 2010). In the absence of a singular authoritative perspective on the developments of computers and art, we put forth one perspective on games in their outflow as art pursued in contemporary technologically-driven contexts.

S. Wilson (2002) explains that traditionally art was generated by historically validated media in a limited context with a delineated set of purposes. With the introduction of new technological forms over the course of the last century, boundaries in culture opened up and created new spaces of artistic experimentation and research. Wilson illustrates further that research is common to art and science and that other shared characteristics between these two fields include sharing the "value of careful observation of their environments to gather information through the senses" and also the use of "abstract models to understand the world" (p.18).

In that sense, the age of new media provided the means, as catalytic force, for a shift of aesthetic appreciation, which artists' incorporated into their research. Quaranta (2009) refers us to Carmagnola's view on this change in aesthetic sensitivities that centres on several points and has also been summarised as info-aesthetics (Manovich, 2000). In summary, new media has replaced acts of aesthetic contemplation with acts of immersion. These acts are made up of a dual dynamic in that immersion disorients the user but also creates omnipotent feelings of co-creation. Carmagnola maintains, as cited in Quaranta (2009), that new media's hypertextuality creates loss of clear lines between author and audience and levels of expression, while eradicating a sense of temporal depth. It further constitutes a form of take-over, where the visual takes over from the textual, the virtual from the physical and in the process eradicating lines of distinction between the real and

imaginary, and between living and non-living.

Already these descriptors characterise engagement with video games, which has often been criticised as a negative development in evolving new media technologies. More importantly, Quaranta argues that this newly emerged aesthetic has been propelled forward through new cultural forms in industry and science where simulation, visualisation and databases are part of the computer-based paradigm of globalisation. According to Quaranta, what lies before artists is the quest to interface these so that they convey the human experience to its fullest.

In this reciprocal effect between content and media, between new technologies and cultural transformation, game aesthetics play a significant role in info-aesthetics. In the short history of new media, the industry of video games epitomises, through ongoing research and development, the creation of ever more sophisticated technological tools to drive complexity, as well as visual and immersive qualities. These achievements are then showcased in the latest versions. The development and implementation of 3D technology, photorealistic renderings, and fast, navigational spaces in real-time has been spearheaded and financed by the video game industry. Again, these developments are integral, they feed back and widen the platforms of operation in industry and science. Baumgärtel (2003), who curated the exhibition "Games. Computerspiele von KünstlerInnen" (Computer games by artists) (2003) in Dortmund, Germany states that video games are part of the "media socialisation" for adolescents in Western industrial nations. Although they might still be marginalised within greater society, this does not represent their proportional importance in cultural and economic contexts.

Games, or the notion of play in art is not a recent development. Modernist movements such as Fluxus and conceptual art of the 1960's used games to create artistic and social commentary. Play, perpetuated by games is seen as diversifying human agency which ultimately is one of the major driving forces of human progress. Arata (2010) writes that "play catalyzes novelty, even within the confines of rule-based games, because there is always a leeway, a play zone, where personal agency and preferences can produce surprising outcomes". According to Baumgärtel (2003) there are a variety of reasons why the traditional art world has not caught on to digital art, including computer-based games and net-art. Among these reasons are practical ones, in that computer-based artistic games violate conventions of presentation in traditional curated spaces. They require set-up of computers that will need to be maintained and safeguarded. Also, the appearance of computer systems in a gallery or museum are reminiscent of an office environment and often seen as an aesthetic insult to the curating eyes. For these and other reasons, most contemporary art exhibitions in the traditional sense will therefore exclude software produced artworks.

Baumgärtel (2003) notes the task of contemporary exhibition spaces is to develop productive ways of presentation of these works that "confront the contradictions and exclusions in the relationship between art and the institution without nullifying them". Further reasoning by the institutional art world, limiting exhibition of digital art, links to the product-oriented definitions of artworks. The absence of a final, sellable product as artwork does not entice collectors in the market-oriented art world into purchasing and selling artistic "codeworks". These types of artworks cannot be sold with the expectation of a large margin of profit. "The dematerialsation of

the art object" (Lippard, 1997 reprinted) remains unrecognised by the institutional and financially-directed art world in an ongoing long-standing situation without further recourse to make amendments, as suggested by art theorists. This situation is exemplified today by the process-oriented nature of contemporary digital art and the lack of exposure of these works in traditional art world contexts.

So where are these digital artworks shown in the end? Parallel to the traditional art world, the last fifteen years have seen a propagation of festivals and conferences where these artworks are shown and can be experienced by an interested public in a short-term presentation format. Over the course of these years, games as art have evolved into a variety of artistic expressions. At first strictly created from code they have since expanded to incorporate physical materials, and have spatial dimension, such as video works and installations, and interventions in public spaces.

Many artists producing games as art are not particularly interested in the conventional gaming content of video games. The creator duo known as "Tale of Tales" are a typical example in their aim to focus on specific aspects in their creation of artistic games. They state that they "explicitly want to cater to people who are not enchanted by most contemporary computer games, or who wouldn't mind more variety in their gameplay experiences. For this purpose, all of our products feature innovative forms of interaction, engaging poetic narratives and simple controls" (Jansson, 2010). One of the earliest artistic games "ars doom" (1995) by creators Orhan Kipcak and Reinhard Urban is a satirical subversion of the commercial video game "Doom". This provided commentary on the art world and its institution by enabling users to 'shoot 'n kill' with artists' tools, such as Georg Baselitz' thumbs, Nam June Paik's remote control or Arnulf Rainer's paintbrush. Concepts addressed by artists creating games are part of a wide-ranging spectrum, covering themes in pop culture, political, satirical and ironical commentary, social critiques, and explorations of the techno-aesthetic dimension.

The duo "Tale of tales" create games that are poetic, both in terms of their visual quality and in their game-play. "Ars doom" was made with a game level editor, and these types of artistic games are considered a 'mod' or 'modification' which is one form of intervention on existing, commercial games. It is also quite common for artists to go back and utilise computers and components from their past. The creator duo "Jodi" created "Jet Set Willy ©1984" (2002), a retro game with bold colours and flat figures that walk around in a Mondrianesque visual structure. It was produced for the Sinclair Spectrum, an early and affordable personal computer in the beginning of the 1980's. A sculptural version of an artistic video game is Olaf Val's "swingUp Games" (2001), the game is made from a free standing structure that utilises transparent plastic and film, bicycle lamps, small circuit boards and a few electrical parts, and these games are played via a simple handheld control. Bridging conceptual game aspects with painful embodiment is performed with Volker Moraw's and Tilman Reiff's "Painstation" (2001), where participants play a form of "pong" while standing around a table structure. Instead of scoring points they receive physical pain through minor electric shocks and blows from a small whip. "Move" (2005), created by Andrew Hieronymi, is a game as installation using computer vision and full-body interaction allowing participants to experience six different types of actions usually performed by avatars in videogames. "Sim-Suite" (2008), created

by Manuela Jungmann in collaboration with John Revill and Michael Ferguson, also focusses on participants' full-body interaction in addition to social interaction, where participants play against each other by standing on wobble-boards. Sim-Suite will be discussed in detail in the remainder of this chapter.

Baumgärtel (2003) points out that the various types of 'mods' in game art are art historically linked to methods of appropriations, redesignations, détournement, recombinations, and reconfigurations found in 20th century modernist art movements. For example, the Situationists invented the strategy named détournement, often translated as 'derailment' into the English language. Debord and Wolman[1] described détournement as reusing preexisting artistic elements in a new context, a context that is mostly antagonistic or antithetical to the original media artwork which is selected based on familiarity to the public. While a derailed artwork may be a satirical parody it is still strongly connected to the original (Ken Knabb Ed. & Transl., 2006). Furthermore, Situationists made distinctions between minor and deceptive détournement. "Minor détournement is the détournement of an element which has no importance in itself and which thus draws all its meaning from the new context in which it has been placed. For example, a press clipping, a neutral phrase, a commonplace photograph. Deceptive détournement, also termed premonitory proposition détournement, is in contrast the détournement of an intrinsically significant element, which derives a different scope from the new context. A slogan of Saint-Just, for example, or a sequence from Eisenstein. Extended detourned works will thus usually be composed of one or more sequences of deceptive and minor détournement " (Debord, 1956/2010). These principles were further laid out with détournement "laws" that would expound the application of détournement in artworks.

All of these afore-mentioned strategies have been widely adopted by many contemporary artists working with games or other forms of expression. The interactive artwork "Sim-Suite", shown in figures 3.1 and 3.2, is an installation game underpinning this thesis. It conceptually appropriates and reconfigures traditional gaming conventions with ecclesiastical symbolism in the spirit of détournement. The artwork provides a platform for the investigation of creativity from the perspective of embodiment and the creative process continuum.

3.1.2 Artist statement

The subsection reveals the artistic conceptual intention behind the artwork Sim-Suite:

> Sim-Suite is a subversive artwork that comments on the role of Christianity and capitalism through the notion of game-play. Elements used in Sim-Suite "simulate" conceptual aspects from Christianity and capitalism as I see them relating to our daily life. We may no longer follow ecclesial thought as our forefathers did but we are deeply imprinted by religious ideas in how we shape culture and morality. Hence, Sim-Suite comments on these ideas mimicking the deceptive ways of the system itself which "enslaves" us on a daily basis. This may not be apparent at first sight, when interacting with an innocuous game that bases its interaction on a number of

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[1]The founding members of the art movement

Figure 3.1: Semi-aerial view of Sim-Suite, Loop Festival, Brighton

Figure 3.2: View of Sim-Suite, Loop Festival, Brighton

traditional gaming conventions but also on an innovative interface, both in an unprovoking and unthreatening manner. The acuteness of the message will only come to the forefront if one is willing to stand back and look at the use of structure, symbolism and references.

Sim-Suite's platform, a large black and robust timber platform that sprawls on the ground, appropriates the cruciform floor plan of medieval churches. The virtuality of architectural religious space was not only constructed according to the order of society, putting everyone in their place literally and figuratively, but it also emphasised and perpetuated the concept of limitation within the good-bad dynamic that we still live within today. Quite literally Sim-Suite players are arranged in the "nave" and the east and west "transcepts", leaving room for the audience to physically fill in an open space near the platform and stand in the position of god, or the "apse". What is meant by this idea is that each one of us is dependent on the opinion and judgements of others whether it would be friends, family, or nations. "Others" are the god we cater to for survival in a capitalistic system that operates on a win or lose basis in a constant struggle to come out on top. Others watch us and we "play" to accommodate and adapt ourselves to be accepted and valued by those around us, which is symbolised by the Sim-Suite audience as they witness our win or lose situations.

These themes are further expounded in the use of numbers and shapes in Sim-Suite's game-play. Three Sim-Suite participants interact with each other, symbolising the concept of "trinity" but also the concept of the nuclear family. With the industrialisation of nations the road to overproduction and consumerism was paved at the expense of communal living where young and old are integrated members of the community and cared for by the larger group. The nuclear family is the biological building block of capitalistic society and functions like the doctrine of the trinity (for example in Matthew's great commission), in that the phenomenon goes hand in hand with high standards of living as a "reward" for compliance with the system, or from a religious point, the doctrine rewards the devout person with his or her nearness to god. Each participant utilises a geometric shape as token to play the Sim-Suite game. The tokens are three architectural symbols from which we construct our environments- they are yet another building block in the system we live in.

The physical movements required to play the Sim-Suite game, to navigate one's token on a virtual game-board, are basic stepping movements and the participants step in place, so to speak, throughout the entire game-play only making headway on the virtual game-board. These stepping movements are reminiscent of hopscotch played by children in the streets. Moving on wobble-boards recalls the first steps in every child's life, a major event for parents and child as a sign of healthy development. The awkwardness conjured up by moving on wobble-boards further signifies the entrainment that we go through as children to become socialised and adhere to the system, to understand that we have to "play" the win-lose dynamic, while parents teach us strategies to come out on top in our daily competitions.

The gaming conventions that comprise Sim-Suite are simple, they entail creating a cross-shaped pattern by building up one's tokens through successive game-rounds, and whoever does it first while minimising losing tokens, or being blocked by others wins the game. The game is played under time pressure which again symbolises our existence where we can only have an unknown number of "rounds" or years until we face the final deadline when our life ends. However, unlike traditional board games Sim-Suite allows for simultaneous turn-taking, which makes the gaming procedure

somewhat chaotic and not as orderly as we pretend things to be. Participants are overwhelmed with stimuli, they have to pay close attention to their interactions and those of their opponents. This is similar to real life in contemporary society where everyone continuously juggles all the different parts in the "game" of their life.

3.1.3 Exhibitions with Sim-Suite

In this subsection we list exhibitions with Sim-Suite where we also collected data for analysis. Details on the data collection are explained in chapter four and six.

- 18.08.2007, Brighton, UK. Loop Digital Culture Festival. This digital festival was a one-day, large-scale celebration of digital culture, spread across four areas in the city of Brighton. The digital culture programme included music and bands of well-known electronic artists, as well as electronic-acoustic music, animation, film, dance, theatre, installations, and VJ performances. All of these events were taking place concurrently in a variety of venues all over the city. The Loop Digital Culture Festival has since become an annual event in Brighton.

- 23.02. - 02.03.2008, Brighton, UK. The 4th Brighton Science festival (2008). It is one of the UK's largest science events. In 2008 it lasted nine days and has since expanded to become a three-week festival. The programme is multi-faceted, ranging across the sciences with talks, lectures, discussions, installations, performances and exhibitions with a multiple track programme at various locations and venues in the city of Brighton.

- 30.08 - 01.09 2008 Battle, Hastings, UK. Workshop on Enactive approaches to Social Cognition sponsored by euCognition. "The workshop will bring together a small group of researchers from different backgrounds who are currently working towards improving our understanding of social cognition by adopting an enactive perspective. Special effort will be made to ensure that the interdisciplinarity of the workshop will result in a fruitful exchange of skills and methods across the diverse disciplines and a discussion of how they can inform cognitive modeling research. Participants will be invited to the thematic development of the event through a series of online pre-workshop discussions" (euCognition, 2008).

- 27.10 - 30.10.2009 Creativity & Cognition conference, Berkeley Art Museum and UC Berkeley, California USA. "Everyday creativity: shared languages & collective action". Sim-Suite was exhibited as demonstration and won best demonstration at the conference. "The 7th Creativity and Cognition Conference (CC09) embraced the broad theme of Everyday Creativity. This year the conference was held at the Berkeley Art Museum (CA, USA), and asked: How do we enable everyone to enjoy their creative potential? How do our creative activities differ? What do they have in common? What languages can we use to talk to each other? How do shared languages support collective action? How can we incubate innovation? How do we enrich the creative experience? What encourages participation in everyday creativity?" ((ACM) Creativity & Cognition Conference, 2009).

3.2 The project "Sim-Suite"

The installation artwork "Sim-Suite" was a collaborative art project led by the author of this thesis, Manuela Jungmann (MJ). Two collaborations of different, interdisciplinary nature were formed in sequential order with some overlap as shown in figure 3.3. In each collaboration, the lead artist

Figure 3.3: Visualisation of the project's timeline, showing both collaborations. The collaboration between MJ-MF is considered the first collaboration (purple colour). It is followed by the second collaboration (orange colour) with collaborators MJ-JR. Ongoing and regular collaboration efforts are indicated with solid colour bars, near-end collaborations with irregular meetings are indicated with breaks in colour bars.

collaborated with one other person. Although the lead artist was the initiator for both collaborations, all collaborators participated equally with contributions and integration of ideas that made up the final artwork.

3.2.0.1 Individual backgrounds

Manuela's (MJ) background is established in the applied visual arts, art history and digital media. She has worked professionally with emerging technologies, specifically as video game artist, and has produced art for and artworks with interactive technologies, including a number of spearheading prototypes in the 90's in San Francisco and the California Bay Area. For the creation of Sim-Suite, she contributed to concept development, interaction mechanics, and has produced all visuals including graphics and animations for the artwork.

Collaborator Michael Ferguson (MF) is an artisan furniture maker, who creates artistic furniture and sculptural pieces from found and recycled materials, such as timber and metal. He collaborated on Sim-Suite with the lead artist in contributing his expertise and ideas in the construction of wobble-board encasements and timber platform in his workshop in Brighton.

Collaborator John Revill (JR) is an academic engineer, who co-created Sim-Suite's game with the lead artist in writing a proprietary Java program. He also contributed to concept development and interaction mechanics. His academic background in computer science is centred on amorphous computing and large-scale sensor networks.

3.2.1 The construction of Sim-Suite

Sim-Suite is an interactive installation constructed from conventional materials used in carpentry, and also from three, commercially obtained wooden wobble-boards. A wobble-board is a piece of training equipment used to exercise physical balance. It is composed of a wooden disk and a hemisphere made from plastic, which is attached to the centre of the disk. Wobble-boards present the physical part of the interface with Sim-Suite's game. On the floor of an exhibition hall, the

Figure 3.4: On the left hand side, we see a video still of Sim-Suite's opening animation in stand-by mode. On the right hand side, we see a video still of Sim-Suite's tutorial animation.

installation will take up a 3 m^2 area and sits a step height off the ground. Approaching Sim-Suite, the spectator will see a large black platform with three wobble-boards arranged and embedded around a square opening in the platform where a screen is visible. The square opening reveals just enough screen necessary to observe Sim-Suite's game graphics, and the remainder of the screen display is covered by the platform and sitting inside of it. When first approaching Sim-Suite, the spectator will see an abstract animation which is running when Sim-Suite is in stand-by mode, a screen shot of the animation is seen in figure 3.4. The stand-by animation is designed to entice spectators to step onto the platform and press one of the orange-coloured buttons located near each wobble-board. The orange-coloured buttons toggle between the tutorial, game and stand-by animation. When in stand-by mode, pressing the orange-coloured button once will start the tutorial which briefly explains, mainly through visuals, how to play Sim-Suite's game. A video still of the tutorial is seen in figure 3.4. When all three spectators are positioned on the wobble-boards around the platform's opening, paying attention to the screen that is horizontally placed between the participants, they are ready to play Sim-Suite's game.

Interaction between Sim-Suite participants takes place by moving on the wobble-boards, using stepping and balancing movements in response to what is displayed on the screen. Concealed infrared analogue sensors capture the motion of the wobble-boards animated by participants through stepping and balancing movements. The sensor signal is digitised and translated by a computer program which drives graphics and virtual interaction. Sim-Suite participants engage in a competition by operating a unique two-dimensional graphic token which represents the participant's actions on the shared virtual game-board. Here participants play by aiming to compose a cross-shape pattern using five of their tokens. Tokens can be navigated in four directions on fields of the game-board, and participants play in successive game-rounds against a timer also graphically indicated on the screen. At the end of each game-round all three tokens in the current game-round freeze in place on their fields of the game-board. The next game-round randomly places three new tokens on fields of the game-board and the game continues until the first participant has completed

Figure 3.5: Sim-Suite's wobble-board encasements as work-in-progress are seen on the left side of the figure. Here, we can see the top surface of one of the encasements showing the wooden rings attached in the centre and four bedsprings placed around it. Next to it we see an encasement complete with wobble-board. On the right hand side of the figure, we see all four platform components unassembled sitting on the workshop floor. The three wobble-board encasements are placed inside three of the platform components.

the pattern. Winning the game also entails various playing strategies which will be addressed in the course of this chapter. Sound effects accompany participants' play. These are coupled to specific game events that occur during game-play.

3.2.1.1 Wobble-board encasements

We constructed around each commercially purchased wobble-board an identical timber structure that encases each wobble-board and reduces its tipping angle by fifty percent. The encasement is seen on the left hand side in figure 3.5. Constructing encasements around wobble-boards guaranteed that these remained stationary when being stepped on. To keep the wobble-boards stationary wooden rings are placed and fastened onto the encasement's top surface and tightly fitted around the spherical, plastic bottom of the wobble-boards. Wobble-boards sit loosely inside these wooden rings. In the same place, underneath each wobble-board's spherical bottom, is a small metal plate anchored to the encasement surface keeping the wobble-boards' plastic bottoms from being worn down by rubbing against the wooden surface of the encasements. The wooden underside of each wobble-board was painted white to assist the functioning of infra-red sensors.

The creation of encasements enabled a reduction of the tipping angle which facilitates more moderate movements required for balancing on wobble-boards. To further support, enhance and create fluency in balancing movements we added four recycled bedsprings which were placed on the encasements' top surface and directly underneath each wobble-board and are seen in figure 3.5.

In the same area underneath each wobble-board, we placed two infra-red sensors on the surface of each encasement. They were placed in corresponding locations on each of the three encasements. Sensors produce continuous readings, measuring the changing distance between the

underside of the wobble-board and the top surface of the encasement directly underneath each wobble-board.

3.2.1.2 Platform construction

In figure 3.5 on the right hand side we demonstrate all parts of the platform. The platform consists of covers for each wobble-board encasement and one cover for a 40 inch screen display. These platform components are assembled as one singular platform when Sim-Suite is exhibited and used for interaction. The topside of the cover for the screen display is inlayed with Perspex to prevent screen damage through the square-shaped cut-away in the cover's topside. On the inside of the screen display's cover, facing out in direction of the audience, we have installed three computer fans to ensure ventilation when the screen display is running covered up. Underneath the cover, the screen display is placed in horizontal position propped up with plastic tubes from plumbing supplies to create air circulation between the screen and the exhibition hall floor. The cover for the screen display also houses electrical parts, interface circuit boards and button trigger electronics which are attached to the cover's inside wall next to the computer fans and is illustrated in figure 3.6. In the same figure we also see two speakers, each located on the inside of the platform that covers the wobble-board encasements which are positioned across from each other in the installation. Cables are fed out of the platform and into a power supply and a laptop which is placed in proximity to the installation.

3.2.2 Technical details

In figure 3.6 we introduce a schematic drawing of the installation with measurements regarding platform components as well as the locations of hardware, electronics parts, and wiring throughout the platform. Technical specifications include:

- For sensor hardware we used six Sharp IR Distance Sensors GP2D120 which measure a distance range from 1.57 - 11.81 inches.

- We used the 8/8/8 phidget interface kit with digital I/O and 8 channels of digital input, 8 channels of digital output, 8 channels of analog input and 1 USB Port. The kit is fully TTL compatible (0V to 5V) with the outside dimensions: 3.20 inches x 2.10 inches.

- Any 40 inch LCD monitor within the size of 39.5 inches x 27 inches x 4 inches to fit under the platform. We mostly used a Sony Bravia monitor, model KDL S40A12U

- Three desktop computer fans, three orange plastic buttons and a set of desktop speakers each and all are wired up and attached to an active USB hub, which are is placed inside the platform.

Initially the software was scripted in Processing (*Processing Software*, 2001) which is a high level java-based scripting software developed for artists and designers. With growing complexity of the Sim-Suite game we switched to Java, using Eclipse as software development environment. Graphics were prepared with Adobe Photoshop and Adobe Illustrator, and animations were produced in Macromedia Flash Mx and exported as sequential frames.

wobble board
metal springs
infra-red sensors
game toggle button
speaker

80 cm

80 cm

95 cm

60 cm

60 cm

110 cm

48 cm

80 cm

PC

electronic wiring

perspex cover
40 " LCD screen
ventilation
phidget electronics
game button electronics

timber platform
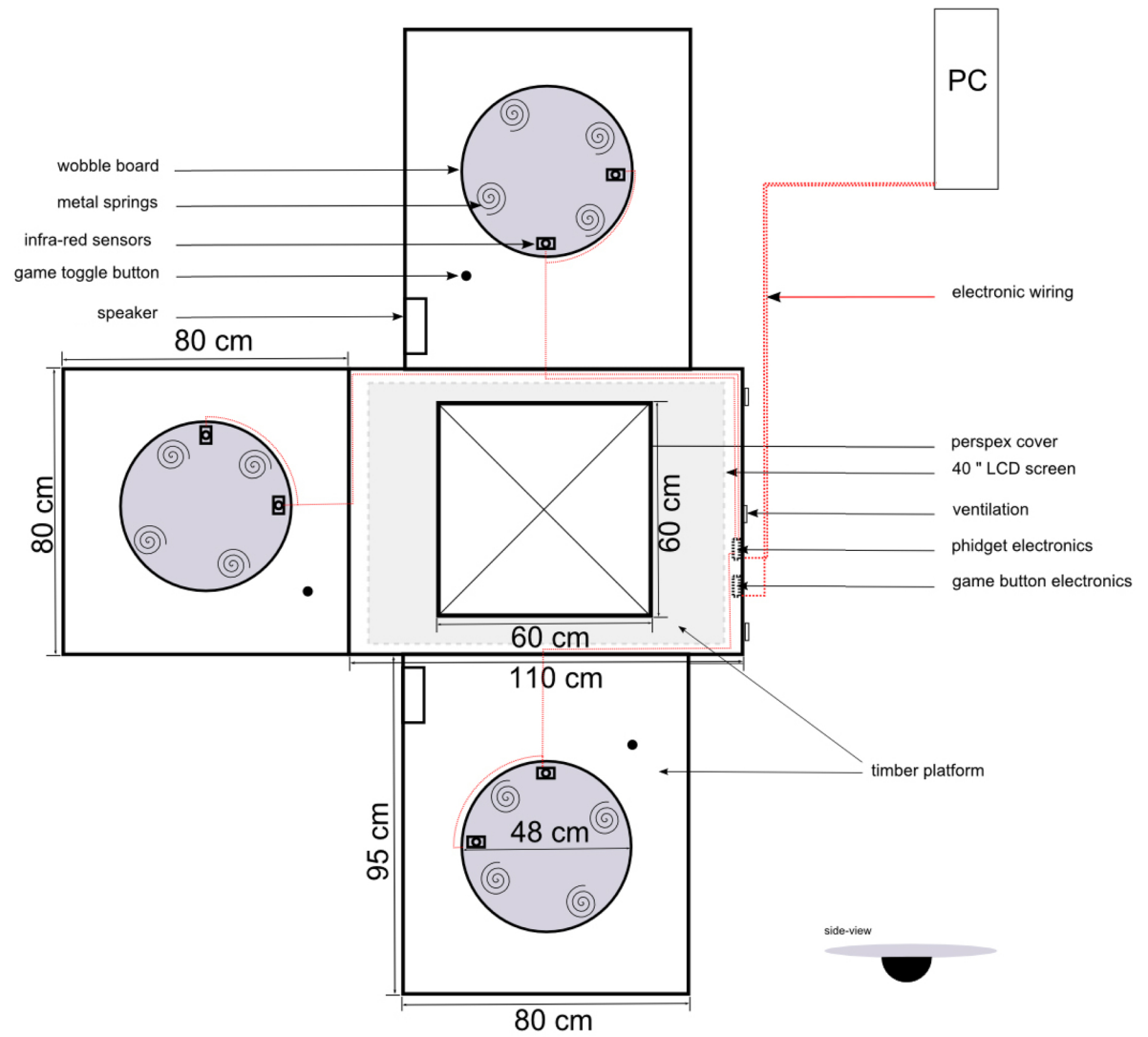
side-view

Figure 3.6: Schematic drawing of Sim-Suite. The lower right hand corner illustrates the side view of a wobble-board.
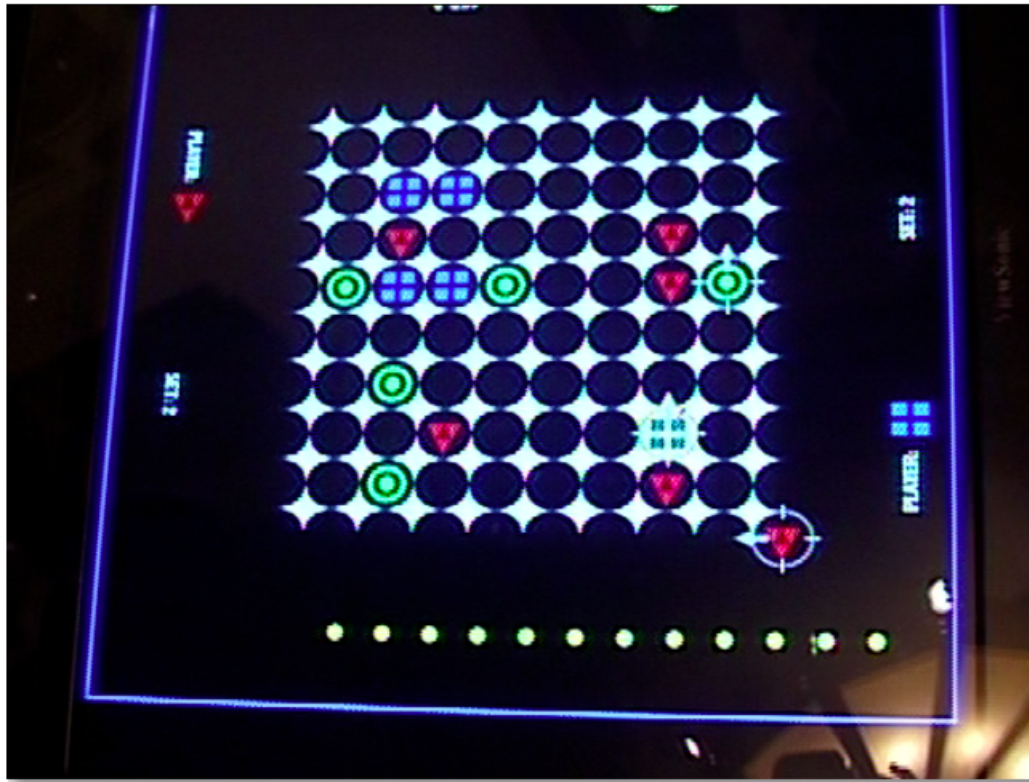
Figure 3.7: A video still of Sim-Suite's virtual interface depicting the game-board with tokens. Along the bottom of the screenshot we see a row of yellow dots. This is the timer graphic which marks the beginning and end of each game-round. Here we see the beginning of a game-round because a large number of dots are visible. These will tick off the screen as the game-round runs out of time and comes to an end. Each player has a graphic panel in front of the game-board's virtual edge. This panel displays permanent and temporary information throughout the game-play.

3.3 Sim-Suite's game-play

Once participants are positioned on the wobble-boards and one of them has pressed one of the orange-coloured buttons on the platform, participants are first taken through the tutorial screens and then to the start screen of the game. The tutorial can be bypassed by pressing the orange-coloured button twice, this will skip the tutorial and go straight to the game screen.

3.3.0.1 Game-board

The Sim-Suite game draws on popular European gaming conventions from the board game genre. It is primarily composed of a virtual game-board and virtual, unique token shapes for each participant. The game-board shown in figure 3.7 consists of 9 x 9 black circular fields on a white background. There are eighty-one fields on the game-board that can be occupied by the participants' game-play which is an estimated twenty-seven rounds if no one loses their token.
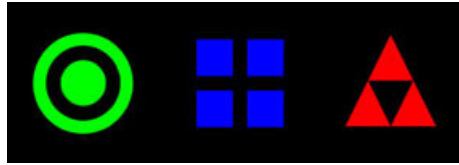
Figure 3.8: Sim-Suite's virtual token shapes: Circle, Square, and Triangle tokens.
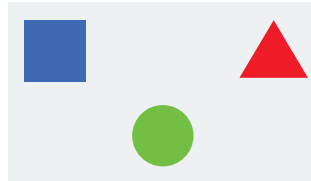
Figure 3.9: Arrangement of token shapes relative to each other in the installation.

3.3.0.2 *Token shapes*

All token shapes are seen in figure 3.8, each token shape represents one geometric shape and colour. Token shapes are linked to their location in physical space, therefore a participant's position on a wobble-board determines the token shape he or she will playing with throughout the game. The basic physical layout of the installation with the corresponding token shapes is illustrated in figure 3.9. We shall be referencing the arrangement of token shapes to each other in chapters four and six.

3.3.0.3 *Timer graphic*

In figure 3.7 we see along the bottom, next to the game-board, the timer graphic indicated by a row of yellow dots. The timer graphic signals to the participants the beginning and end of a game-round. The number of game-rounds in a game is up to the participants' game-play and is limited only by the number of fields in the game. At the beginning of each game-round, fifteen yellow dots appear on-screen, as seconds go by the dots tick off the screen. When the last dot has ticked off, all tokens in the current game-round freeze on their fields of the game-board. Then a new game-round begins and displays a fresh set of tokens for the participants and also a fresh row of yellow dots.

The timer graphic was designed to have two "timing" tables which are randomly chosen by the program. In the first, timings incrementally ascend in milliseconds, from low to high, for each yellow dot of the timer graphic within a game-round. In the second, timings incrementally descend, from high to low, for each yellow dot of the timer graphic within a game-round.

The idea behind the random choice of timings is to create a subtle unpredictability to the timings of the game-play. A slight variation in timings prevents participants from getting used to the time they have and react habitually to the length of a round. Game rounds that vary in length steer participants to the timer graphic for information, they must manage to pay attention to the yellow dots rather than play based on their internal time frame estimation of previous game-rounds. These timing variations are minor and are intended to avoid that participants build up an
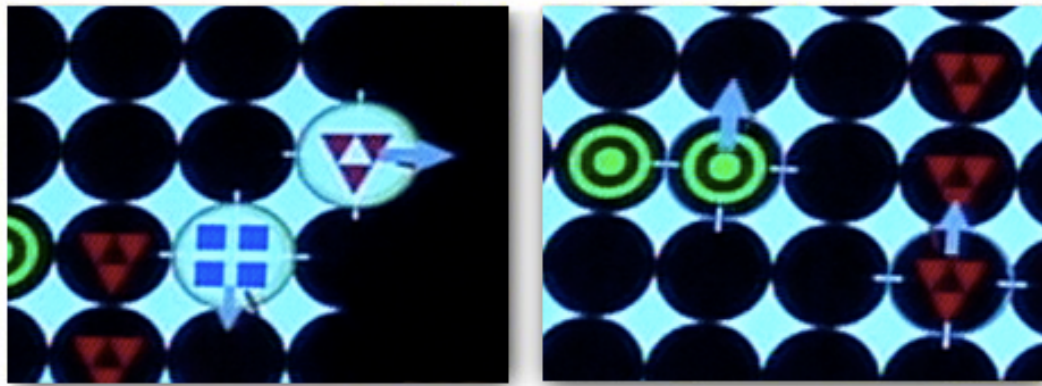
Figure 3.10: On the left hand side, we see the newly and randomly placed tokens. Initially they are briefly highlighted white to assist participants for quick retrieval on the game-board. On the right hand side, token shapes are shown with their directional graphic overlay providing feedback between movements on the wobble-boards and navigation on the game-board.

inner habitual time frame of the duration of a game-round.

3.3.0.4 Basic interaction mechanics

Each game-round begins with the launching of fifteen timer dots on-screen and one token from each token shape. Although tokens are placed randomly by the program, they are placed in such a way that they are at maximum distance from any other ally tokens, which is also dependent on the number of available fields on the game-board in a particular game-round. For example a new token for Circle token will not be placed near other Circle tokens. The idea here is to prevent any token placements that could facilitate an 'easy' win.

When new tokens enter the game, they are at first highlighted white, see figure 3.10, to flag their location on the game-board to the participants. Participants can then move their token in four directions moving on the fields of the game-board up, down, left and right through stepping and balancing movements on the wobble-boards. Each active token has a directional graphic overlay as seen in figure 3.10.

This overlay graphic is designed to support participants' coordination between their movements on the wobble-boards and their navigational orientation in the game. This is achieved with two graphic symbols in the overlay, a red line, which feeds back actual movements on the wobble-board, and waxing and waning arrows pointing in one of the four directions. The red line orients the participant in aligning physical movements with their perceived navigation on the game-board. The arrows indicate in which direction the participant is going to move, and when the tipping of the wobble-board has reached a threshold that enables their token to move onto the next field. When the tipping angle in one direction is maintained long enough to reach the threshold, the arrow has 'grown' to its maximum size. The red line and the white arrow have to line up for the token to move onto the next field of the game-board.

Sim-Suite's game objective entails constructing a cross-shape token pattern created from one
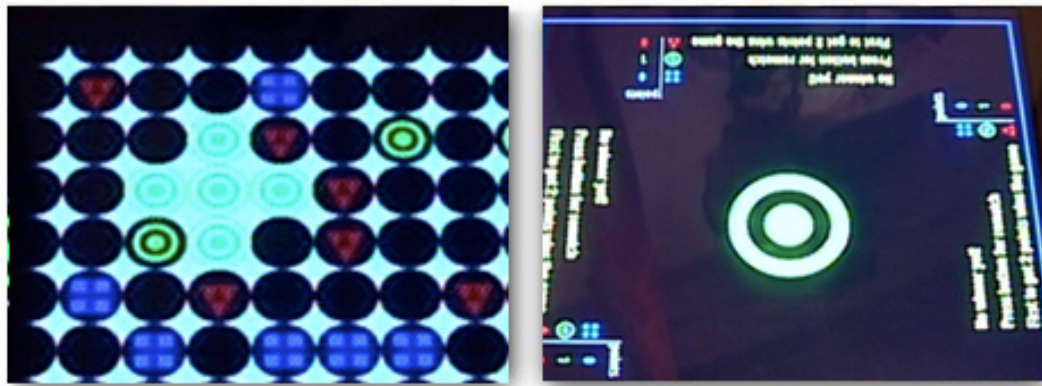
Figure 3.11: On the left hand side of the figure, the winning token shape formation is shown with five Circle tokens. On the right hand side of the figure, the score panel shows that one match has been scored by Circle token and the participant obtains one point.

of the three token shapes. The pattern is composed from five tokens and must be build up over time from consecutive game-rounds. At the beginning of each game-round a new set of tokens and a new row of timer dots are displayed. Once the game-round ends, all tokens are 'frozen' in their current location. A new game-round begins with a new set of tokens and a new row of timer dots. Participants create the winning cross-shape token pattern by building on 'frozen' tokens from previous rounds. Participants move through this cycle until one of the three participants has created the cross-shape pattern with his or her tokens.

As soon as five tokens of the same token shape have been placed in a cross-shape formation as seen on the left hand side in figure 3.11, the first match has been won by that token shape and the participant receives one point. The participant will have to play another match to obtain two points to emerge as the winner of the game. On the right hand side of figure 3.11, we demonstrate in a video still the score panel that comes up on the screen after the first match has been won by one of the participants. When a game is won, the winner's token shape scales up to take over the entire screen estate as seen in the video still in figure 3.12, and presents a 'dancing' animation accompanied by a jubilant, jazzy melody.

3.3.1 Rules, risks, discoveries and complexity

The Sim-Suite game consists of few rules. The basic rules explain how to navigate one's token on the game-board and the objective for winning the game, both are stated in the tutorial screens which we have discussed earlier. Other rules are mentioned through on-screen prompts in the interface throughout Sim-Suite's game-play. There are also a number of interaction strategies that have to be discovered based on proactive engagement by the participants.

3.3.1.1 *Flying off the game-board*

The rule that entails losing one's token during a game-round is not explicitly stated in the tutorial. Instead it is communicated during game-play through prompts in the interface. If, during a game-
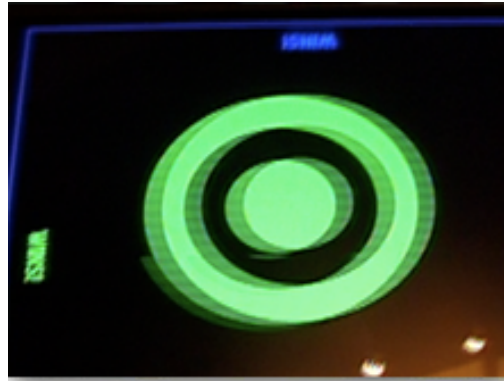
Figure 3.12: Video still of the winning token shape animation.

round, a participant has placed a token on a selected field of the game-board but the game-round has not yet come to an end, the participant is required to maintain his or her token's position on the game-board by remaining stationary, but is also required to move via stepping movements on the wobble-board at the same time. Unless the participant accomplishes this "conflict of interest" successfully he or she will lose the token for the current game-round. The participant is given a grace period of two seconds. At the end of the first second the word "move" flashes on and off on-screen in the panel area between the virtual edge of the game-board and the edge of the visible screen estate in front of the wobble-board. Figure 3.7 shows two of the three graphic panels for Square and Triangle tokens. If the participant stops stepping on the wobble-board and does not pick up this activity within two seconds, the participant will watch his or her token flying off from the virtual game-board via a circular, sweeping animation.

3.3.1.2   *The conflict of interest involves the body*

Previously we described a "conflict of interest" that involves satisfying two opposing conditions during game-play. Here the participant has to be resourceful with their body and also understand where the threshold lies that affords him or her to step on the wobble-board and at the same time maintain a token position stationary in the game. The participant has to search and find suitable and personal ways to reconcile these two opposing demands by the game using cognitive and physical means.

3.3.1.3   *Traversing an occupied field*

During a game-round, a participant's token can cross over fields that are already occupied by 'frozen' tokens from previous game-rounds. As a participant's token crosses over an occupied field of the game-board, his or her token slows down by spinning once over the occupied field. If the participant's token crosses an already occupied field at the end of a game-round and does not obtain an unoccupied field by the time the game-round has come to an end, the participant's token will fly off the game-board in the same, afore-mentioned manner.

3.3.1.4   Wrapping around the game-board

Previously we have described that new tokens are placed randomly into the game at the beginning of each game-round. The algorithm for new token placement has been designed to deliver a token shape away from 'frozen' ally token shapes. If a participant is building on the winning cross-shape token pattern over a number of game-rounds, and receives a new token placed on the other end of the game-board, it might take up precious milliseconds to move the active token from one end of the game-board to the other for continued pattern construction. This is especially the case within games that have accumulated a copious number of 'frozen' tokens due to a high number of game-rounds. Here, it would be an even more significant loss of time to traverse the game-board because it might mean many already occupied fields have to be crossed by the active token. For this scenario there is a short cut built into the game-board which has to be discovered by the participants. When a participant's token reaches the edge of the game-board and he or she continues to move forward on the board, the participant will discover that he or she can 'wrap' around the board to re-surface on the opposing side, essentially discovering the implicit toroidal shape of the game-board. However, the 'wrapping' technique does not apply to the construction of the winning cross-shape token pattern that participants have to create to win Sim-Suite's game, it has to stay in one unit.

3.3.1.5   Complexity of interaction in Sim-Suite's game

In the design of Sim-Suite's game-play, one element in particular builds up interaction complexity between participants. Participants engage in simultaneous turn-taking in every game-round. Conventional board games sustain game-play through sequential, alternating contributions by participants. This allows participants to reflect and strategise on each contribution as individualised input in relation to others in the game. In Sim-Suite's game, to keep up with game developments participants do not have this paced and exclusive concentration available to them, instead they must face a situation that intrinsically divides their attention. Participants must focus their attention concurrently on their own game-play and also on that of their opponents.

Consequently, game-play decisions are made not only on the basis of one's own game-play but decisions must also anticipate those of the other two participants in a fraction of time. These decisions pertain to a multitude of aspects. In the virtual environment, the decision-making begins with the task to select an optimal location on the game-board to commence building the cross-shape token pattern in fulfilment with the game objective. Here, if the token is placed too close to the game-board edge it might prevent the participant from having an expandable range of fields at their disposal in game-rounds further along in the game. There are also many ways to proceed in the order of constructing the cross-shape token pattern, placing one token after another, game-round after game-round, while minimising the potential of having to re-start this pattern building activity in case of being blocked by another participant's token shape. Those who are blocking another participant's token shape are investing their own token, therefore they must decide at every game-round whether it is more lucrative to continue building up one's winning token pattern or whether blocking someone else's token pattern in-progress is essential in preventing the other from winning the match or game. Blocking activities must undergo a shrewd calculation because they

come at the expense of one's own token.

Another factor that increases the level of complexity comes into play later in the game. Games with a high number of game-rounds will fill up the game-board with 'frozen' tokens. As discussed earlier, this will make traversing the game-board more difficult, and also produce naturally occurring token pattern formations that are partially cross-shaped. These partially formed cross-shape patterns present an opportunity for participants to inconspicuously complete these into the winning token shape pattern. Putting it differently, token shape density on the game-board adds cognitive complexity in deciphering opponent pattern-building efforts from a busy game-board but it also present opportunities to appropriate existing variations of unfinished cross-shape token patterns and harness these for the construction of one's winning token shape pattern.

Beyond this level of game detail, participants also operate on a higher level of social interaction when profiling their opponents' capabilities. Due to Sim-Suite's interaction dynamics that play off dividing a participant's attention between two opponents, participants have to swiftly estimate and penetrate the strengths of their opponents. Estimating the strength of an opponent goes beyond the evaluation of their token placement, it implies a grasp on the opponent's physical abilities, adaptive capabilities, cognitive alertness, and effective action in the context of game-play. Profiling opponents serves as requisite in guiding one's decision when allocating attentive efforts to one versus the other opponent. Frequently, the pitfall of this scenario is that participants become exclusive in their focus on one opponent while neglecting the other opponent, enabling that opponent to quietly win the game while no one is paying attention.

Earlier we mentioned a "conflict of interest" situation where the physical body plays a role in reconciling the dynamic between holding one's token stationary in the game and moving ceaselessly on the wobble-board. The ability to effectively manage this situation in one's own idiosyncratic embodied manner is instrumental when the token cross-shape pattern is only one or two game-rounds away from being the completed cross-shape token pattern. In such a scenario the participant who is about to win the match or game becomes a prime target for token blocking by the two opponent participants. At this stage the pattern has been built up and there is one field that will complete the pattern without options, or bring the pattern near completion, and secure winning the match or game. In other words, the participant must navigate his or her token to that field before anyone else does. Racing to that field as soon as the game-round has bestowed new tokens to everyone seems to be the only strategy here. Therefore the participant has to have the ability to move and navigate with relative ease on the wobble-board and must be able to handle sitting stationary on the field of the game-board while the remaining time of the current game-round comes to an end. In that sense, the body has a vital and crucial role in Sim-Suite's game-play.

3.3.2 Creative participation

In the first chapter we elaborated on the starting point of this thesis. We expanded on cultural changes that have precipitated new forms of artistic pursuits. Briefly, these artistic pursuits have been facilitated through access to new technologies, and their use in artistic context has emphasised, developed and reconfigured communicative aspects of art-making. More specifically, in-

teractivity in the arts has affected both artistic communication with the public and the process of art-making. Although interactive artworks are not a new phenomenon, technology has provided the fertile ground that has pushed interactivity to a place which diffuses the notion of 'finished' artwork and communication of ready-made meanings. This notion of the 'finished' artwork is not substituted by an 'unfinished' artwork, instead it constitutes a "field" of interactive, artistic communication with a set of characteristics that were described in detail in chapter one. Therefore, the absence of a conventional art object has obliterated the creator's authorship over the artwork and opened this 'field of artistic communication' to the audience for creative participation within an individualised context.

We turn to Sim-Suite, an interactive installation artwork to further explore the meaning of creative participation. In chapter two we explained that research into creative behaviour defines creativity as a form of problem-solving with a novel outcome or end product, one that is useful in a given social context. The participant playing Sim-Suite's game enters the installation to play a game which has a clearly defined game objective. The problem to be solved here is to fulfil this game objective. The objective is to compose the prescribed token pattern and be the first one to do so in a social network of other participants, who influence and constitute the environment in this problem-solving context. The first step to this process is that a member of the audience steps up and positions his or herself on a wobble-board. This demonstrates the intention of engagement with Sim-Suite's game-play although he or she might not know the specifics of the game. Similarly, creative processes by artists are exploratory where the solution in form of the artwork arises from and through the process. Once the member of the spectating public has stepped onto Sim-Suite's platform he or she has now made the commitment to be a participant in the game-play process.

This commitment extends into the physical realm. Sim-Suite's game-play environment is made up of dynamic social relations with co-players, shaping this environment through their mutual, individual physical expressions. Furthermore, this game-play environment is inclusive of tools, these are the wobble-boards interfacing with displayed virtual graphics. These creative tools are utilised by the participant for his or her physical expression when aiming to achieve the game objective. The motivation to step up onto the platform and change from bystander to active participant articulates a comprehensive commitment. Thus, this commitment extends and comprises the physical body via full-body movements to interact with Sim-Suite's interface.

Sim-Suite's interface is a creative tool which is animated by the participant through personal, unique and undefined movement combinations. As a practice to solving a creative problem, Sim-Suite's physical and virtual tools present in essence the same functionality as conventional artistic tools used in creative endeavours. A comparable instance mentioned in section 2.3.2 is the Chinese ink painter, who gestures and moves his entire body when painting on doors. His physical movements with paintbrush in hand render his individual approach visible in form of systematic brush strokes. His movements are performed within the Chinese ink painting tradition which can be seen as a system of painting. Elements of Sim-Suite's interface belong to the game as a system of reconfigured and conjunct game-play conventions, and these equally trace the unique path of

bodily movements by each participant's individualised approach to the game-play.

The use of these interface elements is guided by an individual's perception. As we have seen earlier in this chapter, Sim-Suite imposes few rules onto its participants. Complexity of interaction and game-play emerges from the properties of real-time interaction mechanics. This leaves much to the embodied interpretation, investigation and discovery by each participant in perceiving Sim-Suite's environment as adaptable, beneficial resource with affordances. The nature of affordances from the perspective of embodied cognition will be discussed in chapter seven, they offer building blocks for strategic engagement when problem-solving Sim-Suite's game-play. Similarly, an artist's creative process in the real-world appropriates environmental resources in the context of creation, where it is up to the individual creator to exploit environmental resources and maximise contribution to the creative process.

3.3.2.1 *Measuring creative participation*

In chapter one we stated that creative processes of Sim-Suite's artistic creators and Sim-Suite's creative participants operate on a continuum. In this subsection we formulate a working definition for creative participation. This theoretical definition serves to guide methodological preparations that are needed to perform a statistical analysis. These preparations entail the extraction of numerical data from Sim-Suite's logfile, and a method for making this data operational via set of variables. Details of this procedure are discussed in chapter four.

Creative participation with Sim-Suite is a process of individual and body-centric accomplishment through the effective use of interface elements; the adaptation to the game-play environment as a resource; and self-directed bodily movements initiated by standing on wobble-boards. Although Sim-Suite's game objective is identical for all participants, to complete the winning cross-shape token pattern, the process to achieving this game objective is unique, personal and individual. We consider this process an original and creative contribution by each participant.

Sim-Suite players' creative participation is a process that creates a trail of real-time, computer-mediated virtual artefacts. In their essence, these virtual artefacts are constructed from numerical information that can be accessed and analysed, demonstrating how participants built their strategies when interacting with each other and Sim-Suite's interface elements.

Above all, Sim-Suite's game is a group activity where the influences of social interaction determine creative engagement, therefore creative participation is a matter of contributing to a group pattern composed from a collection of virtual artefacts. When analysing creative participation, we therefore look at engagement from the perspective of group patterns to explore strategic application and physical aspects. With this approach we can identify different patterns of creative engagement of groups of Sim-Suite players to map out characteristics of creative participation.

We stratify these participant generated real-time, computer-mediated artefacts from two perspectives:

Physical application during game-play

- Token 'flying' off the game-board. The participant loses his or her token in a particular game-round.

- Managing Sim-Suite's 'conflict of interest'. Finding balance between stepping continuously on the wobble-board and holding one's token stationary on a field of the game-board.

- 'Mileage' or fields traversed by token shape when navigating on the game-board in the current game-round.

Strategic token shape placement

- Tactical placement describes effective placement of one's token in the current game-round.

- Tactical blocking describes effectively obstructing another participant's cross-shape token pattern building activity in the current game-round.

We now have a workable conceptualisation of creative participation. The above listed items are used to guide the computation of variables that enable us to measure creative participation. We consider 'Strategic token shape placement' to play a more sophisticated role in creative participation because it combines physical and conceptual aspects when engaging with Sim-Suite's game.

Next, we provide the functional translation of these theoretical understandings by preparing Sim-Suite's logfile, which we explain in section 4.3.3.

3.4 Conclusion

In this chapter we introduced the interactive installation artwork Sim-Suite. We began this chapter by providing an outline of the installation as artwork. We culturally positioned software games as art practice and introduced the conceptual artistic intentions behind Sim-Suite. In this chapter we listed exhibitions with Sim-Suite, gave background to team members, and construction details as well as technical specification of the artwork. We elaborated on Sim-Suite's game-play, the function of interface elements, and emergent game-play dynamics with implicit and explicit game-play aspects. In reference to the previous chapters we defined the concept of creative participation when applied to Sim-Suite. We stated our approach to the investigation of Sim-Suite's creative participation for this thesis' statistical analysis to which the virtual artefacts generated by the participants are fundamental.

This chapter builds the foundation of the thesis' two-fold analysis conducted with Sim-Suite. It connects to the cultural phenomenon of contemporary art-making, this thesis' conceptual underpinning, discussed in chapter one. Sim-Suite is a real-world instance of this type of cultural phenomenon. This chapter presents the starting point for analytical investigations into the creative process continuum. In the next chapter, we explain how we go about these investigations, what motivates the methodologies for this two-fold analysis, and how data is collected and prepared in each case.

Chapter 4

The embodied cognition paradigm as a theoretical lens on mixed methodologies

4.1 Introduction

In the previous chapter we introduced the artwork Sim-Suite, in this chapter we turn to the analytical side of this thesis. Here we introduce several threads to this research, creating a branching point which starts to build up the underpinning of this thesis' analyses and gives background to subsequent chapters. In addition, this chapter explains the main principles of embodied cognition by reviewing relevant literature, which shall be used as a theoretical lens throughout this thesis. We use this theoretical lens to make numerous research decisions, and also apply the principles in an interpretative capacity to analytical findings.

This chapter is structured by dividing it first into two main parts. The first part, which begins in the next section, 4.2, focusses on outlining and explaining the main principles of embodied cognition, especially from the embodied-embedded perspective and the enactive perspective. We conclude this section by stating how this lens is applied in this thesis.

Section 4.3 that follows from here is the second main section where we describe this thesis' methodologies. Here we first introduce background and motivation in adapting a mixed method approach in the study of the creative process continuum. Then we expand into two subsections, section 4.3.2 and section 4.3.3, each elaborating details of the type of methodologies chosen and their application in this thesis. We first give background to this thesis' qualitative analysis, followed by a subsection that expands on the quantitative analysis. We conclude this chapter by reiterating important points to keep in mind for the reading of subsequent chapters.

4.2 Perspectives of embodiment in cognition used as a theoretical lens on Sim-Suite's creative process continuum

In this section we introduce principles of two leading theses in embodied cognitive science: the embodied-embedded approach and the enactive approach. Cognitive science is concerned with the
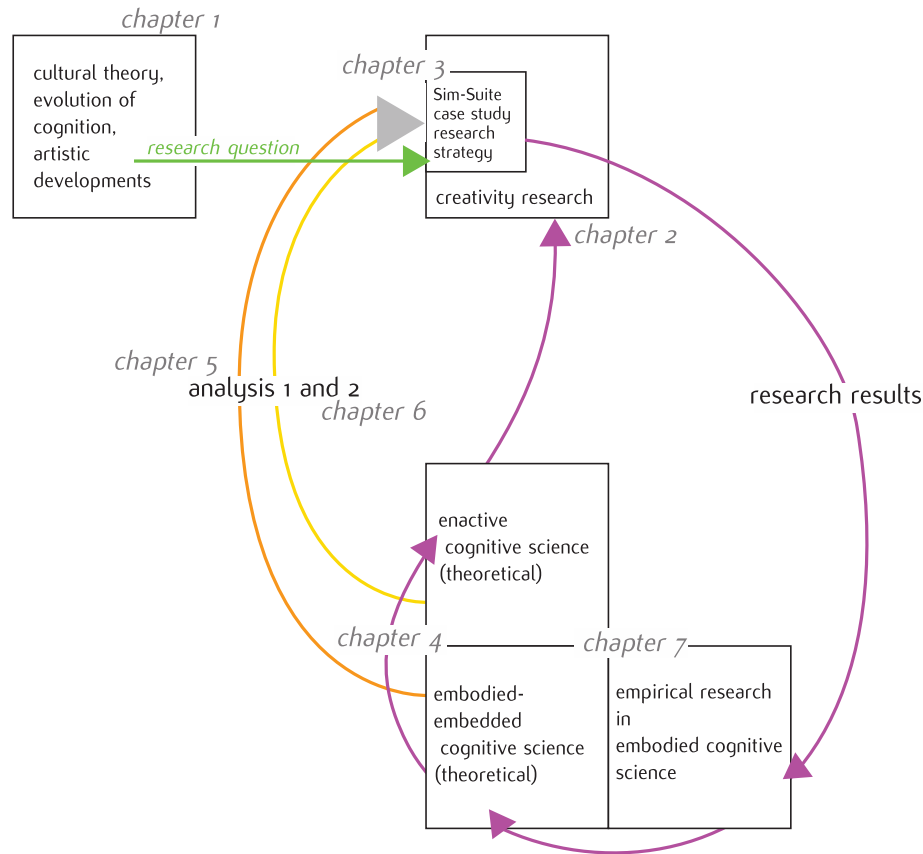
Figure 4.1: Illustration of the thesis' high-level structure from chapter one to seven, and the overall integration of the theoretical lens. In chapter seven, we give an account of the creative process continuum in regards to the embodied cognition themes elaborated upon in this chapter. The concluding chapter eight is not depicted in this graphic.

investigation and understanding of principles and dynamics of species-universal as well as higher cognitive functioning specific to humans.

Since the connectionist conceptualisation of cognition (e.g. Fodor, 1975), cognitive science has espoused an alternative paradigm that is inclusive of brain, body, culture and real-world observations. This recent repositioning understands cognition as process that is self-sustaining, self-determining, self-organised and embedded through and by living organisms. From the many proposals on embodied cognition we have selected two that enable us to integrate the point of creativity more readily, while acknowledging that both approaches are eager to develop a fuller account of lower and higher cognitive functioning, which may some day also include creative cognition. That is to say both approaches comprise differing emphases on the role of the body in cognition and are exposed to ongoing scrutiny by researchers, who are involved in progressing embodied cognition approaches.

For this thesis, which is focussed on the creative process continuum and embodiment, these afore-mentioned aspects of differing emphases and incomplete theories are not of concern. The reason for this is that we are using the following theoretical lens as an analytical tool to uncover

aspects of embodiment in the creative process continuum. On the one hand, we are looking through this lens to study creative processes of artistic collaboration that created the artwork Sim-Suite. On the other, we are analysing the process of creative engagement by the recipients of the artwork.

Hutchins (1995), one of the first researchers to study 'cognition in the wild', claims that cognitive processes are situated and distributed, they are therefore embodied and social. He pointed out that there might be a confusion caused by attributing cognition to the individual alone, without taking into account that the individual operates embedded in the socio-cultural fabric which deeply enmeshes an individual's cognition. He substantiated his claim with studies on ship and airplane navigation in cognitive anthropology, showing that properties of human computation originate from socio-cultural organisation conjoined with an individual's cognition and psychology.

Hutchins' work presented an alternative, plausible view on the architecture of cognition, other than the one that uses computing mechanisms as model for mentality. His conception of cognition resulted from studying cognition in various culturally constituted settings. Hutchins states that "in spite of the fact that we engage in cognitive activities every day, our folk and professional models of cognitive performance do not match what appears when cognition in the wild is examined carefully" (p.371). He developed a model on the basis of 'cognition in the wild' that offers a three-way adaptation to unite *development of the practice* with *development of the practitioner* and *conduct of activity*.

Both approaches selected for this thesis' theoretical lens, the embodied-embedded approach and the enactive approach to cognition, embrace this fact, that an individual's cognition is contingent on the socio-cultural fabric of the environment and thereby playing an active role in cognition. Nevertheless, both approaches to cognition draw mostly on research that is not conducted in the wild. Furthermore, both approaches firmly acknowledge the cultural relevance to cognitive evolution but draw on types of studies that are exclusive of socio-cultural elements. We attribute this situation to the aim of understanding cognition from the 'ground up', where philosophy advances both approaches theoretically, and provides practical pointers to the developing field of artificial intelligence. However, this comes at the expense of possibly using culturally situated observation as measure for an implemented understanding of embodiment in cognitive acts. This thesis' research contributes a perspective of embodiment and cognition which is thoroughly situated and culturally embedded through observations of cognitive functioning in the socio-cultural fabric of the wild.

For the embodied-embedded approach we assemble research contributions from a number of different researchers. The label "embodied-embedded" is used to make a coarse-grained distinction from the enactive approach. Within the embodied-embedded approach we draw extensively on Clark and Chalmer's (1998) work which is the extended mind theory and not strictly embodied-embedded. However, overall, we include work from wide range of disciplines, for example cognitive anthropology to support embodied communication, and that work can be characterised as embodied-embedded. For the enactive approach originated by Maturana and Varela, we have made Thompson's (2007) academic writings our main source of reference. Where relevant we provide input from other researchers, who are investigating from the perspective of enactive cognitive

science.

Before we start laying out the theoretical lens for this thesis, we briefly stipulate starting points and contribution for embodiment from the perspective of creative behaviour. First, we have chosen to outline two approaches to embodied cognition research. They are currently most comprehensive in addressing the spectrum of cognitive aspects of biological brains with bodies. Generally, embodiment as an approach to cognition is in the process of developing a firmer position within the cognitive science research community. Theses on embodiment are classified into body anatomy, body activities and body representations, whereby the latter is divided into bodily content and format (Goldman & de Vignemont, 2009). The investigations conducted for this thesis centre on body activities with self and others.

Second, the diverse views of embodiment (M. Wilson, 2002, c.f. for review) do not make a unified definition of embodiment available. This thesis' research focusses on interpreting local embodiment without making global claims. The findings that are put forth here are specific to the artwork Sim-Suite, where we explore embodiment in the creative process of making the artwork, and also when participating in the artwork. To this extent the goal of this thesis is to provide a new and alternative perspective of the artistic creative process, without refuting existing perspectives on creativity, or generalising from this thesis' findings on how artistic creativity is positioned within embodied cognition theories. To present our perspective we draw on findings and contributions from cognitive science by researchers, who have renounced classical cognitivism and have turned to embodiment in their research practice.

Third, the forthcoming lens is sought to be a frame of reference loosely outlined by two approaches. Both approaches understand cognition to be fundamentally embodied, reaching across the afore-mentioned taxonomy. Throughout the following chapters, chapters five, six and seven, we interpret findings from the embodied position via the themes that have been mentioned in this section. We shall turn to additional resources of empirical research that are not directly mentioned in the theoretical lens but are relating to the social aspects of creative cognitive behaviour. Lastly, we aim to lend a new, embodied perspective on activities to creativity research, one that is understood as constituting the artistic creative process continuum.

4.2.1 The embodied-embedded approach to embodied cognition

The embodied-embedded direction in cognition research, such as work by Hutchins (1995); Clark (1997); Brooks (1991) and Semin and Smith (2008) acknowledges humans as embodied agents, or cognisers, who are capable of creating and exploiting structures in the world. From this perspective an agent's brain is seen as handling the controls of embodied action in the exploitation of environmental structures, which have been shaped through repeated brain-world interactions. The result of such interactions is characterised by emergence, coalescing from the agent's cognitive capabilities in the utilisation and manipulation of external media, tools (including the formalism of language), technologies, but also the storage and transmission competences offered by cultural institutions.

In this theoretical lens, we also include the extended mind theory (ExC), which evolved from

the embodied-embedded approach. ExC advances the idea that the embodied mind is extended into the environment, that some mental processes, of which cognitive processes are a subcategory, are partially composed or constitutive of functioning in tandem with structures in the environment. In their operation, these cognitive processes manipulate, exploit or transform structures in the environment which entails tools, artefacts and technologies since they offer by their sheer existence a way of thinking about the world. ExC theorists are concerned with explaining precisely how coupling of brain, skin and environmental structures determines a cognitive status for each component and which does not limit cognitive processes as skin-bound phenomenon. From this perspective ExC can be seen as a radicalisation of the embodied-embedded approach.

ExC theorists think of embodied interaction with our environment as being 'inhabited' because we conduct ourselves with bodily fluency while attending to tasks at hand. In other words, the dynamics of the body are exploited in conjunction with the environment, while body and environment are united in the interaction. Clark and Chalmers (1998) give such an example with Otto, who suffers from Alzheimer. He relies on the environment to support himself by using a notebook and pencil where ever he goes to record and retrieve information. The question arises how can the cognitive status of pen and paper be determined in this context? A question that has been investigated and answered through a view of functionalism and the parity principle (for a review of relevant arguments see Wheeler, 2008).

This integrated and intricate body-environment confluence described here can be easily seen when it breaks down within the current limitations of digital technologies. These technologies cater insufficiently to the 'inhabited' body, therefore creating user experiences that do not adequately support bodily modes of sensing when interacting with the world. The problem of failure in these technologically engaged bodily actions is the lack of transparency, of interaction focus and options, therefore deterring a person's awareness away from tasks, while re-focussing attention onto equipment or environment. Earlier in section 2.3.3.1, we gave some pointers to problematic issues of cognitive attunement to the virtual, non-physical nature of digital materials in the design of user interaction. In this brief outline we discuss only the most pertinent experiments to accommodate the lens for this thesis.

4.2.1.1 Embodied communication

In this subsection, we briefly outline the model Oberzaucher and Grammer (2008) have conceived on the basis that all human communication is a matter of quality of physical motion. The qualitative physical motion of communication has been captured in a dynamic model (The Bielefelder Model) which aims to explain the motivation of interpersonal communication from the standpoint evolutionary constraints. These constraints centre on honesty, deception and manipulation due to the selection pressure that humans have been subject to throughout history.

This multilevel communication model "operates simultaneously on a signal continuum from indexes (e.g. pitch, body motion, gesticulation) and icons (gestures, facial expression) to a symbolic level (spoken words)". Moreover, the indexing level is not considered a signal but is primarily analogous to human communication where, aside from symbolic communication, "many indicators of non-conscious and non-verbalizable mental processes are expressed through the quality of

motion itself" (p.152).

From the premise that human communication is above all about sharing information, Oberzaucher and Grammer recognise that communication is not only about taking turns in the contribution of new information, but that these acts are underpinned by evolutionary constraints that consequently shape human communication. In particular, deception is the basic constraint on communication but, at the same time, "deception enforces communication on the index analog level" (p.172).

Underlying these evolutionary constraints is the need to cooperate successfully, which involves building trust to ensure continued cooperation. During the act of communicating, successful communication entails control and management of error handling and coping with competing signals from the environment. However, on the basis of selection pressures, communication is driven by self-interest expressed through the pursuit of individual goals, which may be in conflict with the goals of the communication partner. Interactors mutually manipulate each other's behaviour for self-serving reasons while also trying to estimate goals of the other to prevent being manipulated. Here the researchers state that this is the stage where "mind reading and theory of mind evolved, leaving their traces in the way we communicate" (p.154). To accomplish manipulative efforts successfully, two strategies are deployed in the development of deceptive communicative situations. The first strategy is to withhold information, which opens up possible indirect strategies, and the second strategy delivers false information, where this strategy has higher social costs if uncovered.

Thus, communicators are permanently in the situation of possibly being deceived which may be costly and pernicious to one's own survival. For this reason selection pressure to detect deception is of great importance and has resulted in the evolution of specific mechanisms where communication is monitored through feedback systems that serve as a "counter-deception measure". Both systems, the system of mutual manipulation driven by self-interest through deceptive means, creating adaptive communicational advantage over the interaction competitor, and the anti-deception feedback system are permanently optimised. However, the systems are never completely adapted. From this perspective an index level of communication may be the solution for unfalsifiable communication.

Oberzaucher and Grammer investigate the organisation of the indexed or analogous level of communication by drawing on a wide-ranging spectrum of innovative research conducted on human motion. It has been shown that humans can infer emotional states from patterns of movement without grasping the entire detailed shape of the human. Briefly, human motion is determined by two overarching directions, one direction encompasses human body anatomy and weight distribution, and the other is comprised of the neural mechanism as controller and internal states that modify the control mechanism.

Extrapolated from existing research and summarised by Oberzaucher and Grammer (pp.158-161), are four main influences that affect human motion. The first is "individual and sex-specific genetic influences on the biomechanical linkage which can change movement quality". Secondly, "sex hormone influences on muscle build and fat distribution". The third influence is the human body's symmetry of mass distribution and the biomechanical linkages. Fourthly, "current hor-

monal states might change motor patterns" and affect motion quality. The researchers remind us that the observing interactor is equally in motion therefore perceiving additional information as the brain analyses texture and colour independently from 3D geometry (Troost, 1998, quoted in Oberzaucher & Grammer, 2008). These characteristics influencing human motion quality are genetically linked to the human body and are difficult to misrepresent in communicative situations. They may be considered as links to honest communication signals.

Similarly, the Behavioural Ecology View theory (Fridlund, 1991, 1994, quoted in Oberzaucher & Grammer, 2008) states that facial expressions are social tools, mimics of social intention and social motives, they are not necessarily linked to emotions. In other words, a particular social motive may be associated with a number of emotions, and the comprehension of these expressions is part of the co-evolution of these signals. Thus, these expressions need to reliably instigate further actions and the selection process must prevent unintended displays that disadvantage the sender.

From the perspective of the brain-behaviour relationship, the recently discovered mirror neuron system supports Oberzaucher and Grammer's embodied communication model. In the mirror neuron system, in monkeys (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996), as in humans, the same neurons responsible for motor circuits, such as F5, fire in an agent's brain when the agent is observing an action, such as a hand grasping an object, as when the agent is performing that action herself (Rizzolatti, Fadiga, Gallese, & Fogasi, 1996; Gallese et al., 1996; Iacoboni et al., 1999; Buccino et al., 2001, quoted in Oberzaucher & Grammer, 2008).

Considering the adaptive advantage, Oberzaucher and Grammer mention that such a mirror neuron system would help stimulate the construction of a theory of mind of the observed human, and gain insight into the human's intention, which may constitute a "communicative bridge" between actor and observer. Moreover, Gallese (2001) hypothesises that mirror neurons' functionality feed a complex he called a "shared manifold", which gives access to intentions and behavioural tendencies, forming intersubjective communication. Recently it was suggested that mirror neurons function inside cortical neuronal systems that are utilised to perform social cognitive functions, therefore humans might be in the position to use their mental states to predict and explain mental processes of others via movement observation (Williams, Whiten, Suddendorf, & Perrett, 2001, quoted in Oberzaucher & Grammer, 2008). Oberzaucher and Grammer's view is that this "action recognition system" is the receiver part, when demonstrating action tendencies via motion.

The researchers' review is extensive, it also provides research evidence investigating motion quality regarding personality traits. Deducing from research evidence, they state that personality traits are not traits per se but the probability for action tendencies in a given situation. The researchers supplement their position with research evidence from hierarchical pattern synchronisation and coupling. A more in-depth view of these research topics is outside the scope of this chapter.

In conclusion, Oberzaucher and Grammer have provided an overview of research evidence on embodied communication that links the body as physical form to the body's motion capabilities,

whereby motion capabilities are not separate from human action tendencies. With their overview the researchers illustrated that action tendencies have a basic stake in communication, furnishing essential communicative cues that are accommodated by motion and motion capabilities, which may be influenced and accessed by the brain's neural system. Hence, the level of index and analog communication is understood as 'expressive' style. The connection between action tendencies and body construction remains unclear, and here both researchers speculate that the body's development is not isolated from the brain's development. To sum up, we have laid out the basic structure and components for a view on embodied communication, which we consider as underpinning for the 'field of artistic communication' studied by this thesis via a case study research strategy.

4.2.1.2 *Passive dynamic strategies and relational affordances*

Through inhabited interaction, mentioned in section 4.2.1, the world becomes an "unmediated arena for embodied interaction" (Clark, 2008, p.9) where the 'bodily' extended space is both the problem space as well as the resource for problem-solving. An example is the *passive dynamic* strategies used by the body to navigate in the environment. This can be illustrated with engineered humanoids, for example the passive dynamic walker (Collins et al., 2001). This bipedal, walking robot does not have a control system except for the mechanical linkage working in concurrence with gravity, a strategy that mimics evolved passive dynamics by exploiting mass properties, morphology, gravitational forces and biomechanical couplings that are permeating the musculoskeletal system of the human body.

Passive dynamic effects exemplify a key characteristic of embodiment, called *non-trivial causal spread* (Clark, 2008, pp.7-9). Casual spread is understood as "causal contributions" that are coming from beyond the states and processes of the agent's nervous system and are non-neural bodily factors that exploit the environment. These are non-trivial when the factors reveal themselves to be "at the root of some distinctive target feature" (Wheeler, 2005, p.219). An example of non-trivial causal spread is found in the intricate interactions of cricket phonotaxis in mating rituals (see Wheeler, 2005).

In embodied cognition, perception is taken as a direct link between body and environment, which means opportunities in the environment are presented as affordances for behaviour. However, from the perspective of radical cognitive science (Chemero, 2009), Gibson's theory of affordances (Gibson, 1979) must be redefined to fit the dynamics of embodied cognitive science. Briefly, this redefinition then surpasses static ideas about "whether affordances are resources that guide natural selection, or dispositional properties of the environment that must be complemented by some property of animals" (p.139). Instead, Chemero defines affordances as relations between organism and environment. Environmental "relata" in affordances are considered as features, for example Shaquille is taller than Henry, where "the taller-than relation is not inherent in either of them, but depends on both of them for its existence". On the side of the organism, affordances are relations between the organism's abilities and features in the environment. For example, leg length might be important when climbing the stairs but more important is the stepping ability which may diminish with age even though the leg length has not changed. Environment and organism are bound together by the organism's niche which is a set of situations where the organism can ex-

ercise one or more of its abilities. "This collection of situations forms the organism's cognitive, behavioural, and phenomenological niche" (p.148).

It should also be mentioned that Chemero's "affordances 2.0" in-the-making, aims to further combine enactivist studies to complete the revised theory of affordances as brain-body-environment system where "nonrepresentational neurodynamic studies of the nervous system and sensorimotor abilities match up with ecological psychological studies of affordances and sensorimotor abilities" (pp.152-154).

Affordances are not only relational and dynamic, they are part of an action system when an individual extends him or herself in action abilities through the use of external objects and tools to act in the environment. M. J. Richardson et al. (2007) compare the flexibility of an individual's biology, for example improved dexterity through growth, to the actualisation of affordances with external objects or tools which would otherwise be impossible. A simple example is the wearing of snowshoes to enlarge the foot's surface and enhance one's action system. Snowshoes then become a functional part that is integral to the person's action system just as a body part, which can take advantage of the snow's surface, making walking in deep snow possible.

Central to this section is Sim-Suite's wobble-board because it exploits the passive dynamics of humans' locomotion to drive the interface to the Sim-Suite game. Moreover, the wobble-board is the object around which the collaborative creative processes were built up through the exploitation of affordances. Further discussions on affordances are to follow in chapter seven.

4.2.1.3 Continuous reciprocal causation

In this subsection, we look at *continuous reciprocal causation* which has been explained as the "presence of continuous, mutually modulatory influences linking brain, body and world" (Clark, 1997, p.163). While socially embedded, this mutually modulatory complexity acts between components that make up brain, body and world. The nature of these couplings with components is not merely a collection of inputs and outputs. Couplings provide an ongoing and reciprocal exchange that will bring about emergent dynamics of the respective overarching system. Unlike the notion of representation in classical cognitivism which only accommodates orderly 'snapshots' of the world, in the context of *continuous reciprocal causation* we are speaking about temporal, periodic extended activity of a system A which is affecting and is simultaneously affected by a system B. Causal complexity may reach across processes from the brain to the whole body to the local environment.

On the bodily scale, we can cite agent-to-agent couplings, such as jazz musicians improvising together, or performing dancers who are steadily affecting and being affected by neural states. Here, internal process with characteristic and intrinsic temporal features may point to an underpinning of adaptive behaviours creating an accord between inner state and external circumstances. The two schools of research, those who see cognition as involving perceptual and bodily sensorimotor characteristics and those who recognise cognition as continuous dynamical systems, have observed entrainment in their research via synchronised action (D. C. Richardson et al., 2008). Interactional synchrony is defined as the temporal coordination and correlation of movements by interactors due to a principle of self-organisation that is regulated by coupled oscil-

lators (M. J. Richardson et al., 2005), where entrainment occurs as a result of direct, un-mediated perception-action links (Sebanz & Knoblich, 2009).

Let us briefly illustrate a seminal experiment in agent-to-agent couplings. In Kelso's (1995, Ch.2) rhythmic finger motion experiment, two subjects were asked to move their index fingers at the same speed with a side-to-side motion. Using dynamical analysis, two stable conditions were derived from the experiment, either fingers moved in-phase, with synchronised movements involving the contraction of the identical muscles, or in anti-phase with desynchronised movements, involving opposing muscles in the contraction and expansion. Notably anti-phase finger motions were only stable at slow speeds. With increasing speed, at a critical frequency, the finger motions would collapse into in-phase movements.

In a recent study M. J. Richardson et al. (2005) built on previous studies investigating limb coupling with wrist pendulums. The researchers tested interactional synchrony by having subjects perform task sharing by problem-solving, which required identifying the differences between two cartoon pictures within a 20 second period. In six experimental trials subject pairs were swinging their wrist pendulum at a self-selected tempo while visually and verbally interacting with each other, or verbally interacting but not visually, or visually interacting but not verbally. The result of this study gave definite evidence that "visual interaction (information) can unintentionally couple the rhythmic wrist movements of interacting individuals. On the other hand, no evidence was found to suggest that the verbal interaction (conversation) either supports, or enhances, the unintentional synchrony of visually coordinated rhythmic wrist movements" (p.73).

In addition, researchers studying interactional synchrony generally do not associate mental states with synchronised movements because synchronisation transpires when performing rhythmic movements even when subjects are asked not to synchronise.

4.2.1.4 Models of agency

In this subsection, we focus on research that has been conducted into cognitive mechanisms with perceptual and sensorimotor cues associated with agency. In phenomenological analysis a temporal distinction is made in agency between *prior intentions* and *intention-in-action* (Searle, 1983). Several systematic approaches have been developed to explain the various attributes of the sense of agency, and most experimental research on human agency is focussed on *intention-in-action*.

The Two-System theory of visual perception (Milner & Goodale, 1995; Bridgeman, 2000) is an example of a theoretical framework that examines visual signal processing as two distinct streams. The "what" stream visually processes information to consciously identify object properties, such as colour and form. The "how" stream processes visual information for movement control which is assumed to be consciously inaccessible. The agent's conscious detection of changes in visuo-motor coupling are changes that must be recognised by the "what" stream. If this does not happen then adjustments to the movement should be made without conscious awareness of the change.

The Internal Model theory of motor control (Frith, Blakemore, & Wolpert, 2000) is more extensive in explaining how changes to the visuo-motor coupling are consciously registered. The main motor control components involve inverse models and forward models. Inverse models fur-

nish motor commands that are required to accomplish a desired state. Forward models predict the sensory consequences of each motor program to be executed. It is assumed that subjects have awareness of the desired state and predicted consequences of movements, but are unaware of any discrepancies that arise between the predicted consequences and the actual sensory consequences of movements. Numerous empirical studies have provided evidence for the afore-mentioned assumptions.

For example, Fourneret and Jeannerod (1998) showed that subjects were unaware of changes between actual hand movement and visual consequences displayed on a monitor. It was the subject's task to trace a straight line by moving a stylus on a writing tablet while some of the trials were intercepted with angular perturbations in directional bias with 2°, 5° or 10° to the right or left. As a result, subjects judged their hand movements to be straight ahead when they were actually bent. In chapter seven we shall discuss further studies in support of findings from chapters five and six.

4.2.1.5   *Language as material symbols for cognitive niche construction*

In this subsection we explore how language embodies thought. The spoken and written word are understood as modelling symbolic structures which are attuned to the representations and operations of the biological brain (Clark, 2006a, 2006, 2008). In regards to the cognitive process, natural language is not specified by culture and then translated into an established inner coding system, instead language structure and form engender a material symbolic system which is a hybrid cognitive resource. This hybrid cognitive resource functions by coordinating dynamics of internal biological resources with external resources.

Through language we materialise thoughts and structure our environment in pursuit of cognitive niche construction. Cognitive niches enable reasoning by opening up new spaces for problem-solving. Language as a material symbol system creates scaffoldings for bodily form and action in the world which can be focussed in three interwoven claims. The first claim is that labelling the world unfolds a variety of new computational opportunities and aids the perception and identification of abstract patterns in nature. The second claim centres on the attainment of expertise through encounter and recall of structured sentences. The third claim points to self-reflection: humans have the ability to reflect on their thoughts through linguistic structures and have the capacity to direct and guide the content of their thinking (Clark, 2008, p.44).

These claims are supported by looking at a variety of examples in primate research and investigations of relationships between mathematical competence and linguistic expression in humans. Tag-trained chimps, for example, reinforce the idea that linguistic labels for objects in the world effectively economise cognition by grasping complex properties and relations of perceptual array. These chimps are able to distinguish pairings of objects with 'sameness', such as a cup-cup pairing tagged with a red triangle, and 'difference', such as a cup-shoe pairing tagged with a blue circle. Conceptually labelling objects enables agents to focus attention on all and only the items belonging to an equivalence class, for example all objects of the 'sameness' class. It allows the agent to cognitively operate on "artificially reconstituted, inspectable wholes" (Clark, 2006).

Other observations demonstrate analogue representation of the conceptually labelled physi-

cal world through language with spatial organisation of physical objects. Kirsh (1995) analysing cooking behaviour, found that grouping washed vegetables in one area and unwashed ones in another area was performed to reduce descriptive complexity as part of the problem-solving process. Labelling the physical world and spatial organisation of physical objects achieves simplification by means of physical groups that focus perception and bodily activities towards functional and perception-based equivalence classes. In cultural use language channels human activity, ranging from navigating the environment through signage to memorised and recited phrases such as "righty tighty, lefty loosey". This type of language use shares the potential to propel humans into self-instigated behaviour until this behaviour has been internalised and reached expertise.

Language use in humans includes the capacity to record words. The act of recording, such as writing on paper or typing a word on a keyboard, may not entail thoughts about the recorded word, but as soon as the recording is completed the word then becomes a perceivable object. A literal example is a word engraved into stone, the dimensionality of the word will actually cast a shadow. The word as object can be shared and attended to through subsequent thinking, making language a key cognitive tool to objectify, to reflect upon and engage with our own thoughts. More than that, language becomes a cognitive open-ended "superniche", spiralling formations of new cognitive niches (Clark, 2008).

Cognitive niche construction comprises active exploitation and manipulation of physical space and space dynamics creating new cycles of feedback loops. Recall Kirsh (1995) and his "intelligent use of space". He determined that the use of space was threefold: Spatial arrangements and dynamics assist the human in the process of thinking by simplifying choice, simplifying perception, and simplifying internal computation. The latter was analysed in the context of the video game Tetris (Kirsh & Maglio, 1994). Experiments with Tetris showed pragmatic, goal-driven actions, where players will engage in *epistemic actions* to simplify their problem-solving tasks and improve cognition. In *epistemic actions* players will move Tetris' tetromino shapes before they can know where to place them, to reduce time, reduce memory, and error in mental computation. Although these actions may not alter the physical state of the game, for example translating a shape in one direction and then back again, they will alter the informational state of the player.

An example from a collaborative cultural setting that epitomises meticulous niche construction were Elizabethan and Jacobean theatre practices (Tribble, 2005). During theses times, actors had to accommodate their public with a high volume of theatre performance per week without much rehearsal time. In addition they were expected to put on a new play every fortnight. Therefore actors cued their physical space around and on stage, out of sight to the audience, to cope with the demands of performance. Stage doors, exits and entrance were depositories for hanging "plots" to provide just-in-time mnemonics and maps as well as cues for the next script lines.

4.2.1.6 *The human as profoundly embodied agent*

The embodied-embedded approach to cognition understands humans to be "profoundly embodied agents" who have the ability and capacity to deeply incorporate newly formed bodily, sensory, and cognitive structures in support of perpetual negotiations of the agent-world boundary (Clark, 2008). Contemporary society illustrates this with cultural and technological advances. Extended

bodies and reconfigured users are found in a variety of developments. For example, the theoretical premise of brain-machine interfaces (BMI) lies in our ability to detect neural signals and translate volitional commands into control signals for external devices including computers, robotics or other machines (Berger et al., 2008). In practical terms, BMIs are systems designed to aid humans with central nervous system disabilities which affect movement, communication and independent control of one's environment. Systems like these demonstrate an intricate adaptability to create new, alternative pathways which restore, to varying degrees, the ability to sense and act on the world.

Recent developments have shown that this competence to adapt is intrinsically anchored in the spectrum of sensory structures. Sensory substitution, such as pioneering approaches by Bach-Y-Rita (1972) as well as sensory augmentation, such as magnetic perception research pioneered by König (cf. Nagel et al., 2005), are lines of research demonstrating that sensory stimulation and reception can be patched by crisscrossing the available sensory spectrum.

Bach-Y-Rita's seminal work was aimed at answering the question whether a blind person who has never seen can learn to see as an adult? Over the course of eight years he developed a device, a Tactile Vision Substitution System (TVSS), which informs a blind person of his visual environment by stimulating a series of selected points on the blind person's back. He achieved this by converting an image of a video camera into a tactile image which produced the stimuli on the skin. The successful development of this device was based on assumptions of the visual system's detailed functioning, and the nervous system's performance when substituting from one sensory system to another. Sensory substitution and sensory augmentation show that the spectrum of sensory structures is extended to accommodate sensing environmental aspects that are elusive to standard human perception.

Culturally embedded examples by those who have utilised technological prostheses to extend their body are also seen in performances. For example, Stelarc's performance with a robotic third arm and hand is controlled via EMG signals generated by electrodes placed on his abdomen and leg muscles. Other prostheses compensate for impaired bodily functioning, such as the *Dobelle eye*, an artificial technology for the blind which implants a sixty-eight electrode array onto the surface of the blind person's visual cortex. Users of these technologies have reported that after prolonged use and practice a fluent integration occurs through which the person's intention flows into the action itself without referencing the prosthesis. This is comparable to developing infants who do not have control over their bodies and are learning through repeated effort and practice by developing neural circuitry that enables them to eventually turn bodily control into non-conscious activity (Clark, 2003).

To conclude, the review of these types of development show a use-dependent assimilation of tools, including external and non-biological resources with assimilation into the body schema.[1] Their use is not merely knowledge-based. It is accompanied by neural changes that are a sign of genuine assimilation into the bodily structure exemplifying humans as cognitively permeable

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[1] Body schema, coined by Gallagher (2005b), is a collection of neural settings that implicitly and non-consciously define a body in terms of its capabilities for action.

agents. Culturally emerging patterns support these developments by creating a world of wired people and wireless networked gadgets[2] that open up new worlds of human-machine and human-human communication and interaction (Clark, 2003).

4.2.2 The enactive approach to embodied cognition

In this subsection, we now turn to enactive cognitive science, which aims to uncover universal principles of cognition anchored to life, including the role of multiple points of view, such as the one of the human as observer and investigator of cognitive processes. The starting point of enactivists is that cognition necessitates skilful know-how in situated and embodied action. Without reducing cognition to pre-specified problems because cognitive systems supply both, the posing of problems with specified actions as solutions. Enactive advances are inferred from observations in natural sciences, while drawing on neuroscience, psychology, philosophy, phenomenology and especially on theoretical biology.

Enactive key concepts are intentionality and subjectivity which both factor into the overarching principle that cognitive beings are autonomous living systems. The deeper structural and operational mechanism in the understanding of cognitive embodiment is the reciprocal relationship between neural events and conscious activity which ultimately manoeuvres the brain-body-world unity. Life is understood as encompassing the organism, the subjectively lived body in the environment. From the vantage point of cognitive meaning construction, environment is conceptually understood as life-world, or Umwelt.

4.2.2.1 *Phenomenological accounts to complement cognitive understanding of subjective experience*

Enactive cognitive science centres on the lived body in the study of cognition and life. It utilises phenomenology as a way to guide and clarify scientific research on consciousness and subjectivity. Enactive phenomenologists orient themselves by looking at the origins of phenomenology via Husserl and Merleau-Ponty as well as others who understand it as a philosophy of the lived body, using first-person situated methods to investigate subjective experience of mental attitudes towards world, life and experience. The main phenomenological stance is that mental events are actually lived by someone somewhere, which makes the investigation of consciousness and subjectivity compulsory (Thompson, 2007).

Phenomenology presupposes the intentionality of consciousness. Intentionality is not the idea of 'having a sense of purpose' but rather it is a general term to call attention to 'something beyond ourselves' proper to the nature of consciousness. Different types of intentionality are differentiated. Broader views define it as being open to the world, or that which is "other". In a narrow sense, intentionality can also be an object-directed experience, meaning the human is conscious of 'some thing' distinct from self, something that stands in front of it. This object can be a past event remembered, or perceiving an object in physical proximity, or a future event hoped for, or something entirely imagined. But not all intentionality is object oriented. Everyday experiences

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[2]This is evident by the increasing number of technologies that promote telepresence and mobility.

and feelings do not have a clear subject-object structure. They are not "about" an intentional object, but are nevertheless understood as being intentional in the broader sense of phenomenology because in character they are open to the world.

Intentional experiences are specified as mental acts, such as acts of perceiving, remembering, and so on. Mentality is seen as part of life that is temporally extended and dynamically processed through intentional acts. These acts are directed by precognitive habits and responsiveness of the lived body. In short, "intentional acts are performances of a person, a living bodily subject of experience, whose cognitive and affective life is constituted by communal norms, conventions, and historical traditions" (Thompson, 2007, p.24). Therefore intentionality cannot be seen as divorced from mental acts or the intention that leads to the mental act.

Fundamentally, enactive cognitive science is constructed around the understanding that cognitive entities are autonomous systems that reciprocally interact with and are mutually specified by their environment. The dynamic between 'inner' and 'outer' spheres, between systems and environment, is enacted via structural coupling. This dynamic is conceptualised throughout the entire approach and is reconciled by mirroring this rather impartial view with phenomenological personal accounts, providing an "invariant structure of intentional act/intentional object" (Thompson, 2007, p.24).

By comparison, classical cognitivism does not consider dynamics between self and other, it simply disregards intersubjectivity and culture, whereas enactive cognitive science embraces radical embodiment guided by genetic[3] and generative[4] phenomenologies of the lived body. When defining embodiment, enactivists speak of three dimensions which each host an array of subprinciples to which we turn for explanation.

4.2.2.2 *The first dimension: Autopoiesis*

Embodiment engages the cyclic dynamic of bodily self-regulation, entailing organismic functionality and interaction between brain, nervous system, sensors and organs. It also engages the biologically determined affective dimension of organismic regulation which "manifests a range of affective behaviours and feelings typical of mammalian life" (Thompson & Varela, 2001, p.424).

Enactivists have appropriated the Greek words *auto*, meaning 'self', and *poiesis*, meaning 'creation, production' to name their theory *autopoiesis* (Maturana & Varela, 1980). The theory is developed from the starting point of cognition as a biological phenomenon. Here, bodily self-regulation of a cognitive agent, such as a human, has to be seen from the perspective that the agent behaves as a coherent, self-determining unit in its interaction with the environment. This is facilitated by the agent's endogenous and self-organised dynamics that are self-produced and self-maintained enabling him or her to function independently as bound physical unit in the environment. A self-determining unit functions purposefully through identity, which is understood as a process of tangible, coherence-building activity between the organism's components to act in unison on all interactional levels (Varela, 1997). In other words, the cognitive agent is capable of

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[3]Genetic phenomenology analyses how intentional structures and objects emerge through time.

[4]Generative phenomenology considers the life-world as its subject. It delves into the cultural, historical and intersubjective construction of the life-world.

maintaining its physical processes from within itself. It is therefore an autonomous living system.

From the vantage point of Dynamical Systems theory[5], formulating generic characteristics encompasses the understanding that processes are ongoing and continuous, and are not determined by a beginning and an end. These constitutive processes of organisational relations are: (a) recursively dependent on each other for their generation and their realisation as a network; (b) belonging to a system that functions as a unity in the domain they happen to exist in; and (c) construct a domain of possible interactions with the environment (Varela, 1979; Thompson, 2007).

This formula, (points a, b, and c), aims to explain autonomy of minimal living systems by simply illustrating the "bio-logic" of the living cell, the building block of all life on earth (Varela, 1997; Thompson, 2007).[6] Now, if we return to the formula mentioned above and apply it to the cell as a paradigmatic example, then the constitutive processes are chemical; (α) they take place in a metabolic network which (β) also produces its own membrane; and this network comprises a system of unity in the (γ) biochemical domain where it conducts interactions with the environment.

Autopoiesis is underpinned by principles of *organisational* and *operational closure* and *structural coupling*. *Operational closure* pertains to the coherence of the autonomous system's physical processes, such as the neural and chemical descriptions that predicate the operation of the living system. It is this kind of closure that brings forth the "bodily self" of the system. *Organisational closure* relates to the functional and symbolic descriptions that establish closure on the level of the "sensorimotor self", which takes place through interaction (as well as the history thereof) with and perception of the environment assumed by intentional action and behaviour (Thompson, 2007). Moreno and Barandiaran (2004) suggest that both closures are complementary in building an inside-outside dichotomy in living beings (or higher level systems constituted by living beings) that is both constructive and interactive in support of identity and in motivating emergent processes. As for a complex living system such as the human, it is a collection of intersecting and nested autonomous and coupled systems, such as the cellular or nervous system, which bring forth emergent patterns.

Operational and *organisational closure* does not mean that the autonomous system is materially or energetically closed, on the contrary the system is constantly linked through interaction with the environment, which is indicated by the term *structurally coupled*. "Structural coupling refers to the history or recurrent interactions between two or more systems that leads to a structural congruence between them" (Maturana & Varela, 1987; Thompson, 2007). Furthermore, "two or more systems are coupled when the conduct of each is a function of the conduct of the other" and "the state changes of the an autonomous system result for its operational closure and structural coupling" (Thompson, 2007, p.45). The result of any state change perpetuates continued self-organised activity within the system unless the system's closure is disrupted. Examples of these kinds of 'scalable' autonomous systems are a single cell, the nervous system, or an ecosystem.

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[5]Dynamical Systems theory plays a role in the understanding that natural cognition is a dynamic phenomenon and therefore needs to be understood from science of dynamic systems (Thompson, 2007). Extensive treatment of this theory is beyond the scope of this chapter.

[6]Thompson further states that for a system to qualify as autonomous it does not strictly have to be autopoietic. In other words, autonomous systems that are also living systems follow autopoietic principles.

Ruiz-Mirazo and Moreno (2004), who are researchers in enactive cognitive science, have interpreted autonomy in living systems as "self-construction", focussing their perspective through the framework of thermodynamics, which centres on managing flow of matter and energy. To elaborate this approach is beyond the scope of this chapter, nevertheless we would like to point out that there are multiple perspectives in the interpretation of these principles. In chapter five, we shall use these concepts as the foundation of our qualitative analysis where we set up the lens as "network of creative interactions".

It has to be kept in mind that the concept of autonomy is part of a heuristic framework, a cognitive aid, implicating the interpretative and explanatory position of the observer. Significant systemic indicators for autonomy are read as context-dependent and interest-relative. It is possible to shift perspectives and characterise a system, for example the nervous system, as heteronomous (not autonomous or self-governed) but then this no longer describes the same system because here the system is now the larger system of "organism-plus-environment". This heteronomous perspective of the nervous system no longer characterises the nervous system "as a finite cellular or multicellular entity" (Thompson, 2007, p.51).

4.2.2.3   The first dimension: Agency, meaning construction & observer

Defining *agency* is notoriously difficult, though essential when conducting investigations into cognition that are beyond minimal autonomous systems. General definitions of agency centre on ideas such as a subjective viewpoint and the capacity for self-maintenance in interactions with the environment. From the biological perspective this indicates the organisation of a system that actively separates itself from the environment to maintain itself, and therefore has a modifying effect on the environment. From the enactive perspective, the active separation of the agent from the environment is seen to be constitutive of adaptive processes that create internal conditions, and an "organizational asymmetry between the inside and the outside domains" (Moreno & Etxeberria, 2005, p.164).

Recently Moreno and Etxeberria (2005) illustrated how systemic organisation is linked to *agency*. In minimal autonomous systems, the distinction between life and cognition is conceptual because biologically speaking, the metabolic self-construction and adaptation to the environment are based on the same mechanism. More complex organisms include a physical addition to their living system, the development of a motile device as the organism's ability to move by its own means via fast directional movements to pursue preferred self-maintenance conditions. For example, the bacteria move through the sucrose gradient assisted by the rotary movements of the flagella. Self-maintaining processes of an agent entail adaptive action and interaction on the agent's part in conjunction with the environment through the function of motility, which is connected to the level of organismic complexity. When an organism, adapted via motility, evolves and increases in body size, this increase presents more complexity to the internal organisation and means of interaction. At some point the organism's metabolic organisation, which manages resources needed for material and energetic self-maintenance can no longer operative cost-effectively to provide the structural support and the sensorimotor coordination that drive highly-evolved, complex motile devices. Nature solved this problem by forming neurons and the development of the nervous sys-

tem to coordinate sensorimotor behaviour. In terms of cognitive processes, the nervous system acquired a "structural correlate" in parallel to the biological structural processes.

In brief, it was the origin and subsequent development of the nervous system, together with the process of encephalization that led to more complex forms of organismic organisation and interaction, eventually leading to new cognitive phenomena such as emotions and awareness. Neural activity that directed sensorimotor controlled behaviour through emotions and a sense of self formed the basis of mind. The mind's function supported a new form of *agency* through anticipated (versus reactive) control of sensorimotor behaviour. Fostered by sensorimotor systems, these developments influenced perception of the environment, which is here considered the Umwelt because it affords sophisticated possibilities of activities and experiences.

Enactivists appropriate a body of research evidence from neuroscience to conclude that information in natural living systems is processed in a context-dependent fashion. Meaning is brought forth from structurally coupled networks in a specific domain, it is relative to the point of view of self-construction through interaction with the environment. *Meaning construction* is the mechanism where stimuli of direct and indirect relevance trigger processes accommodating assimilation into the living system's current meaning structure, effectively through adaptive agency, compensating new correlations with old ones (Di Paolo, 2005).

When investigating *meaning construction*, there are important considerations to be made about the nature of stimuli and the agent interacting with it. Imagine an animal interacting with a stimulus in the environment and a human as an *observer* of this interaction. In the situation where animal and human encounter the same stimuli *meaning construction* is determined by what meaning the object or stimuli has for the animal, which cannot be intrinsically determined as the object's feature from the observer's perspective, because the *observer* stands independently from the animal as its own structurally coupled network. In other words, the *observer* produces his or her own neural responses based on environmental stimuli and so does the animal, therefore both creating different instances of perception. This notion of coupling proceeds down to the neural level, where no individual neuron is able to detect objectively defined features of stimuli. It is through assemblies of neurons that "make sense of stimulation by constructing meaning, and this meaning arises as a function of how the brain's endogenous and nonlinear activity compensates for sensory perturbations" (Thompson, 2007, p.53). Therefore, information is conceived and formed through specified dynamics, making a difference to the participating and conceiving living system. The process of sense-making is emergent. It is not privy to the individual agent nor the environment, it is central to the relational domain and the dynamics of the agent and the environment (Di Paolo, in Press).

The enactive position on the concept of the *observer* is that subject-independent and objective knowledge is impossible. Maturana (1978, p.31) explains:

> An observer is a human being, a person, a living system who can make distinctions and specify that which he or she distinguishes as a unity ... and is able to operate as if he or she were external to (distinct from) the circumstances in which the observer finds himself or herself. Everything said is said by an observer to another observer, who can be himself or herself.

This leads to the question of how do living systems understand each other, if not by creating and sharing objectively tangible information? To answer, *observers* generate distinctions in a consensual domain conjointly with others through structural coupling. Every observer speaks from the starting point which references his or her cultural background and experiences that he or she has lived through. Therefore any knowledge that is being conveyed or imparted is a form of interpretation depending on this starting point. However, Maturana makes it clear that these interpretations are emergent and situated constituting the consensual domain, they are neither particular to the individual nor independent of the individual, and they are also not reducible to the agent's physical structure or interactional structure. For example, language as a consensual domain, forms behaviour that is mutually shaped and directed, it is not a pre-specified collection of semantics. Maturana (p.50) states:

> The basic function of language as a system of orienting behaviour is not the transmission of information or the description of an independent universe about which we can talk, but the creation of a consensual domain of behaviour between linguistically interacting systems through the development of a cooperative domain of interactions.

4.2.2.4 The first dimension: Identity, sense-making & adaptive agency

Identity and *sense-making* are conceptually related to agency, which we just discussed in the previous subsection. Though at first *identity* and *sense-making* were not considered primary characteristics of autonomous minimal living systems. From the position that an autopoietic organism is inherently teleological, the notion of purposiveness[7] opened up *identity* and *sense-making* as complementary and refining specifications of the autopoietic theory were included (Varela, 1991; Thompson, 2007). *Identity* in an autopoietic system pertains to the production and maintenance of an organismic unity in the presence of change, for example a chemical change, whereby *sense-making* pertains to the system making sense of the Umwelt so as to remain viable. *Sense-making* translates the physical and chemical coupling with the environment into the organismic world of meaning, significance and valency. According to Varela, *sense-making* is intentionality in its minimal and original biological form (Varela, 1991; Thompson, 2007). In summary, the formulated approach to *identity* and *sense-making* states that: (1) an organism is fundamentally a self-affirming, identity-producing process based on autopoiesis; and (2) a self-affirming identity establishes logically and operationally the reference point or perspective for sense-making and a domain of interactions.

Adaptive agency describes an agent's adaptive action when coping with self-conservation, where the system has to move past passive activities of homeostasis, and actively pursue its goals through the capacity to regulate its structural coupling with the environment within the framework of the system's own viability (Di Paolo, 2005). This capacity endows the agent with adaptive qualities as part of the sense-making process, which is practically implemented through self-monitoring, control of internal regulation and control of external exchanges.

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[7]Varela defines it as immanent purposiveness to indicate it is neither an intrinsic property nor a property outside of the system.

4.2.2.5   The second dimension: Sensorimotor control

This dimension is centred on cyclic dynamics of sensorimotor control that enable the agent to couple with the environment through perception and movement, engendering the organism as a situated agent. From the biological perspective, the organism's nervous system connects the sense organs and other sensing nerve endings with the body's effectors such as muscles and glands, creating the unified autonomous sensorimotor system. This creates a cyclic dynamic which is mutually inclusive. It depends on what the agent senses, which will determine how the agent moves, and how the agent moves determines what the agent senses. Thus, operational closure performed on the level of the nervous system brings about sensorimotor agency (Varela, 1997). Because the nervous system is decoupled from the local metabolic constraints, it creates a dynamic domain through sensorimotor agency.

Particular to the development of a sophisticated nervous system in large multicelluar living systems, agency extends dynamically resulting in broader forms of behaviour. Barandiaran and Moreno (2008) explain that the nervous system through electrochemical functioning has its own self-organisation and interactive processes which, although bound by inner structures, body signals, and environment, provide a dynamic domain with open-ended potentialities for interaction with the environment. "It is precisely the open-ended capacity of this high-dimensional domain that opens the door to spatial and temporal self-organization in neural dynamics and generates an extremely rich dynamic domain mediating the interactive cycle, overcoming some limitations of previous sensorimotor control systems" (p.14). Typical, manifested examples of these dynamics are habits, which are composed of aspects of the nervous system, the physiological and structural systems of the body and environmental processes and behavioural patterns (Di Paolo, 2003).

Researchers who are pursuing the dynamic sensorimotor approach have developed strategies to establish an account of the typical properties of sensorimotor experience. This approach has been called enactive perception (Noë, 2004) but is not part of the enactive cognitive science perspective we put forth in this section. While enactive perception has been acknowledged as valuable, the reason for omission from enactive cognitive science and therefore also from this thesis, is that it currently does not incorporate the notion of autonomy and dependent principles such as agency and identity. Perceptual experience is derived from sensorimotor knowledge, which implies an agent or a 'self' embodying knowledge as self-organised and self-sustained entity. Subjectivity lies in the character of first-person experience but does not figure into this sensorimotor account, instead it focusses on a person's conscious reception of intentional objects of perceptual experience (Thompson, 2007).

In the second dimension of embodiment neural activity underpins and sustains (operational and organisational) closure on the level of neurocognitive identity. Through this level of identity, bodycentric relations are intentionally formed between agent and world. The things in the world offer affordances (Gibson, 1979) and strategies for coupling through the agent's sensorimotor capacities and the ongoing parallel functioning of perceptuo-motor systems. Through the body image, the body itself can be experienced as an intentional object by placing conscious awareness at particular parts or areas of the body. The body image of oneself is separate from the concept of

the body schema, which functions in a non-conscious manner navigating and organising dynamic sensorimotor processes that are responsible for perception and action (Gallagher, 2005b, 2005a). Thompson (2007) points out that this distinction between body image and body schema is another problematic issue from the perspective of enactive cognition because it eschews a fundamental form of bodily experience, the pre-reflective bodily self-consciousness. This is the implicit and predominant bodily consciousness that humans experience most of the time. It is at this level of embodiment where the body-body problem comes into play, asking how to reconcile the relationship between the objectively living body in the world, and the subjectively lived body through the sense of self (Hanna & Thompson, 2003).

4.2.2.6   *The third dimension: Intersubjectivity*

The third dimension concerns itself with dynamics of affective states and sensorimotor coupling in the realms of social cognition of complex cognitive living systems, such as apes and humans. Enactive emotion is part of the continuous flow of experience that encompasses the entire organism, and mobilises and coordinates the organism's various biological and perceptual dynamics. On a biological level this includes the entire neuroaxis of the brain stem, the limbic areas, the superior cortex, the visceral and motor processes as well as the psychosomatic networks of molecular communication that are the nervous system, the immune system and endocrine system as taking part in emotional states (Thompson, 2007).

Enactivists have identified five distinct loops in mapping the large neurodynamics of emotional states. These circular loops are comprised of brain, body and environment. They are centred in the limbic system of the brain which is predominately associated with emotion. Emotion, intention and consciousness arise from these loops and are embodied in their self-organising dynamics. An in-depth treatment of the enactive view on emotion is beyond the scope of this chapter. It suffices to remark that the enactive approach is consistent by looking at emotion as an autonomous system with operational and organisational closure. Emotion is considered a feature in the action-perception cycle, mostly via non-conscious brain and body states. As such it is endogenously initiated and outwardly directed through behaviour and, like perception, it is dependent on intentional action.

A person's individual subjectivity includes an innate understanding of intersubjectivity. In fact individual subjectivity is part of the structure of intersubjectivity. Intersubjectivity, involving forms of empathy, is an important theme in psychology and phenomenology, and enactivists also reference Husserl and Stein to create an enactive view on empathy (cf. Leask, 2002, for a discussion on Husserl's and Stein's views on empathy). There are two main enactive concepts when discussing intersubjectivity. They are that self and other enact each other reciprocally through empathy, and that subjectivity is a developmental process of enculturation which is "configured by the distributed cognitive web of symbolic culture" (Thompson, 2007, p.383).

Phenomenologically speaking, intersubjectivity is considered an open phenomenon because the world is disclosed to us as intersubjectively accessible. In other words, intersubjective openness is a structural feature of consciousness. This disclosure occurs because the intentional structure of perception imparts the things of the world "as transcending one's individual consciousness

of them in such a way as to imply their presence to and perceptibility by other possible subjects"
(Thompson, 2007, p.385). Traditionally, one strand of intersubjectivity considers self and other
through bodily presence while the another looks at the generative intersubjectivity of collectively
passed on norms, conventions and traditions. Unlike traditional phenomenologists and particular
to enactivists, is the understanding that intersubjective openness of consciousness is non-reducible
to specific relations because intersubjective openness is part of the structure of subjectivity which
is already present prior to an encounter with an other.

Another distinction has to be made regarding empathy. Enactivists pursue empathy from the
phenomenological standpoint, rather than the psychological one. Empathy is understood as om-
nipresent, a unique form of intentionality, directing the self toward the other's experience. While
empathy shares some structural features with perception and other structural features with mem-
ory, imagination and expectation, it cannot be reduced to intentional acts or constructed from them.
From the phenomenological perspective, the other is experienced as an intentional being whose
bodily presence via gestures and actions articulate the being's experience or state of mind. The
task of phenomenology is to analyse the modus operandus of the other's disclosure as another's
subjectivity, whereby this disclosure is enabled by intentional structures of consciousness. For
these afore-mentioned reasons, enactivists analyse empathy on its own terms.

4.2.2.7 The third dimension: Types of empathy

The enactive view puts forth four distinguishable empathetic processes (Depraz, 2001; Thompson,
2001, 2005, quoted in Thompson, 2007):

> (1) The passive or involuntary coupling or pairing of my living body with your living
> body in perception and action; (2) The imaginary movement or transposition of my-
> self into your place; (3) The understanding of you as an other to me, and of me as an
> other to you; (4) the moral perception of you as a person.

The first type of empathy relates to dynamic coupling with an other on the basis of bodily simi-
larities. This is not due to visual appearance but rather to the understanding and experience that
the other is fundamentally a living bodily subject like oneself. Neuroscience has been able to
show that this dynamic coupling is beyond the perception of action which activates processes of
perceptual recognition for a particular action. It has shown that dynamic coupling goes much fur-
ther by generating appropriate motor processes. Inducing neural responses for appropriate motor
processes has been observed with mirror neurons[8] in the premotor cortex of monkeys and humans
(Di Pellegrino et al., 1992; Iacoboni et al., 1999; Buccino et al., 2001). Neuron mirroring and res-
onance in motor systems demonstrate that perception and action are co-constituted in intentional
agency (Hurely, 1998). Thompson further shows that these concepts are not unique to sensori-
motor capacities, but that research has been conducted demonstrating that emotive and affective
coupling are equally adapted to mirroring and resonance.

The second type of empathy is achieved when one being can mentally take up the other's
perspective by putting themselves in the place of the other in imagination. In humans, cognitive

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[8]Mirror neurons were already discussed in the embodied-embedded approach to cognition

empathy begins to develop in infants (9-12 months) as part of the group of cognitive structures in joint attention (Tomasello, 1999). The infant begins to understand that the other is an intentional agent like the self. Cognitive empathy is more active than the first type of empathy and seemingly only fully developed in humans.

In the third type, empathy moves from imagining the other to empathically understanding the other. From the developmental perspective, this is indicated when the child has learned to participate in joint attentional situations, where social interactions take place between adult and child and both are attending to a third object together. Joint attention is the premise which further leads to language acquisition and symbolic representation. It describes the human ability to monitor the intentional acts of self and others. This type of empathy has also been called *reiterated empathy*. When engaging in *reiterated empathy* one can transpose the self to the perspective of another, which allows the self to grasp that it is "one individual participant in an intersubjective world" (Thompson, 2007, p.399). Also, *reiterated empathy* can be seen as "the experience of oneself as an other for the other - one can gain a nonegocentric and intersubjective view of one's own lived body as an individual intentional agent in a public world" (p.401). We discuss this type of empathy further in chapter seven.

The fourth type of empathy embraces the concept that intentional beings deserve respect which is expressed by understanding an other's beliefs, desires and plans. Rather than being imposed through rules by adults, this occurs on developmental terms. The child acquires this empathetic ability at the same time as it begins to view others as mental agents (Tomasello, 1999).

After having introduced the formal structures of embodied empathetic experience, it is important to note that these types of empathy delineate only aspects of intersubjective experience. All types of empathy occur through reciprocal and face-to-face couplings between self and other via non-linear recursive dynamics which are enmeshed with perception, language, action, emotion and imagination of the lived body. From the greater perspective, intersubjective experience extends into realms of culture, history and the life-world. It is part of the fabric of human mentality from beginning to end. Culture, for example, shapes our human mind and cognitive abilities through symbolic representations. Without culture the human experience is incomprehensible.

In the beginning of this section, the enactive view was introduced as identifying individual subjectivity in the structure of intersubjectivity. To understand how intersubjectivity is steeped in culture Thompson (2007) draws on Tomasello's (1999) and Donald's (2001) work to develop the concept of *enculturation* which describes culture as a constitutive element in the human cognitive architecture. Both Tomasello (1999) and Donald (2001) view joint attention as a cluster of cognitive structures instrumental in the phylogenic, ontogenic and historical development of the human culture of symbolic representation. In joint attention, language acquisition involves the multiperspectival character of language communication, meaning humans can take many different perspectives on things when engaged in the communicative process. Through joint attention dynamics humans internalise, via imitative and cultural learning, the communicated intentions and perspectives of others into symbolic representation (Tomasello, 1999). According to Tomasello (1999) linguistic communication is a form of transmission of cultural knowledge. It influences the

construction of cognitive categories, relations, analogies and metaphors. Children learn through linguistic interactions. They learn to take different conceptual perspectives, including a perspective of their own perspective from the viewpoint of the other.

However, the evolution of intersubjectivity and human cognitive development from the enactive view differs from both Tomasello's (1999) and Donald's (2001) view. Enactivists rely on Developmental Systems Theory (DTS) (Oyama, 2000) when explaining the developmental process of the cognitive domain. Regarding biological evolution, Developmental Systems theorist reject dichotomous accounts such as nature versus culture, or innate versus acquired. In cycles of development, all resources or generative processes, such as genes, cellular machinery, phenotypic traits, behaviour, and social environments count equally although in particular situations certain resources will take centre stage. In DTS "information" is central to developmentalisation whereby here also multiple mechanisms are involved and responsible for transfer.

Thompson (2007) recalls that Tomasello (1999) and Donald (2001) "see phylogeny as equivalent to biological evolution, as opposed to cumulative cultural evolution, which happens over historical and ontogenetic time on the basis of the biological adaptions of the human primate species" (p.410) - and this division takes things back to dichotomous accounts. By contrast, enactivists see "evolution as the evolution of developmental systems; human evolution includes the evolution of a new stage of development, namely, childhood, which is linked to a new form of social cognition; and this new form of social cognition crucially depends on the generative and generational processes of human culture" (p.411).

4.2.3   Conclusion

This completes the introduction to the embodied-embedded approach and enactive cognitive science to impart a guiding outlook throughout this thesis. We aimed to present a broad spread of themes with claims that are relevant for this thesis, and for this reason this review is not comprehensive but rather selective. The themes we have touched upon in enactive cognitive science will be used to focus the analysis in chapter five. In chapter seven, we shall pick up the themes mentioned in both approaches, in reference to the discussion of our research findings, and further build on these themes by supplementing empirical research evidence from embodied cognition with the support of our findings.

The embodied-embedded (and also extended mind) approach utilises research evidence from a variety of sources, which are subsequently conceptualised as part of this thesis. These concepts are centred on the body-based human with higher-level cognitive strategies that support sensing, learning and thought while extending these into the wider world. For this thesis' focus the selected and presented principles have pinpointed bodily activity which comprise perceptual and motor capacities that are involved in inextricable tangles of feedback, feed-forward, and feed-around loops[9]. The embodied-embedded approach talks about boundaries of brain, body and world while heeding to the ongoing cultural evolution of tools that seamlessly navigate these boundaries. From

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[9]This particular wording: "feedback, feed-forward and feed-around loops" has been appropriated from the extended mind approach.

this perspective, this use of digital technologies in creation of participatory interactions with Sim-Suite situates the installation at the heart of the embodied-embedded approach where Sim-suite participants skirt the boundaries of brain, body and world through creative engagement.

The enactive approach to embodied cognition starts 'thesis building' from a central point in theoretical biology with the aim to accommodate a systematic development of enactive principles to expound the cognitive existence of all embodied living entities. Research evidence from other disciplines is instrumental in administering the translation of theoretical constructs with real-world implications. Especially contributions from neuroscience and biology as well as a phenomenological point of view stimulate the development of the enactive approach to cognition in understanding higher-level cognitive processes. In enactive cognitive science principles are interlaced and constitutive which is less optimal for our purposes, for extracting basic principles pertinent for analysis of creative behaviour. We therefore concentrated on the introduction of the basic level of enactive principles. The enactive outlook sees cognition as a systematic process that unfolds over time, which makes this particular approach adequate to anchor Sim-Suite's collaborative creative process in this part of the lens. We do so by focussing on the unfolding relational dynamics that are essential to artistic creation as we expound in the next chapter.

We now leave this theoretical lens and turn to methodologies used in the analysis of Sim-Suite's creative process and creative participation.

4.3 Methodologies

4.3.1 Approaching creative process continuum via mixed methods

This thesis investigates the creative process continuum, comprised of creative conception via creative construction and production of the artwork Sim-Suite, and creative public participation taking place through physical engagement with Sim-Suite. As previously established in chapter two, the creative process operates through mental operations that appropriate extant knowledge structures. Current developments in cognitive research have brought forth understandings of cognition as being embodied, incorporating the physical as thinking and acting in the world. This has been discussed in detail in the theoretical lens of this chapter. These considerations are setting the stage for decisions on methodologies.

Choices of methodology in research investigations are determined by how they best support research goals and context (Gorard & Taylor, 2004). This thesis' main context is composed of aspects in authentic real-world endeavours as they occur in the wild. From the perspective of studying creative behaviour, guidance for choice of methodology must focus on the study of process, and at the same time uphold the importance of differing investigative circumstances as lived experience, part and parcel of the embodied cognition paradigm. These considerations have led to a mixed method approach incorporating qualitative and quantitative methodologies.

A second consideration of this thesis' research methodology is its positioning in greater context of creativity and embodied cognition. As far as the author is aware, this thesis is opening up new territory by bringing the current perspective on embodied cognition to creativity research, which also means acknowledging vaguely defined boundaries between creative cognition and em-

bodied cognition due to inherent constraints. Creative cognition is mostly laboratory tested, divorced from real-life settings, and embodied cognition is mostly advocated philosophically, drawing on established research results from a number of disciplines. Embodied cognition research informs computational approaches in the study of cognition, such as artificial life. It is therefore equally disconnected from real-life social phenomena.

This thesis may contribute to initial investigations of the "how" and "why" under real-world conditions. With these as well as afore-mentioned criteria in mind, the thesis' overall research strategy is that of a case study (Yin, 1994; Flyvbjerg, 2006). According to Yin (1994, p.13) an empirical inquiry that investigates a contemporary phenomenon in a real-life context where phenomenon and context are not easily distinguishable qualifies as the main justification for using case study as research strategy. The nature of this single case as research strategy relinquishes the interactive artwork from its central position to a supportive one, facilitating the study of embodied cognitive traits in creativity. This is defined as instrumental case study (Stake, 1995, p.4).

This thesis' case study utilises a mixed method strategy. It takes on the standpoint of researchers in psychology and social science, who intend to close the qualitative-quantitative divide in research methodology (Gray & Densten, 1998; Bryman, 1988; Creswell, 2009; Gorard & Taylor, 2004; Brannen, 1992; Todd, Nerlich, & McKeown, 2004). From this standpoint it is our aim to decide upon the most appropriate methodology by considering all methods to be equal yet suitable for different purposes. A mixed method approach may also be seen as addressing the creative process continuum from the point of triangulation. In psychology, triangulation is understood as utilising two methods, datasets, investigators or theories (Todd et al., 2004). Conducting research into the creative process continuum with two methods, each with their own data set, we are forging multiple perspectives on the continuum with converging results. Todd et al. (2004, p.8) further states that triangulation, given the right choice of methods with different strengths and weaknesses, yielding similar results "increases our confidence that those results are a true representation of what is going on".

Brannen (1992) points out that in social science the macro-micro structure of understanding society cannot be resolved by analysis with the same method, as it requires different levels of inquiry. Studying cognitive traits of creative behaviour, one is similarly faced with issues of versatility and broadness intrinsic to creativity and the respective structural macro-micro processes of creative undertakings. In this thesis the creative conception, construction and production of Sim-Suite spanning several months, involving three collaborators, a variety of locations and materials, are the overall characteristics of macro structure. It is juxtaposed with the artwork's in-the-seconds creative participation by the public as the micro-level representative of creative process continuum.

In this thesis, we are using qualitative methodology to explore creative macro-level and quantitative methodology to examine creative micro-level. Qualitative analysis is conducted with all three team members who conceived, constructed and produced Sim-Suite. In chapter three we gave background to team members and their involvement with the project. We conducted three dialogic reflection sessions in the tradition of reflective practice (Schön, 1983) and analysed data in text form informed by Grounded Theory (Glaser & Strauss, 1967; A. Strauss & Corbin, 1990).

Both investigations were conducted in sequence and independent of each other just as they are laid out in this thesis. We first conducted the study on the collaborative creative process with Sim-Suite's team members which we analysed using qualitative analysis, we then conducted the study on Sim-Suite's participants, analysing the results via quantitative analysis.

Quantitative analysis was conducted with numeric values from sensor technologies deployed underneath participants' wobble-boards. These sensors translate minute movements by participants and render them into graphical representations on the virtual game-board, enabling participants to navigate Sim-Suite's game. Raw sensor values are captured in Sim-Suite's logfile which records all events in the game on a millisecond time scale. Information in Sim-Suite's logfile formed the basis for statistical analysis. In a succeeding section we explain how we transformed sensor values into variables for measuring behaviour. First, we turn to the next section for more details on this thesis' qualitative analysis.

4.3.2   Methodological background to Sim-Suite's qualitative analysis

Qualitative analysis has expanded from the social sciences into some branches of psychology. During the 1980's, the understanding of creativity broadened, recognising creativity's relationship with social elements defined by people, environment and culture. This has provided creativity research with an influx of researchers who qualitatively appraise creative behaviour, and are also working from the scientific standpoint that creative thought appropriates extant knowledge structures. Qualitative methods contribute to an epistemological perspective of creative thinking and behaviour where cultural and social aspects of a particular situation become part of knowledge construction.

In chapter two we briefly mentioned researchers who use cultural status as an indicator for creative behaviour. Their approach is also qualitative and focusses on case study methods with historical records of and by artists and scientists. The reasoning underlying case study methods is demonstrated by Gruber and Davis (1988, p.246) stating that "the merit of the case study method lies in its ability to consider a larger number of issues together and in their relationships". Although case study methods contextualise famous artists' and scientists' social lives, these researchers belong to a separate branch from the one we are concentrating on because they do not recognise creative cognition operating from within the spectrum of extant knowledge structures.

More specifically, this thesis affiliates with researchers who focus on artistic creative processes in terms of qualitative appraisal. Cawelti et al. (1992) conducted an empirical study into creative processes of five artists: a painter, a poet, a sculptor, a novelist and a photographer. The study design included questionnaires and discussions in conjunction with the Interpretive Structural Modeling technique, a nominal group technique used in socioeconomic disciplines to understand complex situations and facilitate decision-making. Doyle (1998) interviewed five science-fiction writers and applied to the mutual findings theoretical concepts from psychology, phenomenology and literary theory to construct a tentative modal account. D. T. Marsh and Vollmer (1991) studied creative processes of twenty-five artists via interviews and questionnaires. They produced a descriptive analysis with insights pertaining to internal and external dimensions of these artists.

The closest related examples to this thesis' methodological approach with Grounded Theory are two studies by Mace (1997) and Mace and Ward (2002). In the first study, a multivariate approach addresses fourteen visual artists' activities, beliefs and perceptions via semi-structured interviews, which are analysed using Grounded Theory. The second study inquires about art-making processes of sixteen visual artists which were first modelled and then verified by an additional study of nine artist's creative processes. Data collection via interviews took place over the duration of the making of an artwork, and Grounded Theory was used for analysis and creative process model preparation.

This thesis' research is grounded in an authentic situation of art-making. Team members who constructed the installation artwork Sim-Suite were genuinely engaged throughout the entirety of the project. Only once Sim-Suite had been erected, programmed, finalised and exhibited was the question of analysis raised and dealt with. The reasoning behind this approach to authenticity entails preservation of unmistakable real-life events experienced by three people as they occurred in the wild with ensuing contingencies. It also made for authentic interaction without compromising the process' accuracy. Similar to other creativity researchers mentioned above, a method to recollect and look back onto transpired events is required for this thesis' data collection. In choosing a method we aim to maintain this thesis' exploratory focus and orientation towards embodiment throughout investigations. By doing so we lean on the enactive approach to embodied cognition which uses phenomenological accounts in the investigation of subjective experience. The practice of phenomenology builds on self-reflection, and we similarly draw on Schön's (1983, 1987) concept of reflective practice for data collection and for analysis we opt for Grounded Theory by A. Strauss and Corbin (1990). In the next section we render an account of this thesis' qualitative analysis in more detail.

4.3.2.1 Data collection by collective reflection

Schön (1983, 1987) draws on concepts by a number of researchers such as Kuhn, Alexander and Polanyi[10] in conjunction with his own investigative studies to formulate the approach of reflective practice. Central to this approach is comprehension of applied and tacit knowledge by professional practitioners - how these professionals attain and build on practical knowledge in the process of practice. While developing concepts, models and techniques for the reflective practitioner approach he observed professional psychotherapists, architects, teachers, as well as professionals in management, engineering and general science-based practice. Since the inception of this approach, it has propagated throughout professional and academic communities and is predominantly supported by nursing, teaching and learning professions.

Related to Schön's explorations of professionals in design and architecture, recent academic developments have brought reflective practice to creativity, design and creative process supporting computer applications. Johnson and Carruthers (2006) closely link understanding of creative process and *reflection-in-action* dynamics. They explore the creative processes of individuals and groups, comparing traditional design media, pen and paper, with computer supported media while analysing participants' creative processes from the perspective of *reflection-in-action*. Loke and

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[10]Elaborating these influences in more detail is beyond the scope of this chapter.

Robertson (2009) designed a video-based interactive artwork with motion-sensing technology using a human-centred design approach with personas and scenarios. Designing interactions based on human movement, researchers integrate *reflection-in-action* with experimental design methods. Hendry (2008) proposes a framework encouraging creative engagement by users in design and development of open source technologies via email, mailing lists, bug trackers and usage monitoring to raise interactions between users and service centre staff. Applying his framework to a social bookmarking site, he notes how reflective conversations were sustained on a mailing list by many-to-many interactions. Fischer et al. (2005) investigate and model support of social creativity promoting distributed cognition. Acknowledging that creativity leads to interactional processes occurring in relationship with others, the researchers propose association of reflective practitioner dynamics as a way to sustain these relationships and build creative communities. Closest related to this thesis' use of the reflective practitioner approach is a study by Ishii and Miwa (2005) that applies reflective activities after the process of creation. Situated in an educational environment, the researchers ask participants to produce designs with Lego's Mindstorms robotics consumer kit. After task completion, the researchers motivate participants to reflect upon idea generation and production of designs.

The afore-mentioned examples of research activities articulate notions of reflective practice which commonly utilise *reflection-in-action* dynamics. Schön posits that we act spontaneously without premeditated thought or planning. This is not to say that we never think before acting, but we reveal in spontaneous behaviour of skilful practice that knowledge is tacit and implicit in patterns of action. Properties of knowing are actions, recognitions and judgements which have become embodied in our performance without conscious thought. Prior to internalisation of tacit knowledge we may or may not have been aware of the process of how we arrived at *knowing-in-action*.

Reflection-in-action occurs when we perform *knowing-in-action* and the results are unexpected, at which stage we incorporate *reflection-in-action*. If results lead to surprises, good or bad, we tend to reflect to manage interactively the outcome of action, the action itself and intuitive knowing implicit in action. Professionals also encounter unique cases as part of their practice. Unique and uncertain cases are situation specific. They do not offer cues for standard application of techniques. In these situations, solutions are found through identification of particular features via *reflection-in-action*.

Structurally speaking, *reflection-in-action* reframes a problem to reshape the situation. From a reframed problem, the practitioner experiments to uncover consequences and implications of having reframed the problem. Through acts of engagement, discovery of consequences, implications or by appreciation, and further acts of engagement, the situation is being adapted to the frame. Evaluation of frame experimentation is linked to the practitioner's value system. Overall, individual acts of engagement cause new phenomena to be understood, more problems to be solved or previously unknown opportunities. Also, the practitioner's acts of engagement produce unintended changes, giving new meanings to the situation, or as Schön explains, the situation "talks back". The practitioner reflects on back-talk, evaluating its potentials for coherence and

congruence and reframes the situation, commencing the cycle over again.

Adding to this structure of *reflection-in-action* is the integration of past experiences. Although the practitioner perceives a situation as a unique case, it is dealt with by seeing it as part of an existing domain-specific repertoire of previous experiences made up of images, understandings and actions. Seeing a unique case as already present in the repertoire does not mean immediate association with familiar categories or rules. Instead, initial reflection suspends the situation, placing it under the banner of 'similar and different' for further inquiry. Seeing elements of a unique case as part of the repertoire with new possibilities for action can only be judged as adequate and useful in the action itself. In this process, pointers to previous experiences are discovered and enacted without conscious articulation.

This brief outline of *reflection-in-action* makes several relevant points to this thesis' research. The starting point and structural process of *reflection-in-action* acknowledges the physical expression of the practitioner as functional unit of thought and action, which we consider to be convergent with Clark and Chalmer's (1998) view on embodied cognition. Earlier we noted that *reflection-in-action* arises from *knowing-in-action*, meaning the practitioner has professional knowledge, such as theoretical concepts conveyed through linguist terminology and professional tool usage - through these the practitioner's cognitive routines are actively extended into the environment and become the constituents for *reflection-in-action* when the practitioner encounters an unfamiliar situation and seeks to solve the case on the basis of what is known.

From the perspective of reflective practice, the process of reflection is problem-centric which is in line with the scientific definition of creative behaviour as a form of problem-solving. Structural steps of *reflection-in-action* described above are comparable with the collaborative creative undertaking producing Sim-Suite where only the thematic selection of group interaction and full body human movement was deliberated without any further planning of outcome. For Sim-Suite team members, who are also professional practitioners in their respective fields, embarking on Sim-Suite presented a unique case encounter. The reason for this is that Sim-Suite is an innovation in combining materials and forms of interactions, which none of the team members had explored previously. By and large Sim-Suite's collaborative creative process matches an alternate cycle of framing the situation and reflecting in action via group discussion with situational back-talk throughout the creative process until completion of the artwork. This is demonstrated in the findings explained in chapter five.

Schön elaborates further that *knowing-in-practice* naturally entails a period when practitioners look back on action to learn from action patterns in their context. According to Schön (1983, p.61) "in the relative tranquility of a postmortem, they think back on a project they have undertaken, a situation they have lived through, and they explore the understandings they brought to their handling of the case". Throughout collaborations on Sim-Suite, practitioners reflected back in discussion sporadically, for example when travelling together to and from workshop or studio. Schön further writes that the practitioner "may also reflect on practice while they are in the midst of it. Here they reflect-in-action, but the meaning of this term needs now to be considered in terms of the complexity of knowing-in-practice".

Table 4.1: Questions guiding dialogic reflection session.

<div align="center">

dialogic reflection questions

aspects of collaborating together	idea generation process
How did we start and end the project?	How did we generate ideas?
How did we communicate throughout the project?	How did we make sense of ideas?
How did we help each other when working together?	How did we finalise ideas?
What role did other people play?	How did we implement ideas?
How did our working location affect collaboration?	What was the role of materials?

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Researchers in the teaching profession distinguish between "productive reflection-on-action" and "unproductive reflection-on-action", whereby the former indicates an analysis of reflection results (Davis, 2003, 2006). Through an extensive research body, the teaching community has advanced reflective practice to a finer level of detail. Specifically, *dialogic reflection* has been described as a more defined level to *reflection-on-action* which is "deliberative, cognitive" and "narrative". It is a stepping back from events, a mulling over, and exploring of experience and events in an analytical fashion (Hatton & Smith, 1995). *Dialogic reflection* is used by a number of researchers (Davis, 2003, 2006; Hatton & Smith, 1995; Jay & Johnson, 2002; Lee, 2005; Manouchehri, 2002; J. R. Ward & McCotter, 2004). It constitutes a written dialogue with self or a collaborative and shared oral dialogue (Nilsson, Fältholm, & Abrahamsson, 2010; Glazer, Abbott, & Harris, 2004; Fazio, 2009), reflecting viewpoints and reasons behind action items.

For this thesis' inquiry we utilise productive *reflection-on-action* via dialogic collaborative reflection by Sim-Suite's team members to collect data for analysis. The lead artist conducted two reflection sessions in consecutive order, each with one of the two collaborators lasting about 1.5 hours with questions shown in table 4.1. These questions were compiled with the idea to generally outline the process, without inducing or emphasising certain aspects but rather to let important matters emerge through the reflection process itself. Both collaborators had no contact with each other between sessions. A third session was conducted with the lead artist, which was a supported dialogic reflection session with oral self-inquiry, applying the essence of questions shown in table 4.1. The session was communicated to, and further probed by, a colleague. All sessions were audio recorded and transcribed for analysis. Transcripts were analysed using Grounded Theory which we discuss in the subsequent section.

4.3.2.2   Grounded Theory analysis within the theoretical lens

Since its inception Grounded Theory has evolved into multiple strands where adjustments have been made either out of contextual necessity or as an improvement to better utilise the natural human capacity for analysis (Schatzman, 1991; Robrecht, 1995; Kendall, 1999). We selected Grounded Theory as a guideline (A. L. Strauss, 1987, p.7) to analyse data obtained via dialogic reflection by Sim-Suite's creative team members. The analysis yields descriptive results, engendering an interpretative basis from which the body's role in creative cognition will be discussed in chapter seven.

Grounded Theory operates on the assumption that access to reality can be achieved through social constructs, language and shared meanings. Like most qualitative methodologies, Grounded Theory thereby acknowledges the researcher's role as instrument in the analysis with his or her own assumptions and cultural context. Although the researcher is a participant observer directing analysis, and in case of this thesis a participant creator and postmortem observer, the researcher's stance is to remain as distant as possible to expose underlying emergent phenomena. The data collection was carried out using reflective practice. Questions listed in table 4.1 were framing dialogues without being imposed onto interactions between reflecting collaborators. Input received from collaborators varied depending on their breadth and depth of participation in the reflective process. For afore-mentioned reasons we interpret Grounded Theory's flexibility of data sources, its emphasis on data collection and analysis as interrelated processes, as suitable for this thesis' inclination towards naturally evolving, real-world contingencies (Corbin & Strauss, 1990).

A common scientific predecessor to this thesis' conceptual approach further inspired opting for Grounded Theory to analyse collected data. Corbin and Strauss introduce Grounded Theory as deriving "its theoretical underpinnings from Pragmatism" (p. 5). Here, John Dewey's seminal work is mentioned and referred to as direct influence on the discovery of Grounded Theory. Di Paolo, Rohde, and De Jaegher (2007) describe Dewey's Pragmatism as part of the "philosophical affinities" to the core of enactivism. Both of these links mention Dewey's Pragmatism because of its starting point being rooted in, and oriented to, practical and physical reality.

While focussing on emergent phenomena elicited from empirical observation of Sim-Suite's creative process, embodiment is part of the conceptualisation. Grounded Theory classifies incidents, events and happenings into indicators of phenomena that create conceptual understandings. With repeated encounters of related phenomena, categories[11] are developed and related to each other. In this thesis' analysis, categories are drawn from common phenomena insinuated in dialogic reflection data that best describe understanding of creation as embodied process. In the beginning of this chapter we elaborated on two convergent approaches that have determined that cognition is embodied. Embodiment from the perspective of enactive cognition acknowledges that cognitive processes take place in a subjectively lived body where the view point of the agent is equally subjective. Sim-Suite's creative process was executed through the autonomous and self-determined interactions between collaborators with their environment. The collaborators, as self-organising unit, developed into a network of these interactions made up of ideas, physical processes, environmental influences and locations as well as social adaptations that purposefully led the steady evolution of the artwork. Throughout this network collaborators made sense of their actions in reference to the artwork and to each other's coordinated actions. For this thesis' analysis, we appropriate Grounded Theory's theory building process by considering categories[12] developed from concepts as "nodes" in this network. This thesis' analytical results construe perceptible interrelations between these nodes from the vantage point of the physical.
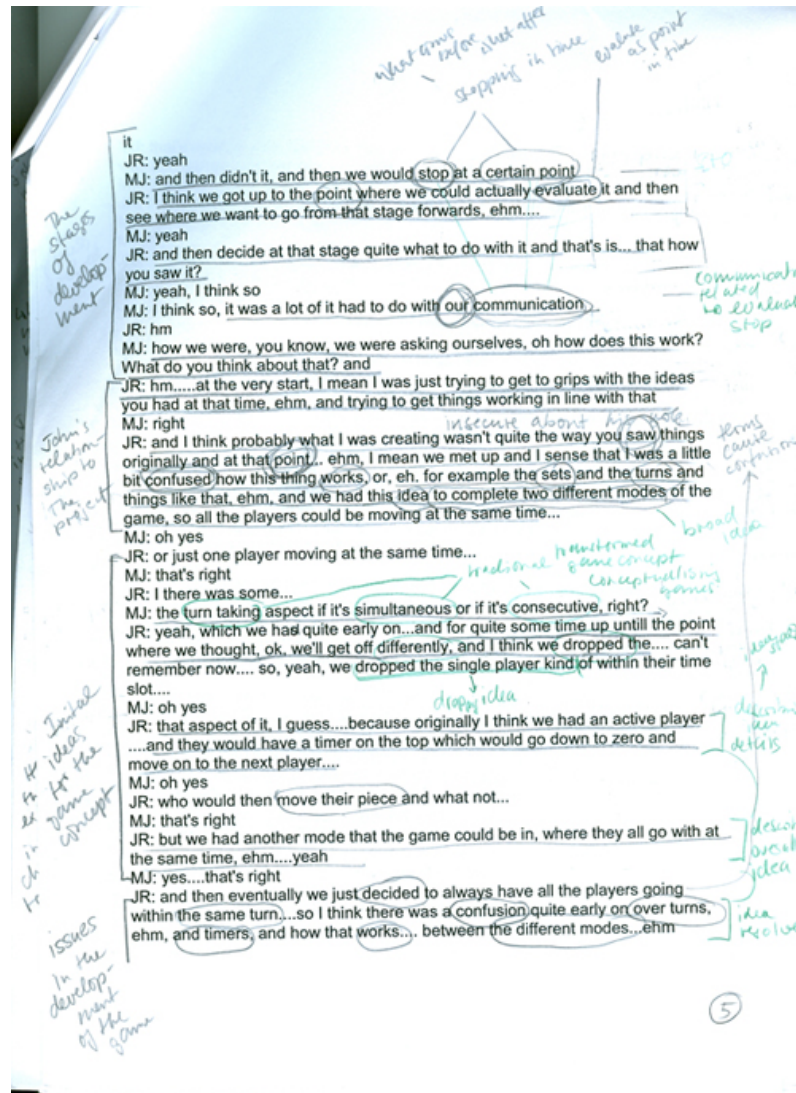
Figure 4.2: A sample page showing the coding procedure which was executed with pencil and paper. In the analytical end stage, transcripts were cut up and transcript quotes were grouped by hand according to their category. This particular page is from the transcript where the lead artist reflects through dialogue with collaborator JR.

questioning play, labeling game ideas, encounter material limits, confusing language,
feedback sharing, conceptualising tool options, discuss in/effective ideas before/after,
late/early development scoping, observation sharing, looking-back discussion,
elaborating expertise, work division talk, efficiency, estimating, argue material limits,
debate construction options, explain tool restriction, discuss material options/use,
understand physical material limits, explain how-to, explain assistance,
sketch demo, forsight, argue for one's understanding, debating idea qualities, synch,
guessing, exhibit attitude, role distribution, laughing, discuss stages,
telling self-responsibility, discussing dropping/deleting idea, decisions on holding ideas,
talk to regulating workflow, harmonising, re-interpreting for clarification,

Verbal Exchange

Idea generation

stages
types
strategies
context

Process Qualities

verifiying, evaluating, re-iterating, altering,
changing, improvising, focusing, sharing, spontaneous,
adhoc, comtemplating, introspecting, reconciling,

Physical Action

programming, hammering, calculating, carring materials, sawing, searching for materials,
folding, hold back, drawing, stepping on wobble-board, testing, coding, copying, drilling,
rendering, illustrating, animating, incorporating, deleting from programme, storing, cutting,
colouring, reshuffling in game events, watching, lifting, organising, creating, painting, counting,
observing others

Figure 4.3: This figure shows an early, preliminary coding scheme, where concepts were collected into preliminary categories.

4.3.2.3   Coding procedure

As previously mentioned we adopted Grounded Theory as a guideline to qualitative analysis. The coding procedure was developed with *open coding* specifications as introduced by A. Strauss and Corbin (1990, pp.61-74). The three transcripts were analysed one by one, and also as a group, through an immersive interactive process that took into account every transcript line. Analysis was executed by analogue means, such as pencil, paper, scissors and tape, which is demonstrated in figure 4.2.

Posing questions to the collected and transcribed data helped create theoretical sensitivity and ensured our starting point for this analysis from the perspective of embodied cognition. The main emergent theme in all transcripts of dialogic reflection was centred on idea generation, how ideas were conceived, what stages were involved, what strategies were deployed, and from what context these ideas emerged. We noted how collaborators communicated with each other, the content of the communication, what kinds of physical activities took place and how these related to the process' temporal dimension. We further looked at relationships between these elements, and how these relationships were influenced by external factors.

After we had established a preliminary coding scheme we then ran the codes[13] again and re-fined them in several steps until we had the final scheme which we administered to repeat data analysis. We created a set of codes that were applicable across all transcripts and another set of

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[11]as understood in Grounded Theory

[12]"Categories" and "concepts" refer to terminology in Grounded Theory.

[13]Codes, as part of the process of analysis in Grounded Theory

codes that covered the collaboration of Sim-Suite's game development with the lead artist and collaborator JR. In chapter five we present our findings together with the final codes as informational graphic depiction.

We now leave this section on qualitative analysis and turn to the complementary, quantitative analysis in the mixed methodology approach of this thesis.

4.3.3 Methodological background to Sim-Suite's statistical analysis

Statistical analysis is used in psychology research as well as the social sciences as the main method for measuring human behaviour and cognition. When reviewing literature on creativity research in chapter two, we explained how the majority of research activity centred on quantifying creative behaviour with psychometric methods. It may be questioned whether quantifying creative behaviour via divergent thinking tests and other pen and paper tests exemplify cognitive traits of creative behaviour. However the question does not invalidate or discredit tools used for analysis. We argue in this thesis that these kinds of research approaches are limited in their research design and in targeting the full spectrum of aspects pertaining to creative thinking and behaviour. Aspects that are excluded from these approaches are far reaching. They not only exclude physical and social elements but also ignore fundamentally the temporal and process-oriented nature of creative behaviour. In this thesis we aim to widen the scope for understanding of creative cognition from the perspective of research design, interdisciplinarity and recent developments in embodied cognition research, while embracing 'tools of the trade'.

Statistical analysis used to evaluate creative thought in 'play', as it is the case with Sim-Suite's game, may be an infrequent research approach in creativity but it is not absent. Kay's (1991) research focussed on limits of understanding found in the discrepancy between unsatisfactory performances by students with creative ability on psychometric tests of intelligence, and incompetent performances by high IQ students' production of creative ideas. Kay suggested that this might be an issue of different strategies used for problem-finding and problem-solving which she investigated by examining attributes common to both. Working from the standpoint that "creative thought implies a process definition of creativity" (p.232) she conducted a study with twenty professional artists, twenty semi-professional artists and twenty non-artists using games in her study design. Kay's reasoning for the use of games with "figural transformation" instead of drawing activities is rooted in transcending age and expertise because requisite skill for these games is subsumed in perceptual knowledge. She further stated that these games should "offer a direct perspective on inherent differences in cognitive processes without the confounding of extensive previous experience by one (or more) group(s) with the task".

The basic alignment between Kay's research approach and that of this thesis, studying creative participation with Sim-Suite's game-play, is the employment of statistical analysis to assess creative behaviour with games. Also, similar reasoning underpins transcendence of age and expertise because Sim-Suite's gaming elements are derived from traditional games in Western culture, whose acquaintance by Sim-Suite participants was made during childhood. Sim-Suite's game-play proposes a new experience of these gaming elements in addition to bringing them closer to

physical expression.

However, Sim-Suite's gaming elements are only similar to traditional gaming elements in their conceptual and visual content, their physical representation is virtual and on-screen. Offering a new experience to Sim-Suite participants includes technology driven interaction with these traditional gaming elements. In this thesis' research, technology bridges participant with researcher because sensor technology provides hard data for statistical analysis. Sensor data translates participants' movements by the millisecond into a useful resource for analysis.

We consider deploying sensor technologies for research design in the study of creative behaviour in line with a wider spread methodological research paradigm that is currently emerging and being adopted by a number of academic disciplines. On the forefront is education (Wang & Hannafin, 2005; Design-based research collective, Spencer foundation) applying technology to research in the form of "design experiments" or "design-based" research approaches while appropriating "technical artefacts as mediating tools" (Bernhard et al., 2007). More evidence of this development is newly funded research, such as computational behaviour science which seeks to capture behavioural signals in order to measure behavioural variables (Georgia Institute of Technology, 2010).

Central to the embodied cognition paradigm is technology as a route to extend our minds into the environment (Clark & Chalmers, 1998). Therefore, coupling sensor technology with creative behaviour investigations is not only a natural thematic extension but also part of this thesis' contribution where technology as communicative medium made available by new media developments is used to study creative cognition - to quote McLuhan (1964), "the medium is the message" in exhibiting how new media is able to extend creative cognition via embodiment.

The next section lays out in detail how sensor values, produced by Sim-Suite participants and captured via logfiles, were processed into meaningful and operationalised data sets. Programming scripts were written in Python, and other mathematical functions in preparation for statistical analysis were performed in Excel software.

Variables are designed from this thesis' position on embodiment in creative behaviour. The main variables compiled for data sets are therefore centred on the two underpinnings of this thesis. The first one is geared to variables on strategic behaviour in game-play which requires inventive and creative ways to mobilise resources for winning Sim-Suite's game[14]. Secondly, we stress the embodiment factor through emphasising variables denoting and expressing different levels of physical activity germane to a number of aspects in game-play. The nature of these variables is discussed in more detail in the subsections that follow from here.

4.3.3.1 *Logfile as basis for statistical analysis*

The main function of Sim-Suite's logfile is to render game events accessible in text form. Typical logfile text lines are shown in figure 4.4. Sim-Suite's logfile prints out game events as they occur in milliseconds during game-play. While creating Sim-Suite's game, printing logfiles on-screen served as a testing tool for referencing settings of implemented interaction mechanisms against screen-displayed events. Once the installation had been completed, it was exhibited publically on

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[14]See chapter three for more discussion on creative engagement.

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3670110 NEXT_GAME_STAGE GAME_FADE_IN to GAME
3670141 TRIANGLE_WOBBLE_DIR_CHANGED DIR_Y_DOWN
3670141 TRIANGLE_WOBBLE_DIR_CHANGED DIR_NONE
3670141 CIRCLE_WOBBLE_DIR_CHANGED   DIR_X_LEFT
3670141 S_TR    83 100 NONE 0.0 0.0
3670141 S_CI     0 59 X_LEFT -10.0 0.0
3670141 S_SQ     0 40 X_LEFT -10.0 0.0
3670250 S_TR    84 100 NONE 0.0 0.0
3670250 S_CI     0 58 X_LEFT -20.0 0.0
3670250 S_SQ     0 38 X_LEFT -20.0 0.0
3670360 S_TR    89 99 NONE 0.0 0.0
3670360 S_CI     0 58 X_LEFT -30.0 0.0
3670360 S_SQ     0 42 X_LEFT -30.0 0.0
3670469 S_TR    90 99 NONE 0.0 0.0
3670469 S_CI     2 58 X_LEFT -40.0 0.0
3670469 S_SQ     0 38 X_LEFT -40.0 0.0
3670579 S_TR    92 98 NONE 0.0 0.0
3670579 S_CI     2 54 X_LEFT -50.0 0.0
3670579 S_SQ     0 38 X_LEFT -50.0 0.0
3670688 S_TR    96 96 NONE 0.0 0.0
3670688 S_CI    13 28 X_LEFT -60.0 0.0
3670688 S_SQ     0 41 X_LEFT -60.0 0.0
3670797 CIRCLE_WOBBLE_DIR_CHANGED   DIR_NONE
3670797 CIRCLE_WOBBLE_DIR_CHANGED   DIR_Y_UP
3670797 S_TR    99 94 NONE 0.0 0.0
3670797 S_CI    43 9 Y_UP -60.0 -10.0
3670797 S_SQ     0 38 X_LEFT -70.0 0.0
3670797 PLAYER_MOVED_OFF    SQUARE (9,5)
3670797 PLAYER_MOVED_ON SQUARE (8,5)
3670907 S_TR    93 98 NONE 0.0 0.0
3670907 S_CI    64 1 Y_UP -60.0 -20.0
```

Figure 4.4: Excerpt of Sim-Suite's logfile. The first column on the left indicates the milliseconds since the program was started, therefore every event in the game can be traced accordingly. The second column declares name of shape or token. The remaining columns show the location of the occupied field on the game-board as well as directional movements by participants on the wobble-board. Alternatively, major events in the game are scripted across these columns.

multiple occasions. It was during these times that we documented via logfiles games played by members of the public. These logfiles are used as basis for statistical exploration in chapter six.

Before logfiles are useful as tool for analysis, games have to be parsed into successful games, unsuccessful games and null games. Only successful games played by participants until completion were used for investigation. In addition to a parsing algorithm written in Python, a proprietary replay tool was created to play back participants' games visually, on-screen without installation set up. Playback of games takes place dynamically in real-time. A typical playback screen is shown in figure 4.5, it is a simplified graphical version of Sim-Suite's game. In this figure, a gray bar shows status of game length at the bottom, and in the upper right hand corner a single white dot implies timer dots ticking off at the end of the current game-round. Darker colour tokens belong to 'frozen' tokens from previous rounds, lighter colour tokens are active in the current game round. Each active token illustrates directional movements in milliseconds animated through rotating, waxing and waning arrows, they are simulating Sim-Suite's graphical overlay.

Playback of participants' games informed preliminary investigation efforts into game events performed by participants as a group. Through graphical visualisation of these games in real-time, participants' game-play behaviour with its various aspects of interaction was highlighted, forming the basis for construction of a scoring system and conception of variables for exploratory statistical analysis explained in chapter six.
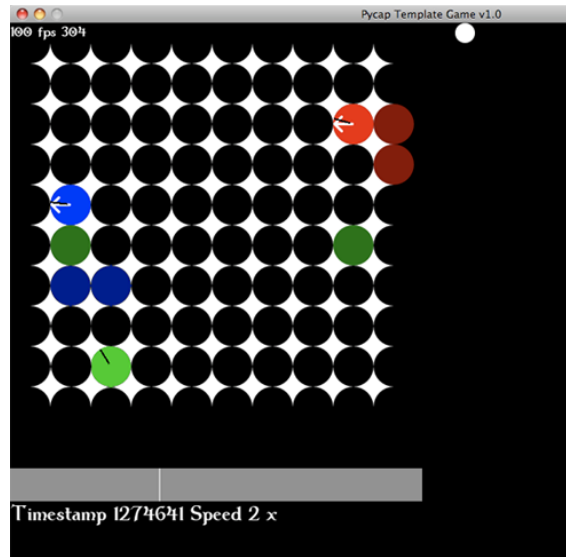
Figure 4.5: Screenshot of the replay tool used to playback participants' games in real-time. The gray bar on the bottom shows the status of game length. Tokens with darker colours are 'frozen' tokens from previous rounds. Lighter colour tokens with white arrows are being placed in the current round. The single white dot in upper right hand corner is the last dot of the timer symbol ticking off at the end of this game-round.

4.3.3.2   Development of scoring system

The scoring system we developed for statistical analysis classified participants' game-play in terms of strategic playing behaviour. Through investigation of games via playback, different types of strategic behaviour became evident. These types of behaviour transpired over a scale of highly strategic play to little strategic play based on an individual's engagement, which may fluctuate throughout the course of game-play.

Strategic behaviour in Sim-Suite's game-play is twofold. The first aspect of strategic behaviour conveys navigating one's token to a field on the game-board and placing it where it is most lucrative in constructing the predetermined token pattern for winning the game. What qualifies as lucrative depends on game context, it changes from one game-round to the next. This kind of strategic behaviour is called offensive behaviour. It compels participants to evaluate everyone's token placement and anticipate upcoming fields to be occupied, as well as pinpointing one's own prospects for placement in the next game-round.

The second aspect of strategic behaviour describes participants' pursuits of obstructing and hindering other participants from constructing and completing the winning token pattern. This is achieved by investing one's token and spending it on blocking another participant's field prospect in the current game-round. Situations for blocking may be obvious to opponent participants or less obvious depending on game context and an individual's capacity for timely judgement of the situation. This is called defensive behaviour. Similar to offensive behaviour, evaluation and anticipation of other participant's actions as well as one's own within the objective of game-play are essential but defensive behaviour implies acting upon one's predictions, against anticipated

$$i+1, j$$
$$i, j-1 \quad i, j \qquad i, j+1$$
$$i-1, j$$
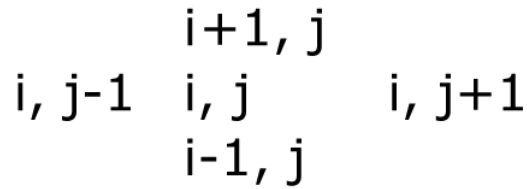
Figure 4.6: Strategic behaviour scoring template referencing field coordinates on the game-board. i= rows, j= columns.

intentions of another.

From studying participants' game-play via playback, we observed that defensively playing participants were more likely to be taking risks by scoping out the game's limitations. For example defensively playing participants discovered that when reaching the game-board's edge and one continues navigating forward to 'wrap around', then one's token shape re-appears on the game-board's opposing edge. This discovery was then utilised as shortcut when traversing the game-board. Another example is having an understanding that when travelling across fields with tokens already placed on them, it causes one's token shape to slow down, consequently highly-defensive playing participants avoided these fields. Instead, these participants would seek out empty fields when traversing the game-board.

The scoring system we developed distributes points to each token shape at the end of every game-round where we evaluate placement by all three token shapes. Token shapes are Circle (green), Square (Blue) and Triangle (Red). Evaluation of token shape placement in the game is performed in reference to the token pattern that is the winning configuration, a cross shape pattern with five tokens from the same token shape. The appraisal procedure of token placement applied at the end of each game-round evaluates the occupied field by each token shape relative to potential cross shape patterns around it. In the scoring system, the cross shape pattern, or the winning configuration, functions as a template against which the 'current token shape placement', meaning the token that was last placed at the end of a game-round, is referenced as fields with coordinates on the game-board. Each field comprises two game-board coordinates (i,j) which are used to identify token positions in the template zone. It is called the template zone because the same basic template is utilised multiple times by skewing the position of the centre token. This will be further explained below, but first we outline the basic template construction. Figure 4.6 shows the basic template with game-board coordinates, i= rows and j= columns.

Overlaying this template onto the 'current token placement' by each token shape, we evaluate position (i,j) by looking for opponent field occupation in: (i,j+1); (i,j-1); (i+1,j); (i-1, j). If no opponent token shapes are present, one point is given for each ally token shape placed within the template. No points are given if an opponent token shape is placed within the template. Next, the current token placement is evaluated as no longer occupying (i,j) but now occupying these positions: (i+1, j); (i, j+1); (i-1, j); (i, j-1). Each of these positions constitutes a separate template within the template zone of five central token positions. Figure 4.7 shows a development sketch indicating the entire template zone. Proceeding in the same fashion, each of these five templates
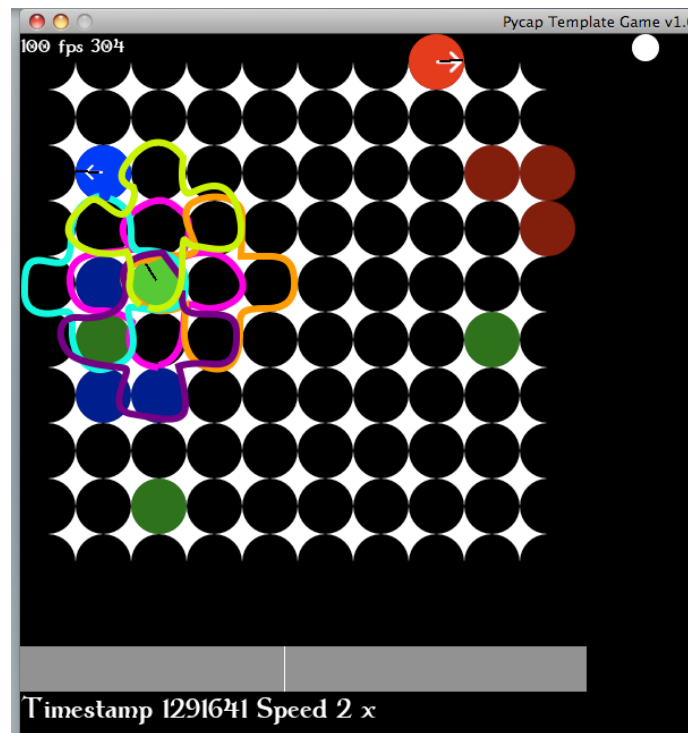
Figure 4.7: Sketch of five templates making up the template zone for scoring strategic behaviour points indicated by pink, purple, orange, turquoise, and yellow coloured lines. The token placement illustrated here is limited in possibilities for constructing the cross shape pattern because it is located too closely to the game-board's edge where the fifth position in the template zone cannot be accounted for.

receive points according to how many ally token shapes are present and no points if opponent token shapes are placed within the respective templates. All points are then added up. This procedure makes up the offensive behaviour scores for the current token placement by each token shape at the end of each game-round.

The scoring of defensive behaviour has identical steps to the scoring of offensive behaviour but we use the opponent token shapes for the calculation of the defensive behaviour scores. To compute defensive behaviour we look at how token shapes play against each other. So for example, we want to find out the defensive behaviour score for 'Triangle-against-Circle token' in a particular game-round. At the end of a round we identify Circle token's current token placement (i,j). We then mentally place the Triangle token into Circle token's current token placement. We then calculate the five positions in the template zone, looking for ally tokens, which are in this case Triangle tokens. We proceed with the evaluation as described above, where we give points for ally tokens that occupy fields inside the templates. No points are given if any opponent token shapes are found on fields inside the templates, which are in this case Circle and Square tokens. We add up the points and now have the score for 'Triangle-against-Circle token' in a particular game-round.

We calculate the defensive score for the remainder, deriving a score for each game-round from 'Square-against-Circle token', 'Circle-against-Triangle token', 'Circle-against-Square token', 'Square-against-Circle token' and 'Square-against-Triangle token'. Offensive behaviour and defensive behaviour scores create three sets of scores for each token shape. Each token shape has one set of scores for offensive behaviour and two sets of scores for defensive behaviour.

A Python algorithm was written to compute strategic values for each successful game. Figure 4.8 demonstrates the program's terminal output for a game with 24 rounds. These values are complied into variables. For the Circle token these variables are *Coff* for offensive behaviour, *Csq* for Circle token's defensive behaviour against Square token, and *Ctr* for Circle token's defensive behaviour against Triangle token. For Square token these variables are *Soff* for Square token's offensive behaviour, *Sci* for Square token's defensive behaviour against Circle token, *Str* for Square token's defensive behaviour against Triangle token. Triangle token's variables are *Toff* for Triangle token's offensive behaviour, *Tci* for Triangle token's defensive behaviour against Circle token, and *Tsq* for Triangle token's defensive behaviour against Square token.

4.3.3.3   The making of variables and data sets

Before describing calculation and computation of additional variables, let us add that when computing strategic variables we also enumerated each game that was used for the calculation of strategic variables values. This variable is called *gameset* and it functions as a game identifier, organising all other variables for each game and making them accessible for further analysis.

We also computed a variable that describes participants losing their tokens during game-play. In figure 4.8, the terminal output shows dashes in some game-round's rows. These imply that no score was obtained because participants flew off from the game-board. Flying off from the game-board could occur for two reasons. The first is that participants were not moving on their wobble-boards for more than two seconds and this triggered their token to fly off from the game-

```
        CIR              SQU              TRI
     No. OFF squ tri  OFF cir tri  OFF cir squ
     1.  5   5   5    -   -   -    4   4   4
     2.  7   3   3    3   3   8    4   2   4
     3.  6   4   1    1   6   1    -   -   -
     4.  5   3   1    5   3   1    5   3   3
     5.  3   3   5    0   11  0    -   -   -
     6.  -   -   -    5   2   4    3   3   8
     7.  2   5   2    3   0   2    6   4   4
     8.  0   8   2    4   4   4    3   3   3
     9.  0   4   5    -   -   -    -   -   -
     10. 8   3   3    0   0   2    2   2   2
     11. 5   5   1    0   4   2    1   1   1
     12. -   -   -    0   7   0    -   -   -
     13. 0   0   0    0   0   0    -   -   -
     14. 11  2   2    0   2   0    -   -   -
     15. 8   0   0    2   0   5    -   -   -
     16. -   -   -    -   -   -    -   -   -
     17. -   -   -    0   7   0    -   -   -
     18. -   -   -    0   11  0    -   -   -
     19. -   -   -    -   -   -    5   3   3
     20. 2   0   2    1   1   1    -   -   -
     21. 1   1   3    3   0   0    4   3   2
     22. 0   0   0    -   -   -    6   0   0
     23. 4   0   2    4   0   2    4   0   2
     24. 4   2   0    7   0   2    10  1   1


     TOT.  71  48   37   38  61   34   57  29   37
     Avg.    2.84    1.92    1.48    1.52   2.44   1.36   2.28   1.16   1.48
     fly.    6   6    6    5   5    5    11  11   11
     mj43-mac-mb:game_analyse mj43$
```

Figure 4.8: Typical terminal output calculating values of strategic variables for Circle token (*Coff, Csq, Ctr*), Square token (*Soff, Ssq, Str*), and Triangle token (*Toff, Tsq, Ttr*) in a game with 24 rounds. Dashes in the output indicate participants flew off from the game-board in a particular round.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	game set	round	Coff	Cflyoffs	Csq	Ctr	Soff	Sflyoffs	Sci	Str	Toff	Tflyoffs	Tci	Tsq	Itci	Itsq	Ittr	cfldmvgme	sfldmvgme	tfldmvgme	maxrnd
2	1	1	-1	1	0	0	4	0	4	4	-1	1	0	0	0	5078	7125	1	10	9	8
3	1	2	5	0	5	5	5	0	5	5	2	0	2	6	22375	7219	4609	14	7	9	8
4	1	3	1	0	9	1	3	0	7	3	3	0	3	7	5781	5610	3437	8	6	10	8
5	1	4	-1	1	0	0	1	0	1	3	3	0	1	7	3578	4375	3766	9	5	8	8
6	1	5	7	0	3	3	3	0	1	1	4	0	1	4	3735	4687	3765	9	6	8	8
7	1	6	0	0	2	2	0	0	0	0	4	0	2	5	5125	3766	4719	7	5	7	8
8	1	7	5	0	0	0	-1	1	0	0	12	0	1	1	5406	3578	4141	7	8	5	8
9	1	8	7	0	3	3	6	0	2	2	8	0	0	3	4641	2812	2297	4	5	6	8
10	2	1	5	0	5	5	3	0	3	7	3	0	3	7	5000	2625	8000	4	7	3	8
11	2	2	7	0	3	3	3	0	1	5	4	0	2	4	7250	4047	3500	3	8	8	8
12	2	3	-1	1	0	0	-1	1	0	0	5	0	2	2	5515	4094	9718	8	6	4	8
13	2	4	1	0	3	3	0	0	2	7	3	0	1	1	6125	8437	4484	9	10	10	8
14	2	5	-1	1	0	0	4	0	2	4	2	0	2	7	2078	9735	10219	5	5	6	8
15	2	6	8	0	1	3	4	0	2	4	4	0	1	3	15781	12672	5250	10	4	12	8
16	2	7	10	0	2	2	-1	1	0	0	6	0	0	0	8172	10281	4047	8	9	11	8
17	2	8	5	0	3	3	5	0	2	2	5	0	0	0	2953	4484	4594	8	4	4	8
18	3	1	3	0	7	3	3	0	7	3	4	0	4	4	2953	4375	4656	13	10	10	8
19	3	2	-1	1	0	0	4	0	4	2	-1	1	0	0	13891	4390	2297	5	9	5	8
20	3	3	2	0	5	2	6	0	4	4	7	0	3	3	6343	8313	15625	10	8	7	8
21	3	4	6	0	2	2	7	0	3	3	5	0	3	3	3672	2953	3360	11	9	11	8
22	3	5	0	0	11	0	4	0	2	4	-1	1	0	0	2735	3188	3609	8	6	10	8
23	3	6	9	0	2	2	4	0	0	0	-1	1	0	0	3500	5407	5844	7	4	8	8
24	3	7	10	0	2	2	-1	1	0	0	2	0	2	7	5140	5468	2953	8	7	9	8
25	3	8	11	0	1	1	6	0	1	1	0	0	6	0	2625	3141	4156	8	6	5	8
26	4	1	1	0	5	5	3	0	7	3	3	0	7	3	3172	3797	4344	7	5	4	8
27	4	2	4	0	2	4	5	0	1	5	3	0	3	7	3829	2547	6454	8	10	6	8
28	4	3	3	0	7	3	3	0	5	1	5	0	3	3	3719	4047	8860	9	5	3	8
29	4	4	6	0	1	1	-1	1	0	0	-1	1	0	0	3500	4734	12281	11	6	4	8
30	4	5	3	0	3	1	1	0	12	1	0	0	4	3	4578	7782	4172	12	8	6	8
31	4	6	6	0	1	5	5	0	2	4	1	0	5	1	5250	4922	11656	11	10	2	8
32	4	7	0	0	2	2	7	0	0	2	0	0	9	0	2844	8938	9219	13	7	3	8
33	4	8	0	0	2	2	10	0	1	1	1	0	1	10	5797	4485	6578	10	6	7	8
34	5	1	5	0	5	5	5	0	5	5	4	0	4	4	4016	8266	5750	8	7	10	9
35	5	2	6	0	4	2	-1	1	0	0	6	0	4	4	11438	5484	5203	5	10	8	9
36	5	3	2	0	2	9	6	0	4	4	3	0	7	3	12156	4141	7344	3	8	5	9
37	5	4	1	0	11	1	2	0	4	0	4	0	4	2	15000	5422	3500	0	5	9	9
38	5	5	-1	1	0	0	0	0	2	4	5	0	0	4	5266	5907	2422	5	2	11	9
39	5	6	0	0	0	6	5	0	2	2	5	0	1	1	4360	3281	2141	6	5	11	9
40	5	7	-1	1	0	0	8	0	2	2	3	0	3	0	3500	3593	2515	8	6	9	9
41	5	8	1	0	12	1	-1	1	0	0	9	0	0	0	4812	3062	3281	6	9	10	9
42	5	9	4	0	4	1	1	0	3	1	10	0	0	0	4125	5219	2188	2	3	8	9
43	6	1	5	0	5	5	3	0	3	7	3	0	3	7	4546	11047	8093	9	6	7	9
44	6	2	-1	1	0	0	5	0	3	3	4	0	2	5	2532	6781	6454	4	5	8	9
45	6	3	5	0	3	5	7	0	2	2	-1	1	0	0	16000	7157	5907	9	5	7	9
46	6	4	3	0	5	3	-1	1	0	0	-1	1	0	0	4813	5797	3250	8	7	9	9
47	6	5	3	0	1	1	2	0	2	0	1	0	1	8	4875	4703	5250	8	5	7	9

Figure 4.9: View of variables compiled with 'raw' data in Excel. In strategic variables, the negative number (-1) in offensive behaviour columns indicates no score obtained because the token flew off from the game-board.

board. Participants received warnings via flashing text on the interface that they must move on their wobble-boards prior to the two-second time limit. When two seconds are up and participants have not yet moved on their wobble-boards their token flies off from the game-board. The second instance for losing one's token during game-play is the required placement of one's token on an unoccupied field of the game-board. While traversing the game-board during game-play, participants can cross over already placed tokens but must occupy their own field at the end of each game-round. If they fail to reach a field of their own, their token flies off from the game-board. The 'fly-off' variable is calculated by keeping count for each round of a participant's token that flies off from the game-board. The variable is expressed as *Cnoflyoffs* for Circle token, *Snoflyoffs* for Square token and *Tnoflyoffs* for Triangle token. Later in this section we return to this variable and explain how it was implemented to compose the data set in Excel software.

The algorithm used to compute strategic variables and 'fly-off' variables was slightly amended to compute a variable that records the longest time a participant's token is held stationary on a field of the game-board during a game-round. When discussing Sim-Suite's interaction mechanism in chapter three we mentioned a conflict of interest that arises during game-play. It arises when a participant's token is already placed on a selected field of the game-board before the end of a game-round, requiring the participant to hold this token's position until the end of the round. In avoiding flying off from the game-board, stepping movements on the wobble-board must be performed under two seconds but one must also keep one's token stationary on the selected field of the game-board at the same time. Resolving this situation entails finding a way to move about physically, satisfying both conditions. Algorithmic calculation of temporal latencies on the fields of the game-board are retrieved via Sim-Suite's log file by comparing intervals in milliseconds when a token moves off one field (cf. fig. 4.4, PLAYER_MOVED_OFF) and onto the next (PLAYER_MOVED_ON). The highest value in each game-round is captured and expressed as variable *ltci* (*lt* implies "longest held stationary") for Circle token, *ltsq* for Square token and *lttr* for Triangle token.

The last variable to be computed from Sim-Suite's logfile determines number of fields traversed on the game-board in the course of a game-round. It is a complementary variable to both strategic behaviour variables and variables connoting basic physical activity. It is expressed as *cfldmvgme* (*fldmvgme* implies "fields moves on game-board") for Circle token, *sfldmvgme* for Square token, and *tfldmvgme* for Triangle token. We deployed UNIX shell scripts using 'grep' and 'wc' commands to count all instances of string "PLAYER_MOVED_OFF" in logfile. The output was 'grepped' again to separate strings by token association for Circle, Square and Triangle tokens. The output was further processed in Excel software using the VLOOKUP function to replace the default prefix with appropriate game identifiers of the variable *gameset*. This concludes our explanation of extracting variables from Sim-Suite's logfile for the thesis' exploratory statistical analysis. The variables obtained can be classified into strategic variables and corporeal variables which we shall elaborate more on throughout chapter six.

Other variables were added during the compilation of the data set in Excel software. The data set tabulated variables' values on a round by round basis, constituting 'raw' data. Figure 4.9

demonstrates a view of variables compiled with 'raw' data in Excel software. Additional auxiliary variables were created, they are variable *round* which enumerates each round in variable *gameset*, and variable *nrig* (*nrig* implies "number of rounds in game") which states maximal number of rounds per round in *gameset*. This data set was called 'roundswithingames'.

A second data set was compiled from the 'raw' data set by tabulating the variables means. This data set is called the derived data set. It was compiled by importing the 'raw' data set into SPSS and conducting 'Case Summaries' procedure for all variables excluding values (-1) of strategic variables *Coff, Soff* and *Toff*. These values (-1) are not representing actual offensive behaviour count, the negative number (-1) was used as a code to label 'fly-offs' from the game-board. SPSS output of variable means was pasted into a separate Excel file also tabulated by *gameset*. This completes the background on quantitative methodologies for this thesis.

4.4   Conclusion

In this chapter we have presented information covering several areas that are central to this thesis. This chapter is intended as a reference point within this thesis, which assembles starting points for ensuing chapters, chapters five and six, as well as underpinnings on embodied cognition for chapter seven.

This chapter comprises two main sections, in the first main section we explained principles that constitute two theses in the embodied cognition paradigm, the embedded-embodied approach and the enactive approach. This theoretical lens is sought to guide this thesis' explorations, analyses and discussions. While we are introducing two approaches to embodied cognition research we are not limited to either approach, rather we see both approaches as one platform to draw from when reasoning about embodiment in creative behaviour. In chapter seven we draw, in support of our findings, on additional research themes within the embodied cognition paradigm. As previously stated, this thesis' aim is to break new ground in an exploratory manner by conveying an embodied cognition perspective on the creative process as continuum. For this reason, as well as the fact that the embodied cognition paradigm is in development, it is therefore most appropriate to make unrestricted use of embodiment research in cognition.

The second main section laid out our overall approach to methodologies by first rationalising the choice of mixed methods in this thesis' context. Here, we introduced each approach, first qualitative then quantitative, and respective methodologies as they apply to data collected for this thesis' analyses. In the section on the qualitative analysis, we motivated and described data collection via dialogic reflection sessions analysed by Grounded Theory. Qualitative findings are expounded in chapter five. In the section on the background of the quantitative analysis, we introduced Sim-Suite's logfile and extraction and conversion techniques that generated variables, and two datasets for statistical analysis. We now turn to chapter five where we discuss findings of the qualitative analysis.

Chapter 5

Exploratory qualitative analysis of the collaborative processes creating Sim-Suite

5.1 Introduction

In this chapter we present our findings from this thesis' qualitative analysis conducted on the collaborative creative process that produced the interactive installation Sim-Suite. In chapter three we introduced Sim-Suite, the materials and components of the installation, the game-play and the various aspects of emergent interaction dynamics. In chapter one we outlined the changes in artistic creativity. In contemporary artworks, such as the one Sim-Suite represents, artists and audience are no longer divided into active creators and passive receivers. Instead, both parties interact through the 'field of artistic communication' to create an instance of the artwork. This active engagement requires both parties to be creative. We have stated in chapter one that creative processes by both parties operate on a creative process continuum. To investigate this continuum we have proposed two research sub-questions and a mixed method approach.

In this chapter we use the first sub-question to guide our exploratory qualitative analysis. Regarding the artistic collaborative creative process we ask: "What are the embodied cognitive aspects that are expressed as creative preparation of the 'field of artistic communication' in a long-term, collaborative engagement?"

In chapter four we explained the methodological approach of this study in the context of the theoretical lens of embodied cognition. The theoretical lens is used as a mindset to analyse data collected for this study with the purpose of highlighting the body's role in cognitive functioning in physical reality. In this chapter we present the qualitative results, and in the concluding section we put our findings into context. In chapter seven, we give an account of the creative process continuum by placing findings from this chapter and chapter six next to each other. We then discuss these 'relational' findings by contextualising them with their respective theme in embodied cognition.

Briefly, the collaborative creative process that conceived and constructed Sim-Suite took place

via two separate, interdisciplinary collaborations, each with the lead artist MJ and one collaborator. MF, an artisan furniture maker, collaborated with the lead artist to create Sim-Suite's wobble-board encasements as well as the timber platform. JR, an engineer, collaborated with the lead artist to create Sim-Suite's digital game operated through analogue sensor technology and driven by wobble-board movements. Details on the creators and the installation were already discussed in chapter three.

This chapter is divided into two main sections. In the next section, 5.2, we first present a summary of our findings, and discuss the beginning of the artwork mostly from the perspective of the lead artist prior to the collaborations. We then take a look at the early stages of both collaborations regarding their interdisciplinarity. In the following section, 5.3, we turn to the findings on both collaborations. As discussed in section 4.3.2, we collected data via dialogic reflection sessions with members of both collaborations. An explorative analysis was conducted on data produced by these sessions which gave perspective on the unfolding developmental process in the form of two descriptive models. The first model presented in this chapter consists of stages in the creative process that were found to be common to both collaborations. The second model presented in this chapter is an in-depth focus on the second collaboration, the production and implementation of Sim-Suite's game. Here we present findings that clarify how elements of the creative process are interrelated as both collaborators move through the process of creation. On the basis of these findings we draw conclusions in the last section, 5.4, of this chapter.

5.2   Summary of findings

This analysis' findings first explain the conception of the creative project mainly involving the lead artist's process of framing the project's themes, engaging with others during this process, and pinpointing a commercial object in support of continued creative exploration. At the end of the lead artist's initial process the first collaboration started up with collaborator MF. From the point of view of creativity research, we make a case for conceptual combination, restructuring and insight as the main creative thought processes for thematic selection engendered by the lead artist's exploration. We support findings by quoting relevant passages from the lead artist's reflection session.

We then shift to collaborative beginning stages and present findings on aspects of interdisciplinarity. The lead artist's collaboration with MF reveals similarities in working styles. In the MJ-MF collaboration we see task sharing directed towards 'minor' tasks because those tasks are possible to execute without expert knowledge in carpentry. By contrast, the second collaboration exhibits a balanced integration of expert knowledge in the digital domain with matched task responsibilities. At the outset of the second collaboration both collaborators move through a period of adjusting their interaction patterns due to differences in working styles. Both accounts of collaboration beginnings are supported by associated passages from reflection sessions.

Next, we present findings in the form of two descriptive models. In the first, we introduce findings that assembled the modelled stages of both creative processes: Sim-Suite's timber construction and game implementation. Here we identified four stages that are linked in circular

succession and cohere to form the collaborators' shared understanding. Stages are depicted in the form of informational graphics by drawing on Tufte's (1992) pioneering approach to visual representation of results in qualitative analysis. With this approach we aim to portray more accurately the complexity of both processes while featuring their commonalities. The common stage of creative processes starts with verbal exchanges between collaborators and ends with the stage of collaboratively evaluating conceived and implemented ideas. The concept of stages is understood as heuristic in communicating the complexity of the collaborative creative processes that produced the artwork Sim-Suite. It is in no way implied that the stages proceeded linearly. We support our findings by explaining each stage and by comparatively quoting passages from both dialogic reflection sessions with collaborators MF and JR. By concentrating on the presented quotes of both collaborators, rather than the lead artist, we exemplify process commonalities from contrasting perspectives and give a more complete picture of each stage.

The second descriptive model focusses on the second collaboration. This collaboration entailed collaborators MJ and JR working with the wobble-board encasements and analogue sensors to create a proprietary software program. The second model elaborates on relationships between elements that make up the creative process of the second collaboration. The main elements in idea generation and implementation are conceptual context, game evolution or complexity, environmental influences and observation. We explain how these elements are related from the collaborators' anthropocentric perspective, while depicting them once more via a visual representation in the form of informational graphics. These informational graphics are tailored to the findings, they therefore do not resemble the foregoing graphical representation. Again, we supplement the presentation of this model by quoting passages from collaborators' session to contextualise the model with actual dialogic reflections.

In the last section of this chapter, we conclude our findings by mapping them onto the formerly established theoretical lens, and discuss the relevance of these findings from the perspective of embodied cognition.

5.2.1 Beginning the artwork: thematic approaches and working styles

The beginning stages that motivated the making of Sim-Suite established thematic concepts, appropriated a physical object, and entailed social interaction between the lead artist and others. In creativity research generating ideas is equated with creative thought and does not involve physical activity. Over the past decades this is where most research had set focus, isolating creative thought from creative process by studying types of idea generation, such as divergent and convergent thinking, which we discussed in section 2.2. This particular beginning phase has been termed *early cycle* by researchers who conduct research in fields of applied creativity. Here they are confronted with creativity as process and distinguish between *early* and *late cycle* therefore taking creativity's temporal aspects into consideration.

From findings of this thesis' study, we see that the early cycle merely served as an orientation period, which included the thematic selection for the artwork and engendered ongoing creative engagement. Thematic choices did not produce well-formed ideas that could be executed in sub-

sequent steps. Instead the lead artist, who generated the artwork's theme, was impelled through discussion with others to synthesise her creative explorations with a physical object.

Thematic choice constitutes two separate concepts, "full-body motion" and "group interaction", which the lead artist seeks to combine in the artwork. Combining concepts, which has been termed *conceptual combination*, is a well-researched approach to creative cognition, and a frequently evoked form of thinking in creative applications, including linguistic approaches (Welling, 2007). Conceptual combination was discussed in section 2.2.1.6, under conceptual synthesis with experiments conducted in the development of the Geneplore model.

In the following brief excerpt the lead artist reflects on the first thematic choice in reflection session with DH:

MJ: "I was interested in a theme of standing and moving in a way that every body stands and moves, you know nothing too complex or ... something that everybody can do and I had read research literature that was quite fascinating, it talked about the idea that we actually constantly have to balance to stand up right, we never stand still and it was showing how people sway all the time, and there is a constant moving of your centre of gravity that keeps you from falling over... and that there is a threshold that we basically experience as standing still, but still when you measure it there is swaying going on ..."

DH: "That was your initial theme?"

MJ: "So my initial theme was that I wanted to explore full-body motion that is accessible to everybody and it's not necessarily only about people who are very fit, or people who dance ... everybody... something we're all experts at ..."

Then a second theme emerges:

MJ: "I'm also very interested in group interactivity, so when people as a group interact ... where the computer is not really part of the interaction, only a facilitator of the interaction ... too much interactive [art] work is focussed on human-computer interaction ... what I mean by that is the computer is given too much importance ... you know, the interesting bits are social engagement between the people ... so the human to human part ... at least in my opinion"

What occurs next is that the lead artist switches to analogical thinking to bridge the two themes:

MJ: "it [the project] actually evolved right out of the theme itself ... so when I visited the theme ... then I had this idea of a moving ground, which is sort of an interesting idea ... somehow it mirrors what is going on with us ... although we are moving all the time we're never standing still ... yet, we have a hard time standing still on a moving ground ..."

Subsequently, the lead artist engages socially with others which leads her explorations away from conceptual contemplation into concrete physical and material reality. Here thoughts are cen-

tred on appropriating a commercial object and the practical steps involved for implementing a mechanism that measures movement.

> *MJ: "so then I spoke with a friend who does practical work in robotics and we were talking ... somehow the idea of a wobble board came up so then ... I think it all just evolved from there ... you know ... because we talked about wobble boards we immediately tried to brainstorm on how would you measure that, how would you measure the action on the wobble board?*
>
> *MJ: "... these sensors measure the distance of the angle of the board to the ground and I thought that was a great idea....so then I knew that it could work ... I ordered a wobble board just to have one ... it's made out of wood and it was clear to me that the rest [of the installation] would have to be made from wood too ... as a way to shape the wobble-board into something more robust that people could be moving on"*

From these findings we note that during the early cycle, problem finding is defined as vaguely outlining the artwork's theme. During the process of artistic exploration, the lead artist changes thematic representation to an analogy because "standing on moving ground" restructures the original theme of "full-body motion" (Knoblich et al., 1999, 2001). Restructuring information in creative thought is considered to be a preliminary cognitive process in developing insight (Sternberg & Davidson, 1996). The appropriation of a commercial object, a wobble-board, creates a step from the conceptual stage into physical reality, and enables access for more shared exploration. This process of acquiring a commercial object may be interpreted as having reached cognitive insight because it completes the early cycle by determining a definite direction for creative progress.

At this stage, the first collaboration between the lead artist and collaborator MF, the artisan furniture maker, started up. Related findings will be discussed in the succeeding section. We now focus on early stages of both collaborations.

5.2.1.1 The collaborator's working styles

As professional practitioners, each collaborator entered into an interdisciplinary collaboration. The collaborators' roles therefore necessitated that their respective expert knowledge was tailored to and integrated with the project's demands (O'Donnell & Derry, 2005). In the context of this project, collaborations proceeded in an unstructured fashion, oriented towards creative exploration while encouraging individuals to take initiative. It is a typical characteristic of artistic creative process to explore themes and materials from which the focus of activity emerges, because artistic work is centred on process and less so on fulfilling of a set of preconceived expectations (Mace & Ward, 2002).

The interdisciplinary nature of both collaborations required adjustments in working styles due to different methods and paradigms anchored in professional practice. In the following brief excerpt, both collaborators of the first collaboration give a perspective on how they approach their work. They were exploring new territory together with similar working styles:

> *MJ: "when we started working on Sim-Suite together, we started pretty much from scratch ...*

we had the wobble-board ... I brought in the wobble-board ... and I said this is the wobble board"
    MF: "yeah"
    MF: "it was completely unknown territory for both of us ... so it was ... your ideas and your skills were completely different to mine but we had to work together ..."
    MJ: "so we were able to formulate a way to do that"
MF: "of course we did"

The lead artist reflects on working together with collaborator MF:

MJ: "I work in a very intuitive way, I don't work in a structured way ... generally I start with a theme and explore, or I start with something I have made already ... with Michael [MF], that worked from the beginning quite well, Michael is an artist ... there was an immediate understanding, that's how we do it ... there was no real adapting in how we worked together"

Collaborator MF reflected similarly on his working style:

MF: "The process by which I make furniture is more artistic than design, whereas a lot of people design furniture with drawings and then work to their drawings ... but I don't do that at all with my work, I work off the cuff ..."
    MF: "I never make more than one thing anyway, so I'm always making prototypes ... but the thing is that when I'm making furniture it's more of a ... I'm just working purely by feeling ..."
    MJ: "right ... and you were able to share this approach with me because we were both ... working from a sort of ... place of feeling ... I mean I came in I had a feeling of where this was going ... and I had no idea really what it was going to look like in the end ..."
    MF: "yeah, no, no ... you had no idea ... well, neither of us did ..."

We now turn to the second collaboration where lead artist and collaborator JR entered the collaborative creative process on Sim-Suite's game development. In the following brief excerpt the lead artist reflects on working together with collaborator JR:

MJ: "With John [JR] there was definitely the habituating of the more intuitive in flux, ad hoc way, and that he had to get used to it ... he did not say anything, he didn't say oh I don't work this way or anything ... so there was definitely a getting used to each other, to the way we talk and way we work, and I think when he picked it up it was very obvious that's what was happening ..."

Collaborator JR reflects on his working style and on working with the lead artist:

JR: "I think, probably at the start, it was quite a shock to the system to work with an artist. It's a very different style of working ... I'm just fairly used to working with in the engineering world for example, where everyone is using the same language as it were and have all the same

ideas in mind. It's a very similar mindset but then when we started off working I think we were approaching things very differently, and then slowly came to understand how each other work, and what not ... we just kind of came to a common ground eventually, and then just kind of slowly evolved the whole thing as we saw it ...

Both collaborators mention that working together created the need to adjust language use with each other to ensure effective communication. In the following brief excerpt, collaborator JR explains in more detail how language use became synchronised between collaborators.

JR: "I think right at the very start ... we both were using similar words ... but had actually ... I think we were using different meanings for the words at that point, so effectively using different languages to try and explore the space ... and then slowly that converged and when we were talking about things we were talking about the same thing and we had this common understanding ... and also as that happened we were also exploring what we could do with the game [the virtual content of the installation] as well ... up to a point where actually now we had a feeling that we understood it a lot more and knew the ways in which we could, you know, change things and what not ..."

In the second collaboration, mutual adjustments were made regarding working styles and language use to guarantee productive interactions leading to the project's successful progress. The premise from which the collaborators were operating had several decisive features. Self-motivated and voluntary interest in the project; open communication exchange as equal partners in a working relationship; and shared contributions and responsibilities led to a self-organised collaborative creative engagement. These features are typical ingredients of interaction patterns that trigger high collaborative creativity with innovative outcomes, they are rarely observed in commercial settings (Argyris, 1969; Kirton, 1976; Kratzer et al., 2004; Nijstad & Paulus, 2003). On the other hand, artistic collaborations, such as performing musicians and stage performers, thrive on creative synergy which is based on personal motivation and voluntary participation (Kurtzberg & Amabile, 2001; Sawyer, 2003). As we have seen with these findings, newer art forms, where collaborative engagement is an essential aspect, exhibit the same starting points as traditional collaborative, interpretive art forms, and bring about creative synergy by devising successful interaction patterns.

Interaction patterns in collaborative creativity determine a collaborator's capability to initiate creative expression. Competence in communication is a major aspect in supporting constructive interaction patterns that build up shared understanding in creative collaborations. Differences in language use, as we saw in the second collaboration, is typically found in interdisciplinary collaborations, but is not attributed to discipline-specific terminology but rather to undetected specialised use of common words (Kylén & Shani, 2002; Epstein, 2005; Sonnenburg, 2004).

5.3 Late cycle: collaborative construction and implementation of the artwork

The preceding section discussed findings from the early cycle which included thematic selection and starting points, such as the working styles of each interdisciplinary collaboration. This section combines and illustrates findings from both creative collaborations, the lead artist with collaborator MF, and the lead artist with collaborator JR. Findings are focussed on the artwork's late cycle, its construction and implementation. In the first collaboration this refers to the structural support made from timber. In the second collaboration this meant the development and implementation of Sim-Suite's game and analogue sensor hardware.

In chapter four we outlined the theoretical underpinning of embodied cognition for this thesis. In this chapter we present findings from qualitative analysis that are conceptualised from the viewpoint of embodiment as discussed under the enactive approach to embodied cognition in section 4.2.2. Enactive cognitive science specifies that networks of interaction are established and operate throughout spheres of biological, physical and social embodiment. These networks of interactions function on all spheres through structural coupling to their context. They are organisationally and operationally closed, which enables each network to carry the pulse of interaction (biological, physical or social) through the network. Networks function through self-production, self-organisation and self-maintenance. Complexity is formed from nested and interrelated networks that engender coherence through mechanisms of autonomy and adaptivity.

By conceptualising this analysis' findings from the enactive perspective, we understand the creative process of each collaboration to be networks of interactions constituted by two individuals via shared creative intent and interdisciplinary collaboration. We speak of 'inter action', rather than action, to note that actions are mutually specified between cognisers and their environment. Each collaboration's network of creative interactions is structurally coupled with itself via the interacting collaborators and the interactions with the environment. Here are two distinctions to be made, the generating force that creates a self-produced boundary between the collaborators and their actions in the world, meaning specific actions only pertaining to the network of interactions that is responsible for the making of the artwork, is the process of ideation. This process closes the network organisationally by creating shared understanding. Ideas that are generated between the collaborators are birthed from mental conceptualisation, and capture the possible way to express each collaborators intent with the artwork. This way of thinking about a 'world of creation' is build up over time through verbalisations, discussions and exchanges between the collaborators, which are then synchronised in a singular idea, the idea to be implemented next. The material expression of this ideation-bound network is evident in the implemented ideas that have been created as artwork-in-progress and that can be viewed by anyone. Though, this material expression is not a one-to-one reflection of the ideation-bound network, which is inaccessible to any spectator, it lags behind the collaborators' current internal and verbalised state and intentions. Thus, the artwork-in-process can be understood as a trace of completed and recorded ideas.

The second distinction to be made is that the collaborators are structurally coupled in the context of their environment through the means that are used to create the physical manifestation of the artwork, which incorporates skilled movements, materials and tools. These support the

process of ideation as well as the material expression of this process. The emphasis here is that the collaborators interact as equals, meaning the execution of the task involved in the creation of the artwork occurs through self-responsibility. In other words, collaborators do not instruct each other. This then entails for each collaborator to devise ways of implementation through the use of specialised skill sets (interdisciplinarity) where expert knowledge is appropriated and applied to 'think outside of the box' and from the place of one's intent of creative expression. This self-responsible application of skills in the context of the ideation-bound network closes the network operationally.

The findings in this analysis are presented in the form of two models that show networks of physical and social dependencies and how these interrelate throughout the creative process. Each model is built up from conceptualisations of dependent phenomena which are shown from two perspectives. One perspective depicts the overall stages, the second perspective shows how the elements within stages relate to each other. The first perspective or first model we introduce in the next section explicates a view of the overarching network of creative interactions common to both collaborations. This view focusses on cycling stages of the creative process. It is imperative to understand that these stages are not meant to convey a linear procedure of the collaborations' creative processes. The stages proceeded in recursive fashion but without consistent sequencing. For example, stage three may have been preceded by stage one because of issues arising from the context of implementing a particular idea. Every stage is context-dependent on a particular situation which is what creates order in the process, but this is difficult to capture in a model. Also, since this perspective looks at common denominators between both collaborative approaches, it omits finer details.

The second perspective or the second model, provides a more detailed treatment of the collaborative creative process. The second model describes how elements in networks of creative interactions relate to each other throughout the second collaboration where collaborators developed Sim-Suite's game. The second model begins with 'idea generation' which is comparable to the second stage in the first model, where ideas were generated and formed, and illustrates a detailed view of specific aspects related to collaborative game conception and implementation. Game creation comprised a longer creative process because of its complexity. Also, collaborators reflecting on the creative process of game creation provided much richer data to elaborate on process details than those of the first collaboration.

5.3.1   Collaborative creative processes of timber construction and game implementation

In figure 5.1 we have graphically visualised the results of Sim-Suite's creative process data analysis. Inspired by pioneer Tufte (1992), this graphic visualisation of qualitative data realised from Sim-Suite's creative process analysis conveys results without renouncing the data's complexity which may have been lost in translation with a simplistic chart depiction. These results correspond to data from two separate collaborations, the first one centred on the physical construction of wobble-board encasements and timber platform, the second centred on game development with digital and analogue materials, programming and graphics. Figure 5.1 graphically illustrates stages

common to both collaborations. Words in clouds that appear larger and with stronger hues were repeated more frequently in the collected data. In this section we discuss these findings in reference to each stage graphically detailed in figure 5.1, and support each stage by quoting relevant passages from dialogic reflections by the lead artist's two collaborators.

5.3.1.1   Stage 1

In the first stage we concentrate on the upper part of figure 5.1, where we see a cloud of words that depict forms of verbal exchange. This stage is the entrance into Sim-Suite's creative process symbolised by the pink triangle at the top of the figure. This is also the beginning of each new cycle after successful assessment of an idea, which recurs throughout the entire creative process. Here, verbal exchange helped collaborators to make adjustments in each other's understanding of the situation. Verbal exchange also enabled collaborators to clarify next steps in the process, deciding together what was most effective in building upon the previously completed cycle. In both collaborations, perceptions and issues raised by the collaborators throughout the project were brought to a common denominator. Once there was a common understanding it created a starting point that led collaborators to the next stage. Verbal exchange further meant discussion of ideas; occasional sketching out of ideas for example on pieces of wood; a pooling together of ideas and reflecting on practical solutions; and contemplating possible ramifications of ideas further into the process. All of these interactions proceeded in a spontaneous manner and generated ad hoc results. As the creative process had passed initial cycles, stage one further served to look back on ideas and issues that were experienced earlier on.

Collaborator MF reflecting on stage 1:

MF: "... it depends on there were ... ehm, obviously hours of workshop time, where it was literally hands-on ... there were also many other hours of work just discussing it [the project] ..."

MF: " ... I mean the thing is ... I can remember debating with you often how something should be put together, where something should go and how it should move..."

MF: "... it [the collaborative process] was creative ... there was no blueprint, we weren't working from architectural drawings"

Collaborator JR reflecting on stage 1:

JR: "... we had some confusion over terms and sets ... we had ... and games ... we had this three tier of ... ehm ... division of the game ... ehm ... and I think initally quite some meetings we had this kind of confusion between us about what constitutes the set, what constitutes the turn, and many sets or turns to a game ..."

JR: "... because we started off with a fairly abstract goal, we wanted to explore, you know, some stuff ... and ehm, so we had to start somewhere, ehm, we can't just go directly to the finished thing which we don't know what it's going to be quite just yet ... so yeah, we just kind of started off with this and some bits ..."
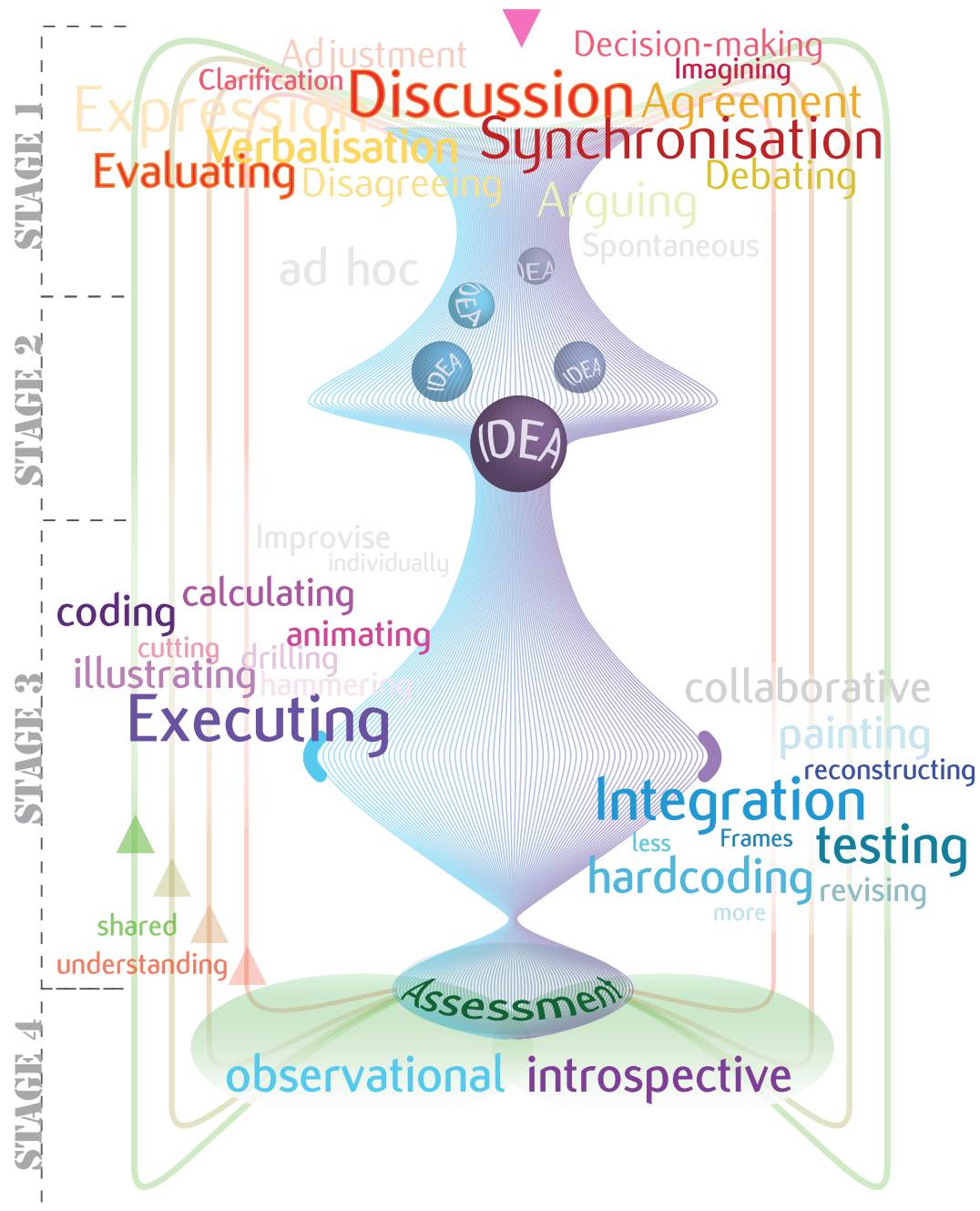
Figure 5.1: Descriptive model I: Visual representation of the common stages in the collaborative creative processes. This representation depicts one cycle, with stages indicated to the left of the figure. 'Word clouds' demonstrate activities that are centred on each stage.

5.3.1.2   Stage 2

We return to figure 5.1 to discuss stage two which represents the transition from verbal exchange to execution and implementation of an idea. In figure 5.1, this is illustrated with the word "idea", graphically contained in a sphere to symbolise that verbal exchange engendered an idea that was conceptually complete. Mutual understanding and conceptual steps to act upon the idea had reached satisfactory status between collaborators. One idea at a time was developed by executing and implementing the idea into the artwork-in-progress.

Collaborator MF reflecting on stage 2:

MF: "well yeah, but it had to be contained somehow otherwise it [the wobble-board] would be too random, so it had to be contained in a particular area ..."

MJ: "... that was a pretty straight forward kind of thing ..."

MF: "yeah, yeah, I would say so ... I think that was probably one of the first things that we ascertained ..."

Collaborator JR reflecting on stage 2:

JR: "I think we had the initial ideas which, ehm, propelled us in a direction, ehm, until we realised we can actually navigate ourselves once we gained confidence and more of an understanding of the game and possibilities of it ..."

JR: "yeah, trying to work out the very core important parts, distinguishing them from a number of ideas, and also just when you got a set of ideas to kind of reduce that down into just trying out one at the time you got to think, you know ... because right if I start ... I just need to get something working and from there slowly add bits to it, just get it working ... maybe we both had to kind of ... managing the other person's expectation as it were .... right from the start up to the point where we understood what was possible ..."

5.3.1.3   Stage 3

The third stage describes collaborators' actions that brought about physical results. In figure 5.1 this is referenced as the graphic area with most volume, where word clouds are located across from each other indicating task activities. Before ideas were translated into actual content, there were two steps necessary. The first step meant the task was executed by the collaborator, who had expert knowledge and skills to do so, and if possible was supported in the task by the second collaborator. In a subsequent step, individual production results where integrated into already existing content of the artwork-in-progress.

In the second collaboration, expert knowledge and skills were more specialised with digital materials, therefore more tasks were executed individually. The creation of Sim-Suite's game built on the interface structure as part of the working environment. In instances where collaborators were working away from this environment, for example on their individual specialised tasks,

they had to improvise in their work by mentally recalling physical aspects of the interface structure. In the first collaboration which took place in MF's wood workshop, collaborator MF led the construction of the wobble-board encasing and platform construction. Task sharing here actualised more collaborative action, especially in repetitive tasks such as screwing or drilling into timber. Working with physical materials and tools in a wood workshop, materials in the environment had a direct influence on how a certain idea was executed and implemented into the timber construction. This was due to the workshop's provision of found and recycled materials which became ad hoc material for task execution.

Collaborator MF reflecting on stage 3

MF: "yeah, we did lots of things ... we tried all manner of, ehm ... springs ... "

MF: "... but actually a lot of stuff we ended up using came from the workshop"

MJ: "yes"

MF: "like the bedsprings, which were kind of a fundamental part in the end"

MF: "the foam even, I remember even wrapping it [the wobble-board encasing] in fabric so the foam didn't deteriorate ..."

MF: "... once there are certain things in place, like once we had our discussions ... or once we'd done some drawings, or had tried some things that failed ...

once we knew a certain point, where the point was we were heading towards ... then we could both shut up and work towards it ..."

Collaborator JR reflecting on stage 3

JR: "I think some of the smaller and quicker things we went to the lab [studio] and we tried all these things out in the time we were both there and in the same room with the installation, ehm, because they were very small and quick to test out, but some of the larger more fundamental changes that we realised would needed to be made ... we just go off do our separate thing, and come back reconvene and have a look at it again ... "

JR: "I mean, sometimes when I went off and did something and just made something up ... yeah (laughs) when we got back ... we said, oh, I did this and that, or you go off and do some stuff, and do pretty much the same thing, just made this stuff up. So we kind of "glue" these back in [to the game] when we got back to the lab [studio] ... yeah, and see it all come together ..."

5.3.1.4   Stage 4

The final stage in the creative process' cycle was reached once an idea had been successfully integrated into the artwork-in-progress. In figure 5.1 stage four is shown by a green-coloured graphic cloud carrying the words "assessment, observational, introspective". Purposefully located on the bottom of the figure, this graphic visualisation is meant to convey that all previous stages "stand upon" the last stage, determining whether or not a conceptual idea had value in the making of the

artwork. Judgement was passed through introspection by each collaborator testing out the now advanced artwork as unit of interaction, or by observing other people's interactions and their reactions and comments on the artwork-in-progress. Reasons for unsatisfactory results were either the concept conveyed by the idea failed, or the idea's physical and material execution failed to integrate successfully with the rest of the artwork. In the former, the cycle returned to stage one. While in the latter case the cycle returned to stage three where collaborators had to find more appropriate ways to execute the idea for better integration.

Collaborator MF reflecting on stage 4

MF: "because it always did ... the fact that it came together as it did on the last day really ... ehm ... was a mixture of hard work and good fortune ..."

MJ: "yes I agree"

MF: "... and intuition"

MF: "I think trying it [the encased wobble-board] relentlessly or getting people to try it along the way... ehm ... probably helped us ironing out a lot of wrinkles ..."

MF: "apart from Wolfram [another artist in the building] who was there anyway at that time ... but everyone would stop by for a cup of tea would end up standing on the wobble-board for a while ..."

MJ: "... that's right"

Collaborator JR reflecting on stage 4

JR: "yeah, we did take them out [feedback arrows in the game] for a while and I think it was quite confusing for people who are playing it [the game] ..."

JR: "... and we realised that there was a problem it was mainly from just looking at the people who were playing it or often playing ourselves and realising that doesn't quite work, ehm, how else could it be ... perhaps if we change it that way (laughs) or give it a try ... give it another go and it's still not quite right if we do this ... give it a try it does not work ..."

This completes the presentation of findings on the four stages of Sim-Suite's collaborative creative process. On the one hand, each cycle through the four stages was instrumental in producing the final artwork, on the other hand, after each cycle collaborators grew in their shared understanding of each other and their process together. Shared understanding was synthesised from each passing cycle and furnished a new entry point for the newly beginning cycle. We had mentioned in subsection 5.2.1, when we discussed collaborators' working styles, how communication was an important aspect in forming effective interaction patterns to establish creative synergy, therefore we briefly present findings on shared understanding.

5.3.1.5 Shared understanding

In figure 5.1, the graphical depiction of vertical lines with arrow heads make up a prominent part on the left and right side of the figure, connecting the previous stages in circular fashion with each other. Alongside of creating the artwork physically, collaborators gained shared understanding of the project as well as each other. The collaborations laid down a common track between collaborators, with failures and successes, allowing for contemplation on past and future events, while attaining insights into each other's way of thinking, imagining, perceiving and expressing. Shared understanding was accrued by the sum total of circumstances spanning skill sets, materials, responses by others to the work-in-progress and time frames available for the project. Shared understanding was built up progressively with each process cycle that implemented a new idea, passing through all the stages of the creative process.

Collaborator MF reflecting on shared understanding

MF: "... and what appeared to work when people tried it ... what was possible to do, not just with the material, but with the limitations on tools and machinery that we had ... the limitations on my ability and skills ... but there were ... I suppose with every ehm, decision that was made had to take in all of those factors didn't it?"
MJ: "exactly, yeah ..."

Collaborator JR reflecting on shared understanding

JR: "... it would more and more ... it became much easier to kind of do changes ... and we kind of knew where the other person was coming from, ehm, and it was just a lot smoother ..."

We have now completed surveying the common stages of Sim-Suite's collaborative creative process. Both collaborations cycled through these stages regardless of materials used, tasks at hand, or differences in expertise and skill sets. Focusing on stages to understand the course of action, does not explain how elements are related to each other within stages. In the next section we take a closer look at how elements, such as environment and evaluation, are related to each other.

5.3.2 Idea generation and implementation of Sim-Suite's game

In the preceding subsection, we introduced the overall stages that were common to both collaborations using different materials and skill sets. In this section we present a finer level of detail from findings on the second collaboration between the lead artist and collaborator JR. Central to this collaboration is Sim-Suite's game development. During the second collaboration the collaborators worked with the finalised wobble-board encasement and all necessary analogue and digital hardware and software.

In figure 5.2 we graphically illustrate the network of creative interactions shaped by elements of this collaboration. Previously we have already introduced graphical visualisation as strategy to supplement the presentation of our qualitative findings (Tufte, 1992). In this subsection we

use this strategy again to highlight relationships between elements that constitute collaborators' network of creative interactions. We shall be presenting findings of reciprocal dynamics, which are descriptive of the collaborator's situated idea generation and implementation in the context of Sim-Suite's game development. The connection between figure 5.2 and figure 5.1 in the previous section is stage 2, which is indicated in figure 5.1 by 'idea' spheres. Although elements discussed in this subsection are viewed from a more detailed perspective, there is some overlap with stages discussed in the previous sections and illustrated in figure 5.1.

5.3.2.1 Relating conceptual context to idea generation

In figure 5.2 we see that 'conceptual context' contains both collaborators as well as ideas generated for the artwork. Collaborators work from *within* the 'conceptual context' by conceiving ideas for game-play, or some form of play, using wobble-boards and sensor technology as interface. The broad exploration over the lack of precise directive in their creative endeavours places this conceptual context into wider cultural definitions of play, game, game-play, gaming elements and gaming strategies. It is the link to shared cultural understandings of play and game which are drawn upon for the collaborative creative act. It is also in this context that collaborators make adjustments to synchronise and align communication and interaction patterns, as discussed in subsection 5.2.1.

'Conceptual context' is the mental territory from which the collaborators depart from and return back to according to their creative results. 'Conceptual context' as mental territory is joined with physical reality by spawning a perceptual vantage point. From this vantage point, idea generation is directed from within lived experience. This lived experience constitutes social interaction, for example observing others interacting with the artwork-in-progress.

The following excerpt from reflection dialogue between collaborators demonstrates how idea generation emerged from within the 'conceptual context' of lived experience. In this excerpt the collaborators compare two situations of idea generation. The first one is the intent to implement an idea that is commonly found in traditional game strategies, conveying the concept of placing an "obstacle" into a player's path. The second situation is linked to an 'observation', a practice play with members of the public as participants, that produced a circumstance in the game that had not been accounted for during the game development. It quickly had to be remedied with the creation of a particular "draw" graphic.

JR: "You mentioned at some stage that you wanted to have something else to happen ... which no one [player] could really control"

MJ: "this I do remember vaguely ... I remember wanting to do something that shakes them [the players] up"

JR: "... yeah and that's where the kind of obstacle thing comes in, or the thing we were talking about destroying a token or something ..."

MJ: "... but see I had no idea when we were at this stage I didn't know that would be an idea that would come up ... it just sort of evolved out of the situation ... within itself you know, it came sort of to me ..."
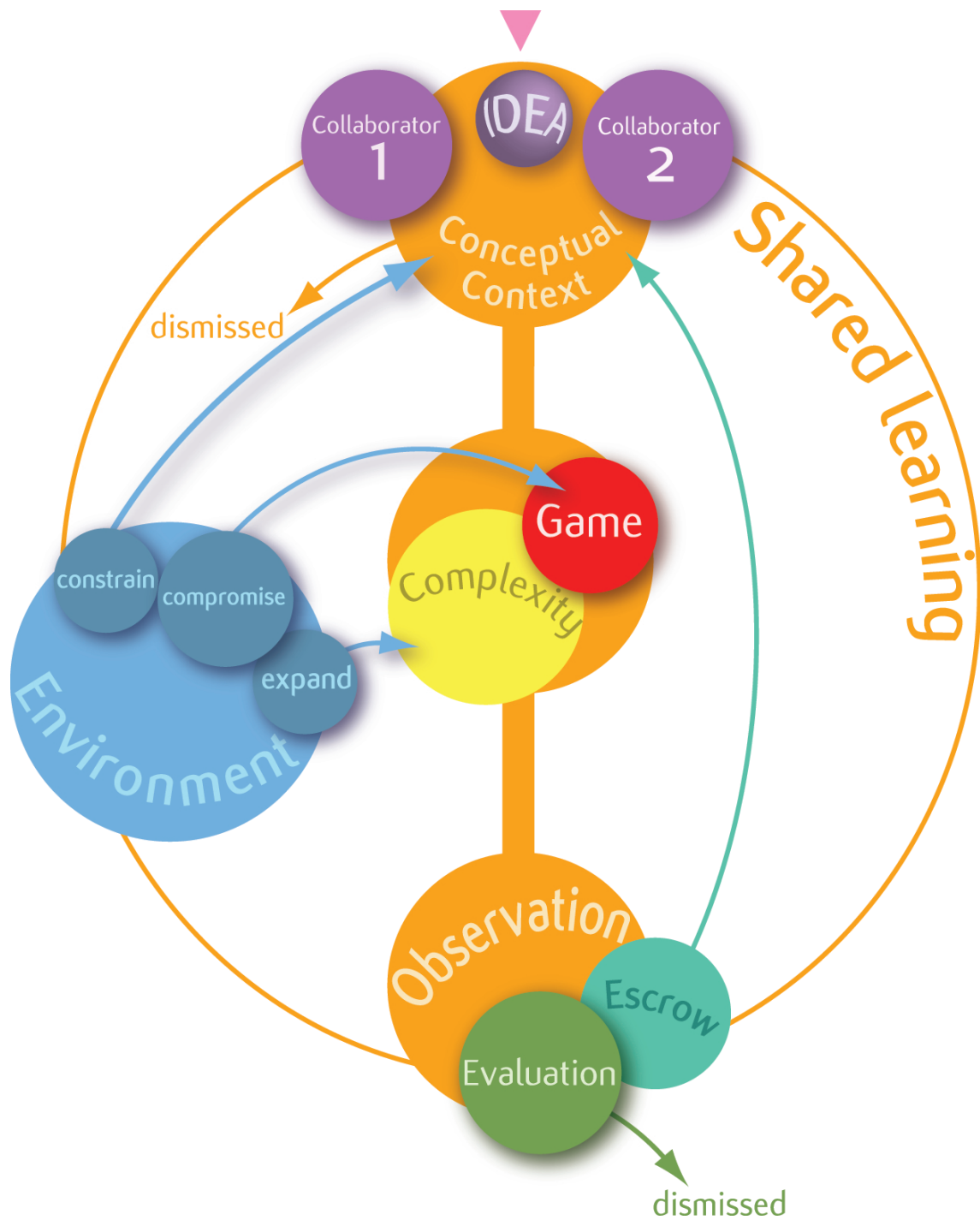
Figure 5.2: Descriptive model II: Visual representation of relationships between elements of the collaborative creative process that produced Sim-Suite's game.

MJ: "similar to, ehm, remember ... I had to make the graphic the night before [the first exhibition] because we didn't have a "draw" graphic"

JR: "... we didn't realise that was going to happen (laughs)" [after watching a group of participants practice play and create a "draw" as final outcome]

MJ: "because we didn't realise it was going to happen ... there were so many things like that ..."

JR: "we had a "draw" and I think we had some winning screens already ... but we didn't have a winning screen for the draw situation (laughs) yeah and we just needed to come up with something with all the players on it at the same time"

5.3.2.2   Relating environment to game development

Returning back to figure 5.2 we highlight the role of the 'environment' in the creative process. 'Environment' is a broad term that delineates and circumscribes external situations, conditions, access to materials and tools, physical locations such as studio or workshop but also the virtual, software environment that framed this creative endeavour.

With the actualisation of each idea, the artwork-in-progress grew in 'complexity'. How this increased level of 'complexity' was achieved depended on interrelations with the 'environment'. Environmental influence on creative thoughts shaped these thoughts into a tangible and physical product via a threefold dynamic that regulated game implementation and development. Aspects in the environment could either have an expansive effect, or a constraining effect, or cause the collaborators to come up with compromises when implementing their ideas. It could also be a combination of these influences on the work. These 'spheres of environmental influences' are shown in figure 5.2 as residing in the graphically depicted 'environment' field.

Figure 5.2 illustrates constraining influences by the 'environment' on 'conceptual context'. The project's collaborative nature was one of free exploration without imposed conceptual limits. Cultural conventions and definitions of play and game were the initial starting point within the 'conceptual context' when generating new ideas. These ideas were then evolved in a physical context. Putting it differently, collaborative exploratory actions were brought forward out of 'conceptual context' until they reached their limits in the physical world. Ideas then had to be re-directed in response to some form of limitation and an alternative path had to be forged. For example, certain limitations were reached in the manipulation of the materials, or other constraints were encountered, such as time constraints.

Figure 5.2 demonstrates an 'expansive' influence by the 'environment' upon creativity, where supportive developments acted as enabling force on the creative process. One example that functioned as support was the availability of a temporary studio space. Physical space gave access to store the wobble-board encasements and platform, which were previously stored in the workshop, but also monitors, sensor technology, cables and other hardware so that they could be used any time, day or night. Comfortable working conditions included the physical testing of every idea (discussed at a later stage), which optimised the creative process until completion. For the collaborators to freely unfold their collaborative creative process meant that they were able to move around the physical parts of the artwork-in-progress. The ability to do so enabled the collabo-

rators' mental efforts to unfold through their physical body which made their creative process unencumbered and free flowing. In the final stages of the 'game development' a small gathering with friends was arranged in the studio for test runs and feedback.

In figure 5.2, environmental influences operated directly on 'game' developments requiring collaborators to strike a 'compromise' between what they had in mind and the possibilities available during the implementation procedure. Compromising their ideas meant stripping an idea to its essence and seeking to convey this essence in digital form. When collaborators worked with ideas by finding a compromise during the implementation procedure, this may be construed as working along the seam of creative thought and physical reality. In other words, an idea may have been conceivable on the basis of imagination, but conditions, materials and tools were unable to support a real-world counterpart of this idea. Therefore, collaborators were bound to explore ways that would bring idea and real-world into coherence.

Although we have discussed spheres of environmental influences on the collaborative creative process of Sim-Suite's 'game development' as three separate entities, environmental influences could come together for a compounding effect. In some instances ideas could be entirely dismissed from the 'conceptual context' the collaborators were working in. One such example was a broad idea roughly laid out by the collaborators during the early stages of 'game development'. The idea was to create a separate mode of game-play. For purposes of production efficiency, the collaborators decided to leave an idea as placeholder in the game test bed, to be returned to and fully fleshed out later on. After some time spent in further 'game development', they returned to this place holder and rekindled their idea for implementation. As indicated in figure 5.2, realising that conditions had changed, because of time constraints imposed by their 'environment', they had to 'dismiss' the idea from their 'conceptual context' permanently, while considering this to be a lamentable decision.

In the following excerpt we return to the sphere of environmental influence that necessitated collaborators to strike a compromise during the implementation of an idea. The collaborators reflect on Sim-Suite's attract mode which runs when Sim-Suite is in standby, to attract participants to enter the installation. Ideas for video and animation had to be compromised because of technical and software limitations. A similar scenario was also experienced by the collaborators when they implemented Sim-Suite's tutorial for game-play.

MJ: "when we started to work on it there wasn't a welcome screen ["welcome screen" is the attract mode of the game which is an animation that loops in standby mode] and there wasn't a tutorial ... there was basically that one [virtual game] board and that was it ... so I had to come up with some ideas where ..."
JR: "I tried to get an animation in there and we were hoping to get a video in there ..."
MJ: "yes (laughs)"
JR: "and we head up against technical problems with [the software called]'processing' and memory, the way it deals with images and videos and nothing was really, it was kind of a compromise in the end wasn't it?"

MJ: "it was!"

JR: "you had to follow a limited set of frames to work with and a fairly small size as well"

MJ: "I think I had to make it shorter didn't I, I think I had one in the beginning and it was too long so I had to take out some frames ..."

JR: "yeah"

MJ: "and I was trying to remember today what I cut out ... it must have been one of the graphics ... It's basically sort of a pulsating kind of graphic ... so I took one pulse out, I took one movement out and I do remember squeezing it and ..."

JR: "it might have gotten slightly smaller as well when we just had some text around the sides"

MJ: "yes ... that also ... oh one of the reasons why we made a tutorial initially just like that on the screen is because we didn't have anymore [computer] memory"

JR: "we were hoping to have that in an animation as well or in a video"

5.3.2.3 Relating observation to evaluation and conceptual context

In figure 5.2, we see an orange graphic shape with three main fields directly connected with each other. 'Observation', 'game' 'complexity' and 'conceptual context' - these are conceptualisations that are specific points of reference for each collaborator as situated cogniser in the creative process. Earlier we explained that 'conceptual context' is joined with physical reality through a perceptual vantage point, providing a mindset as starting point for actions and interactions in the collaborators' creative process. Sim-Suite's game is the physical manifestation of this mindset and also the subjective perceptions expressed by the collaborators. In figure 5.2, it is therefore centrally placed between collaborators' 'conceptual context' and collaborators as observers. As mentioned in chapter four, the enactive perspective acknowledges that through our inherent observer stance we perceive subjectively and construct meaning accordingly. Throughout the collaborative game development, collaborators as observers were receiving consistent and perpetual feedback from physical reality on what had been created in terms of social interaction. They also perceived the latent potential of their creation, or the direction in which the work was unfolding naturally. However, the collaborators were mostly unaware of a persistent observational feedback loop between their creative intent, the outcome, and each other's, and other people's actions and reactions. On some occasions, the observational feedback loop became apparent to them without deliberate intent to observe. For example, this occurred the first time Sim-Suite's game was publicly played by participants. After such an occasion, both collaborators reconvened and shared their newly gained, and mostly broad, insights into their creation.

There were also junctures of deliberate 'observation' during the creative process, which are accounted for under the label 'evaluation' in figure 5.2. Deliberate 'observation' was performed with the intent to evaluate whether or not a particular game event, or the game as unit of interaction was successful. The former notion of evaluating singular game events refers to the collaborators' standard practice to implement a game event and immediately 'try it out' to assess it physically. This was done individually through a point of introspection, or intuition, as a form of self-evaluation through the acting body. The latter notion of deliberate 'observation' was directed towards oth-

ers, where collaborators recruited friends or colleagues as participants in Sim-Suite's game-play. This type of evaluation occurred at a later stage, when the game as unit of interaction could be evaluated rather than a series of unconnected game events. In these situations, collaborators deliberately observed others engaged with Sim-Suite's game-play while gauging from participants' physical movements and reactions whether game events were successful or had failed. In some cases participants verbalised their perceptions of Sim-Suite's game-play, which also supported the collaborators' 'evaluation' efforts. If a game event was assessed as being unsuccessful as implemented concept, it was taken out of the game and the concept was 'dismissed', which is graphically indicated with an arrow (next to 'evaluation') in figure 5.2.

In the following excerpt collaborators reflect on how they evaluated their work by using their introspection and intuition but they also reflect on the necessity of observing others play Sim-Suite's game to become aware, and able to better assess the game's interaction mechanisms.

JR: "... and when we realized that there was a problem it was mainly from just looking at the people who were playing it, or often playing ourselves and realising that doesn't quite work ... how else could it be perhaps if we change it that way (laughs), or give it a try, give it another go and it's still not quite right if we do this way ... give it a try ... it still does not work ..."

MJ: "what's the quite right thing? when you're saying you tried something and it's not quite right ..."

JR: "an intuitive feel I guess and also from seeing other people play it and just realising from either comments they're having or just from realising they are struggling ..."

JR: "I think we really did need that feedback from other people ... because ..."

MJ: "yes"

JR: "...by that point we were almost blind to some of the effects in the game"

MJ: "that's right"

JR: "... that are very obvious to other people coming to it fresh ..."

MJ: "but isn't that interesting that we both were blind to them because we both were so involved with the game"

JR: (laughs) "yeah, yeah"

MJ: " ... even though there is two of us ..."

JR: " ... we couldn't see the woods from the trees at that stage"

5.3.2.4 Relating evaluation to escrow

Returning to figure 5.2, we see that within the field 'observation' is an additional field labelled 'escrow'. In some cases an already developed game event was unsatisfactorily assessed and removed from the game. But the concept expressed by this game event had future potential, therefore the game event was placed into 'escrow'. At some later stage, this game event was returned to the game and revised to fit the evolved game context and 'complexity' level. Some game events went into holding several times because their concept was relevant but either execution or location within the interaction mechanism was not entirely satisfactory. Other instances included the

development of game events based on traditional game concepts. Once these game events were executed they were placed into holding because there was no real game context for them at this time in the game development, or the game event was causing confusion in the game-play at this stage.

The idea of 'escrow' allowed collaborators to go through the motions of physically creating game events that were at first dominated by cultural background and traditional associations of play and game. Collaborators did not perceive these game events as complete or as sufficiently original. But if these physically manifested 'visualisations' were evaluated as basically acceptable, they were then held in 'escrow'. This meant a kind of holding pattern where these game events were suspended from the game but available for instant retrieval. Meanwhile the game development continued to move on to other parts of the game.

In the following excerpts, collaborators first reflect on a game event created to score and display player's points, which also included the development of a scoring system. Initially, collaborators created a traditional approach to score Sim-Suite's game-play. This approach was revised multiple times to ultimately become a distinct concept suitable for the game context. Secondly, collaborators reflect on a game event that was created, implemented and placed into holding multiple times but without revisions. The concept communicated by this game event entailed a hidden shortcut that would allow players to instantly move from one side of the playing field to the other. This game event was put into 'escrow' because collaborators were not sure if it added to the interaction mechanism of Sim-suite's game-play. Eventually this shortcut was included and remained in the game. Also, collaborators reflect on other game events or decisions on interaction mechanism that presented a similar situation, such as whether or not a player can move across another player's token.

MJ: "... and then we had lots of revisions of this thing, do you remember that?
JR: "yeah so ... what different turns and rounds (laughs) and then we had those, we had the scoring"
MJ: "the display of the state of the game too ... it's almost like we made it more complicated in the beginning and then less and less complicated"
JR: "... we suddenly realised which bits were important and to keep ... and then just kind of got rid of all the other stuff which kind of wasn't really necessary it turned out"

JR: "... just the number of different ideas and different things that we did actually try ... since the very start we have gone through, we have tried a lot of different things, really ... I was just surprised by the sheer number of them, I mean little things, like, say move your piece the end of the board and we had two different ways we could deal with that ... we could either ... just not let them move anywhere, or let it wrap around like a kind of donut ... or some shape like that"
MJ: "... that's right and then the decisions also went back and forth at first we didn't and then we did it again ..."
JR: "... and also being able to move on to other people's pieces as well ..."

MJ: "oh yes"

JR: "the whole idea of yes you can ... no you can't ... or yes you can but ... if you don't move off something bad happens ..."

5.3.2.5 Relating shared learning to all elements

In figure 5.2, 'shared learning' graphically encircles all elements in the figure thereby indicating that the aspect of learning relates to all elements. Each action and interaction within the creative process provided an opportunity to learn individually and collectively. Through shared learning collaborators developed a shared creativity and built up their consensual domain. Within the consensual domain, collaborators started out by exploring ideas within a shared 'conceptual context'. This 'conceptual context' was bound by the 'environment' and focussed by a slowly emerging vision or direction of the Sim-Suite game. The vision flourished once collaborators had learned to move past re-creating traditional concepts of play and game and tailored their approach uniquely to Sim-Suite. Through shared learning collaborators were able to discriminate from the many possibilities of ideas for exploration and make adjustments to accommodate limitations placed upon them by the 'environment'. At the same time, collaborators as observers learned to appreciate cognitive capabilities of participants and incorporated this knowledge into their vision of the game. But they also learned to cope with their inability to evaluate implemented ideas beyond their own subjective perception. Shared learning progressively influenced each incremental step in the creative process until the artwork was completed.

We have now completed the presentation of this thesis' qualitative analysis and its findings.

5.4 Conclusion

In this section we create links between this analysis' findings and principles in embodied cognitive science as postulated in the theoretical lens in chapter four. This is part of this thesis' overall exploratory approach. It suggests ways of thinking about theoretical conceptualisations of embodiment from the real-world perspective, and the cognitive aspects that have been foregrounded in the preparation of the 'field of artistic communication' in this long-term, collaborative engagement. We set out to analyse the collaborative creative process, by those who created the artwork Sim-Suite, from data obtained through dialogic reflection. The theoretical lens from which this analysis was conducted drew on enactive principles in embodied cognition. From this perspective we looked at the collaborative creative processes as networks of creative interactions within their social embedding and material environment.

A general conclusion from these findings is that creative behaviour was invoked by mental processes and completed through the integration of physical action and the handling of material content. In the first section of this chapter where we discussed findings from the early cycle of individual as well as collaborative processes, we demonstrated that through the physical and the material world ideas were triggered for creative exploitation. Ideas were then restructured using linguistic symbols to graft an externalised dynamic scaffolding, and encourage active and physical

creative engagement.

The first instance of this restructuring was revealed during the problem-finding stage of thematic selection for the artwork leading to insight. Insight was discussed in chapter two as possibly occurring through analogical transfer. In these findings we see that the contextual cue of "full-body motion" created spontaneous analogical transfer, with more tangible, physical qualities, namely "standing on a moving ground". This step led to creative insight which guided exploration even more concretely into the physical and material world by advancing the project to the selection of a physical object, the wobble-board. Recall that experiments underpinning the Geneplore model requested subjects to use their imagination in utilising drawn representations of three-dimensional preinventive forms for inventions that were both practical and creative. By contrast, in this study's real-life context it was linguistic restructuring that led to an actual object as starting point for invention.

From the findings we saw that the second instance of restructuring took place within the overarching problem-solving activity of Sim-Suite's game creation. The collaborators were creating their cognitive niche using linguistic symbols for scaffolding by creating a common language between each other. They were labelling concepts of game-play interaction routines that corresponded with the material (including the virtual) reality they were dealing with during their creative process. Cognitive niche construction opened up pathways for idea generation and implementation where language and physical materials functioned as an inseparable unit, and enabled collaborators to manage these pathways within the limits of the environment.

Dynamical linguistic structuring and restructuring for cognitive niche construction implies operating relative to the knowledge base of existing cultural practices (Clark, 2006a, 2006; Lakoff & Núñez, 2001; Donald, 1991). In the course of the project, Sim-Suite's collaborators transformed existing cultural practices, related to several domains, into a vehicle for creative expressions. Here, two perspectives were demonstrated by this study's findings. In the first perspective, we saw that individual expert knowledge rooted in conceptual paradigms disclosed through methods and tool use offered a starting point to enter the collaborative process and self-determine one's participation. During the process of game development, when this expert knowledge was applied within idea generation, execution and implementation, the actions involved were based in cultural practices. These actions were transformed to adopt, add, reconfigure and adapt traditional game-play interaction routines into the unique context of Sim-Suite's interface, essentially granting creative innovation.

In the second model we mentioned the notion of 'escrow' which may build on the research that was discussed on cognitive niche construction with epidemic actions in section 4.2.1.5. These actions appeal to mental state changes through active participation in the problem-solving task, although the outcome does not have actual results in advancing the solution. These types of actions are considered as simplifying one's cognitive load and improving cognitive engagement. In the context of our findings, the rendering of conventional game-play concepts into physical form allowed the collaborators to evolve these concepts creatively. Having created a manifested visualisation first, the collaborators were able to innovate these concepts into a new form because

they were working from perceptual feedback loops. Otherwise, the collaborators would have had to revise these traditional game concepts mentally, holding the entirety of a game concept in their imagination. Devising the notion of 'escrow' suggests cognitive offloading to increase the collaborators' creative capacity.

We saw that situated creative acts are influenced by environmental cues and affected all aspects of reflective thinking, verbalised thinking, and action. Enactive cognitive science posits that agents, in this case the collaborators, enact a meaningful world through embodied action where perpetual and biological motor capacities function together intertwined with the environment. In real terms that meant the creative process emerged in proportion to a layering of constraining, expanding and compromising dynamics and the social aspects and capacities that could function within these influences. We saw in the second collaboration that influences from the environment upon the creative process had immediate effects on how these enabled and shaped creativity and application of collaborators' skills sets. During the second collaboration when collaborators' were working on independent tasks without access to the physical interface components, creative mental processes were applied without the physical as guiding principle. In these cases collaborators had to draw on their improvisational skills for task completion. In the first collaboration, the richly stocked wood workshop provided a material resource in the collaborative construction of wobble-board encasements and platform. Available materials simply deposited within the immediate working environment offered solutions to ideas and problems that could not be grasped solely by mental efforts and subsequently executed through appropriate action. Finding solutions was a matter of trial and error in finding appropriate materials to complete construction efforts.

Beyond the fact that immediate influences from the environment have impacted the collaborative creative process dynamically, this influence also extends to a larger, temporal scale. These are the aspects that operate in defining a cultural age of society. Here we saw that the creative process creating Sim-Suite utilised technologies and materials available in this day and age, which reiterates the gap addressed by this thesis. The initial research gap mentioned in the first chapter rose out of context of art forms that have taken advantage of new tools and therefore instigated a domino effect on all aspects of contemporary artistic creativity.

Enactive cognitive science postulates that by definition cognitive systems as situated agents have a perspective of the world that is subjective. With regard to real-time existence, agents are stimulated by simultaneous parallel activities of perceptuo-motor systems, which propel them into an ongoing process of updating their situated subjective perspective while adjusting to dependent contingencies (Varela, 1991). Due to this defining and re-defining of the agent's subjective perspective, the lived experience is flexible and heeds momentary potentialities. These potentialities are directed by intentional acts. In the creative process of both collaborations, planning was not an aspect of creative engagement, interactions and steps forward were conducted mostly moment to moment as lived experience. The collaborators handled every moment as it occurred and dealt with the contingencies accordingly. A self-organised structure of actions emerged from the creative engagement in both collaborations, although each collaboration was differentiated by task activity, usage of materials, methodologies and technologies. We demonstrated this "natural order" with

the cycling four stages (not necessarily sequential) in the first model.

We saw that collaborators as observers performed intentional acts that enhanced their creativity based on their capacity for subjective experience and intersubjectivity. The collaborators' creative process was guided through the intentional act of constructing an interactive artwork, which composed an experience for 'another'. This meant that 'another', namely Sim-Suite's participants, were physically and cognitively committed when engaging with Sim-Suite's game-play. The intentionality to create the artwork for 'another' through empathetically relating to the 'other' was grounded in observation as part of the subjective experience. We discussed in chapter four that in enactive cognitive science the primary stance on intentionality is that it is object-directed experience, where the object is present in shared space. In the case that the object is absent, subjective experience evokes (rather than remembers) the object in question through re-representation. In modelling the collaborative creative process, we defined observation from the enactive disposition of subjective experience.

In enactive cognition, observation is the 'default' state of subjective experience. In this research, observation brought about intentional acts and empathy in two ways. In the first instance collaborators assessed their incremental work by testing it out introspectively with the 'other' in mind as undefined, 're-represented other'. In the second instance, collaborators deliberately observed 'others', as they watched them interact with the artwork in shared space. The collaborators then judged the success of their work by participants' reactions, actions, and comments. The collaborators' subjective experiences of these situations entailed perceiving and sensing participants' engagement through their empathetic capacity. For example, collaborators understood if a participant was struggling in testing the wobble-board or playing Sim-Suite's game, although they might have not been able to reason through the cause for this struggle. Passive or involuntary coupling of one's living body with that of another through perception and action is the primary type of empathic embodiment from the enactive standpoint.

Lastly, we address 'shared learning' and 'shared understanding' as connective fabric between all elements in both models. Shared learning is the active aspect of shared understanding. Shared understanding is discussed in the second model as relational activity relevant to all elements of the collaborative creative process. Here we draw on the concept of sense-making discussed in enactive cognitive science, which is understood as the result of the self-affirming, identity-producing process from which sense-making emerges in an adaptive manner within the domain of interactions. 'Shared learning' resulted in 'shared understanding' giving identity to the collaborators as a coherent unit, as creators of Sim-Suite. In this united process, 'shared understanding' created persistent feedback loops between the collaborators and their engagements, reaffirming the project's objective through their verbal exchanges, actions and assessments of their work.

This concludes the qualitative analysis of this thesis. In the next chapter we are looking at Sim-Suite's creative participation via quantitative analysis.

Chapter 6

Exploratory statistical analysis of creative engagement by Sim-Suite's participants

6.1 Introduction

In this chapter we present the quantitative analysis in our mixed method approach to this thesis. This chapter's analysis represents the parallel approach to the qualitative analysis performed in chapter five. In chapter one we explained that advancements in contemporary artistic creativity have blurred the dividing lines between artists and audience. Both parties are creatively engaged, they are actively taking part in the 'field of artistic communication'. In chapter five we investigated the collaborative creative process of the Sim-Suite team members in the preparation of the 'field of artistic communication'. In this chapter we investigate the creative participation by members of the public when engaging with Sim-Suite's 'field of artistic communication'.

In chapter one we proposed a supporting research sub-question for this analysis: "What are the embodied cognitive aspects that are expressed as creative participation in the 'field of artistic communication' in a short-term, immersive engagement with others?" This question has been guiding the exploratory approach to this quantitative analysis. In this chapter we present the statistical results.

The analysis explained in this chapter is structured in four stages, respectively sections 6.2, 6.3, 6.4, 6.5. Each stage represents one step into this thesis' statistical exploration of Sim-Suite's logfile data. In section 4.3.3, where we provided background to this thesis' quantitative analysis, we explained in the subsequent subsections how we computed variables and data sets from Sim-Suite's logfile. Data extracted from Sim-Suite's log file was first parsed into individual and complete games. These games were replayed via a specifically written program and studied to extract a number of variables. In subsequent steps these variables were made operational as spreadsheet data in the form of two data sets. The first data set contains data of individual games on a round-by-round basis, the second dataset, derived from the first one, contains the means for each variable of individual games. As previously explained this allows the analysis to be conducted

within games as well as across games.

Our statistical results are contextualised in section 6.6 where we conclude this chapter. In chapter seven, we give an account of the creative process continuum which incorporates the results of this chapter, and answers the overarching research question of this thesis. Here, the results from chapters five and six are placed next to each other in the context of a series of themes in embodied cognition.

This thesis' statistical analysis is conducted with software SPSS (Release 18.0.2 2010), utilising descriptive statistics, Pearson's correlation, cluster analysis (Ward's method), cross tabulation and case summaries, as well as various conversion formulae utilised in Microsoft Excel (Version 12.2.5. (100505)). This is an exploratory analysis, aiming to identify patterns of creative social interaction through a set of variables that capture key elements of the designed interaction mechanism in Sim-Suite's game-play.

6.1.1 Summary of analysis

In this section we give a brief overview of this thesis' analysis which is expanded and reported in detail in the four stages of this chapter. In the first stage we introduce classes of variables used in data sets, and also present these graphically as pictograms throughout this chapter to simplify reading results in a variety of contexts. In this stage, we perform descriptive analysis on the derived data set noting a positively skewed result with a disproportional number of 5-round games. Because of the minimal social interaction of these games, we therefore reduced the derived data set to only include games having 7 or more game-rounds. A correlation matrix of all variables' intercorrelations was then produced with the smaller sample. Defensive behaviour emerged as a variable with which numerous other variables correlated. This was taken as suggestive that defensive behaviour is an important factor or dimension of gameplay.

In chapter three we suggested that *strategic token shape placement* is part of the stratification of creative participation in Sim-Suite. In section 3.3.2.1, *strategic token shape placement* was defined in two ways: 'tactical placement of one's token in the current game-round' and 'tactical blocking of another token shape in the current game-round'. Defensive behaviour scores are grouped in the latter, they present an opportunity to investigate potential game-play patterns related to this aspect in Sim-Suite's creative participation. In consideration that defensive behaviour plays a strong role in forming variable correlations on an elementary level, we see this result as a starting point from which to conduct further statistical investigations.

Consequently, in the second stage we home in on defensive behaviour. First we standardise scores to normalise the range of units present within the derived data set. For example, one unit is in milliseconds for variables that yield the longest time a token is held on the game-board in a particular round, another unit is an integer with binary value, such as variables indicating a token's fly-off from the game-board in a particular round. Subsequently we computed a composite variable from the defensive variable means of all tokens, and calculate descriptive statistics for this compound variable. We use this variable's median to create two groups of games via a median-split.

The first group of games contains scores below the median, it is the low defensive behaviour group; the second group of games is made up of scores above the median, it is the group of high defensive behaviour scores. Splitting defensive behaviour scores into two groups of low and high scores provides a comparative view to types of creative participation. From the perspective of 'tactical blocking of another token shape in the current game-round', higher scores of defensive behaviour point to more or better tactical blocking. Hence, they show more creative participation within the 'field of artistic communication', and therefore may exhibit different patterns of game-play than those of low defensive behaviour scores.

Next, we approach each group with cluster analysis to elucidate cluster groupings with common attributes. Cluster analysis is useful in this context because identified cluster groupings are groups of games that share similar underlying relationships between variables. These relationships are difficult to discern through visual perception and a statistical, computational approach such as cluster analysis can render underlying features accessible. This supports our aim, focussing on the understanding of embodied cognitive aspects related to the procedural character of creative participation through potential game-play patterns by groups of participants.

We perform cluster analysis and produce 3 cluster groupings of games for each group, that is 3 in low defensive behaviour scores and 3 in high defensive behaviour scores. To aid the interpretation of each emergent game cluster, we identify the intercorrelations between variables for each game cluster. We calculate correlation matrices to illustrate relationships among variables in each cluster grouping. Here we discover a number of attributes for each cluster grouping in both groups of defensive behaviour scores. We introduce two types of symmetry correlations, panoptic correlations, token axis distribution, and self-referential correlations.

In the third stage we focus on the average difference of low and high defensive behaviour scores to provide a complementary perspective to the previous one on variable relations. Here we present the means of the main variable classes of low and high defensive behaviour scores, and look at the highest and lowest variable means of each variable in each group defensive behaviour scores. The results support and confirm phenomena discovered in the second stage of the analysis.

Stage four is the final stage, here we take a look at games over time by utilising 'raw' data, that is we analyse the data set comprised of games by rounds. In this stage we devote our attention to corporeal variables which provide information on player's physical activity. Three corporeal variables for each token shape are investigated in their trajectories over time. The results show support for synchronous movement, or interactional synchrony as it is called in cognition research, and also token axis distribution uncovered in the previous stages.

We conclude this chapter by contextualising results from the perspective of embodied cognition, by mapping it to research topics of coordinated joint attention, task sharing, action observation, joint action, and relate these to this analysis' results on synchronous movements and physical location in space.

(a) *nrig*

Figure 6.1: Pictogram of timeline variable *nrig*

(a) *Coff*   **(b) *Csq***   **(c) *Ctr***
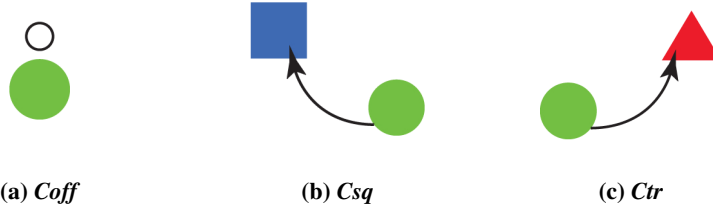
Figure 6.2: Pictograms of passive and active strategic variables for Circle token

6.2   Stage 1: General statistical overview

In this stage we first introduce components needed to conduct statistical analysis. We start by defining and listing variables and sample size. We follow this by implementing descriptive analysis on these variables, and demonstrate on a number of histograms a positively skewed result. This initiates a reduction of the sample size, eliminating games with less than 7 game-rounds. With the new sample size of games 7-rounds and higher, we assess the relationship of variables and variable types via a correlation matrix. This matrix emphasises correlations with variables that express defensive behaviour. We pursue this notion further in stage two.

6.2.1   Introduction to variables and pictograms

Variables are established around token shapes. Sim-Suite's game engages three players and each player represents him or herself in the game using one of three unique tokens. The three tokens have each a specific colour and shape. Circle token is green, Square token is blue and Triangle token is red. We shall be listing variables that are token specific but also other variables that are higher-level variables which determine attributes across games, we call these global variables.

The derived data set contains the following variables:

gameset

A global variable enumerating the total number of games in the data set. This variable has no corresponding pictogram.

nrig

This global variable stands for "number of rounds in games". It indicates the total number of rounds in a game in the *gameset*. It is also called *maxrnds* in the 'raw' data set. The pictogram

(a) *Cnoflyoffs*   **(b)** *ltci*   **(c)** *Cfldmvgme*
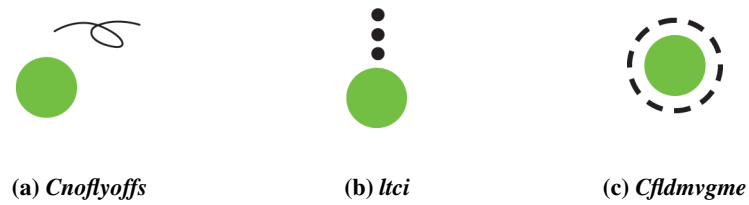
Figure 6.3: Pictograms for Circle token's corporeal variables.

(a) *Soff*   **(b)** *Sci*   **(c)** *Str*
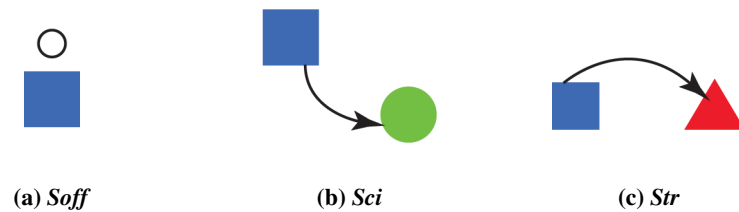
Figure 6.4: Pictograms of passive and active strategic variables for Square token.

(a) *Snoflyoffs*   **(b)** *ltsq*   **(c)** *Sfldmvgme*
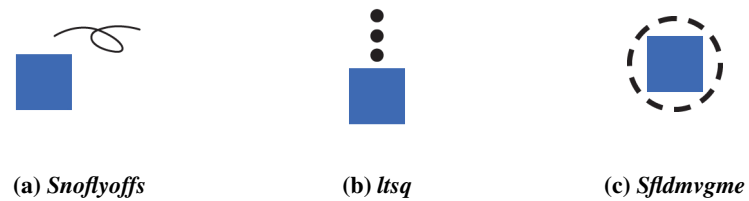
Figure 6.5: Pictograms for Square token's corporeal variables.

(a) *Toff*   **(b)** *Tci*   **(c)** *Tsq*
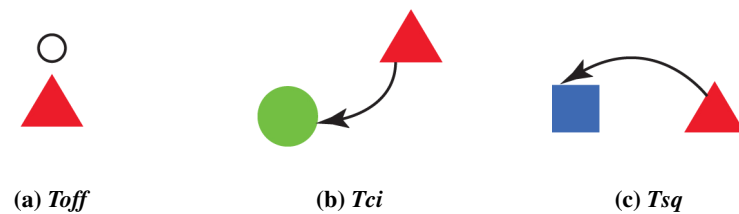
Figure 6.6: Pictograms of passive and active strategic variables for Triangle token.

(a) *Tnoflyoffs*   **(b)** *lttr*   **(c)** *tfldmvgme*
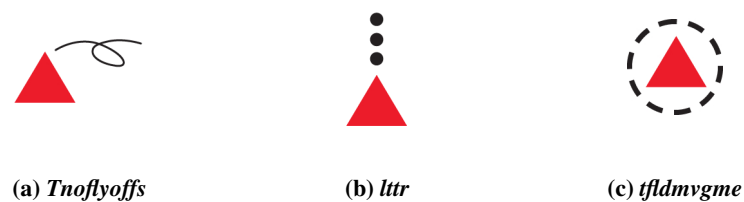
Figure 6.7: Pictograms for Triangle token's corporeal variables.

for this variable is illustrated in figure 6.1.

winningshape

This variable indicates winning token shape per game expressed as variable with three letter strings: "CIR" "SQU" "TRI". This variable has no corresponding pictogram.

Coff

This variable indicates Circle token's offensive behaviour.
The pictogram for this variable is illustrated in figure 6.2a.

Csq

This variable indicates Circle token's defensive play against Square token.
The pictogram for this variable is illustrated in figure 6.2b.

Ctr

This variable indicates Circle token's defensive play against Triangle token.
The pictogram for this variable is illustrated in figure 6.2c.

Cnoflyoffs

This variable indicates the number of times Circle token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.
The pictogram for this variable is illustrated in figure 6.3a.

ltci

This variable indicates Circle token's longest-held position in milliseconds on a field of the game-board.
The pictogram for this variable is illustrated in figure 6.3b.

Cfldmvgme

This variable indicates Circle token's number of fields traversed on the game-board per round.
The pictogram for this variable is illustrated in figure 6.3c.

Soff

This variable indicates Square token's offensive behaviour
The pictogram for this variable is illustrated in figure 6.4a.

Sci

This variable indicates Square token's defensive play against Circle token.
The pictogram for this variable is illustrated in figure 6.4b.

Str

This variable indicates Square token's defensive play against Triangle token.

The pictogram for this variable is illustrated in figure 6.4c.

Snoflyoffs

This variable indicates the number of times Square token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.

The pictogram for this variable is illustrated in figure 6.5a.

ltsq

This variable indicates Square token's longest-held position in milliseconds on a field of the game-board.

The pictogram for this variable is illustrated in figure 6.5b.

Sfldmvgme

This variable indicates Square token's number of fields travelled on the game-board per round.

The pictogram for this variable is illustrated in figure 6.5c.

Toff

This variable indicatesTriangle token's offensive behaviour.

The pictogram for this variable is illustrated in figure 6.6a.

Tci

This variable indicates Triangle token's defensive play against Circle token.

The pictogram for this variable is illustrated in figure 6.6b.

Tsq

This variable indicates Triangle token's defensive play against Square token.

The pictogram for this variable is illustrated in figure 6.6c.

Tnoflyoffs

This variable indicates the number of times Triangle token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.

The pictogram for this variable is illustrated in figure 6.7a.

lttr

This variable indicates Triangle token's longest-held position in milliseconds on a field of the game-board.

The pictogram for this variable is illustrated in figure 6.7b.

Tfldmvgme

This variable indicates Triangle token's number of fields traversed on the game-board per round. This pictogram for this variable is illustrated in figure 6.7c.

All variables are categorised and each category has been named to reflect the type of variable that is represented. There are three categories which are listed and briefly explained below.

6.2.1.1   Strategic variables

This class of variables is shown in the form of pictograms in figures 6.2, 6.4, and 6.6. Within this category are passive and active strategic variables. Passive strategic variables describe offensive behaviour which is the primary pursuit of good token placement on the game-board. Passive strategic variables are *Coff*, *Soff* and *Toff*.

Active strategic variables describe defensive behaviour against opponents. Each token shape has two opponents, thus two active strategic variables. They have been introduced by their pictograms in the afore-mentioned figures, they are *Csq* and *Ctr* for Circle token; *Sci* and *Str* for Square token; and *Tci* and *Tsq* for Triangle token.

6.2.1.2   Corporeal variables

The pictograms for corporeal variables are shown in figures 6.3, 6.5 and 6.7. Each token shape has three different corporeal variables *Cnoflyoffs*, *ltci*, *Cfldmvgme* for Circle token; *Snoflyoffs*, *ltsq*, and *Sfldmvgme* for Square token; *Tnoflyoffs*, *lttr*, and *Tfldmvgme* for Triangle token. These variables express physical activities during game-play, of which the basic one tracks the number of fields traversed on the game-board per round. Physical activities have to do with the player's ability to manage his or her token in the game. If unable to do so, one loses one's token when it flies off the game-board during a particular round. Thus, keeping track of "fly-offs" is captured in a corporeal variable. Other physical activities include holding one's token stationary on a field of the game-board during game-play while having to move on the wobble-board at the same time. Physical ability manages and accommodates these aspects of game-play.

6.2.1.3   Timeline variable

This variable is a global variable which depicts number of rounds played in a Sim-Suite game. The game length of a Sim-Suite game is dependent on the number of rounds played by all three players until the end of a set. This variable is shown as pictogram in figure 6.1. Remaining variables such as *gameset* and *winning shape* are not categorised in classes.

At this stage, the sample size is

$$n = 220 \tag{6.1}$$

There are 220 games in the derived data set, which range from 5-round games, the minimal number of rounds that have to be played to win Sim-Suite's game, to 24-round games which are the maximum number of rounds per game in the data set. 24-round games were the longest games played by Sim-Suite participants.

6.2.2 Central tendencies for variable means

The derived data set was imported into SPSS and statistical procedures were performed which will be broken down for this thesis into four stages. In this first stage, descriptive statistics were calculated to obtain a general overview of the derived data set. Results are shown in figure 6.8. In addition, frequency distributions were elicited from descriptive analysis. We are showing some examples of frequency distribution in the form of histograms on a number of variables, such as variable *nrig* in figure 6.9, variable *Cnoflyoffs* in figure 6.10, variable *Snoflyoffs* in figure 6.11, and variable *Tnoflyoffs* in figure 6.12.

In general variable means in figure 6.8 for variables specific to Circle, Square and Triangle token do not exhibit notable or significant differences. There are some individual differences for example, the variance for Square and Triangle tokens are closer in value than that of the Circle token. The Triangle token stands out for high offensive behaviour signified by *mode* at 8.40 and *maximum* at 9.00. In contrast to Circle and Square tokens, Triangle token has a rather low value in *mode* for variable *lttr*.

In the figures that show frequency distribution, for example variable *nrig* in figure 6.9, we see a positively skewed result. Here, the highest frequency is 62 with 5-round games followed by frequency 42 with 6-round games. Frequency distribution of variable *nrig* is dominated by 5-round games. These positively skewed results persist throughout the derived data set as we have demonstrated with histograms of variables *Cflyoffs, Sflyoffs* and *Tflyoffs*, see figures 6.10, 6.11 and 6.12.

When playing Sim-Suite's game, creative behaviour is socially enacted. In the interest of the thesis' aim to reveal aspects of embodiment in creative behaviour particular to the situated artwork Sim-Suite, the collection of the data 'in the wild' reveals noise which has to be addressed before we start the main analysis. In the subsection 3.3.2.1 we stated the definitions of creative behaviour within the Sim-Suite game, these were used to design statistical variables. A closer look into the frequency distribution of game length and the heavily skewed result, discloses that games with the game length of 5 and 6 rounds do not contain a sufficient number of rounds to incorporate the full complement of indexes (as defined in 3.3.2.1) that are needed to make a reliable statistical point. In consideration of these reasons, as well as the fairly large sample size (n=220) available for this analysis, we omit all 5-round and 6-round games from further statistical investigations.

The new sample size for the remainder of this analysis is variable *nrig* is greater or equal to 7-round games:

$$n_7 = 117 \qquad (6.2)$$

We now leave descriptive statistics and turn to an exploration of relationships among vari-

	nrig	CIRCLE Token				
		Coff	**Csq**	**Ctr**	**Cnoflyoffs**	**Itci**
Mean	7.68	4.93	2.61	2.51	0.97	5666.67
Median	7.00	4.95	2.56	2.40	1.00	5528.65
Mode	5.00	5.00	2.00	2.00	0.00	4981.83
Std. Deviation	3.16	1.72	0.88	0.87	1.21	1328.06
Variance	9.96	2.95	0.77	0.75	1.47	1764000.00
Range	19.00	7.60	4.57	4.77	6.00	8014.63
Minimum	5.00	1.00	0.43	0.43	0.00	3050.00
Maximum	24.00	8.60	5.00	5.20	6.00	11064.63
		SQUARE Token				
		Soff	**Sci**	**Str**	**Snoflyoffs**	**Itsq**
Mean		4.94	2.60	2.58	0.93	5714.33
Median		4.75	2.50	2.40	1.00	5488.42
Mode		4.00	3.00	2.00	0.00	5371.80
Std. Deviation		1.78	0.86	0.94	1.25	1466.01
Variance		3.16	0.73	0.88	1.57	2149000.00
Range		7.46	4.70	6.23	7.00	10464.27
Minimum		1.25	0.70	0.38	0.00	2762.40
Maximum		8.71	5.40	6.60	7.00	13226.67
		TRIANGLE Token				
		Toff	**Tci**	**Tsq**	**Tnoflyoffs**	**Ittr**
Mean		5.13	2.55	2.58	0.9	5695.98
Median		4.90	2.43	2.50	0	5498.80
Mode		8.40	2.40	2.000a	0	2630.17
Std. Deviation		1.80	0.83	0.82	1.358	1388.76
Variance		3.23	0.69	0.67	1.844	1929000.00
Range		7.57	4.66	4.50	11	7891.63
Minimum		1.43	0.94	0.90	0	2630.17
Maximum		9.00	5.60	5.40	11	10521.80

a. Multiple modes exist. The smallest value is shown

Figure 6.8: Results for descriptive analysis conducted on strategic variables and some corporeal variables with mean, median, mode, std. deviation, variance, range, minimum and maximum of variable means for a total of n= 220 games.
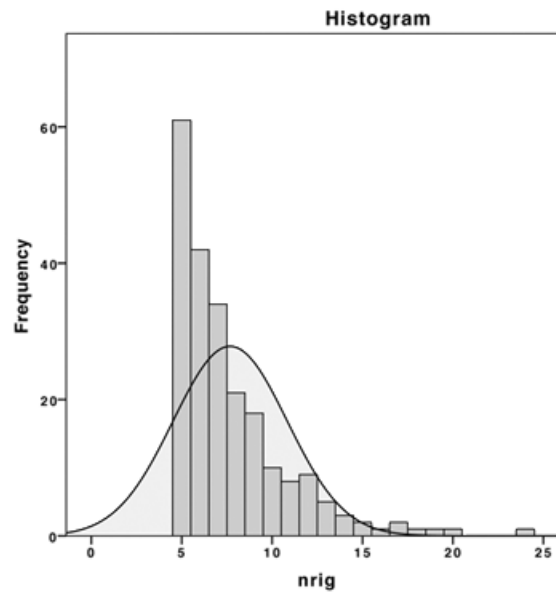
Figure 6.9: Frequency distribution of number of rounds in games, expressed by variable means of *nrig*. The normal curve is plotted to show distribution as positively skewed.
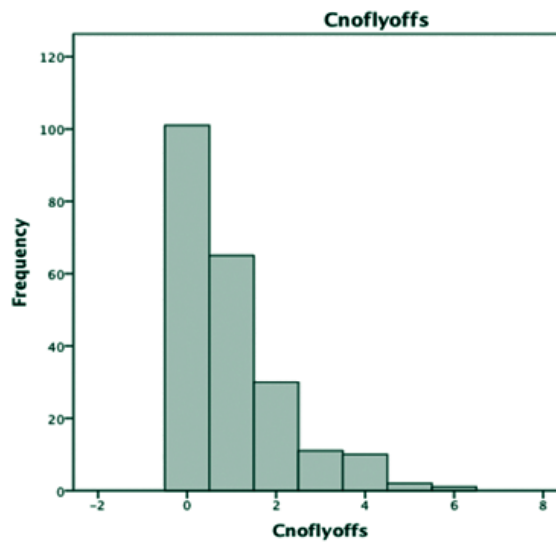
Figure 6.10: Histogram of variable means *Cnoflyoffs* illustrates a positively skewed result.
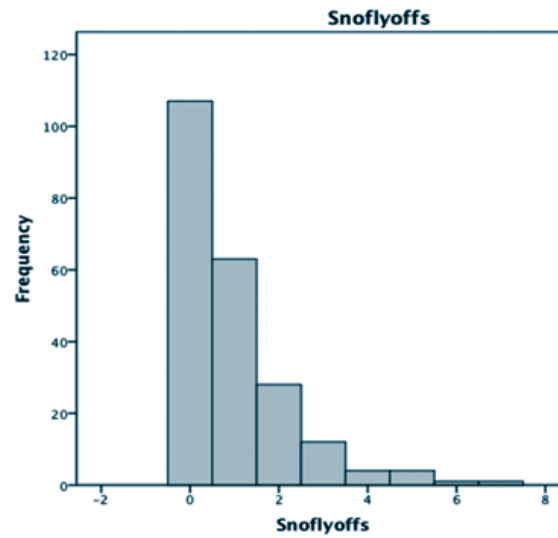
Figure 6.11: Histogram of variable means *Snoflyoffs* illustrates a positively skewed result.
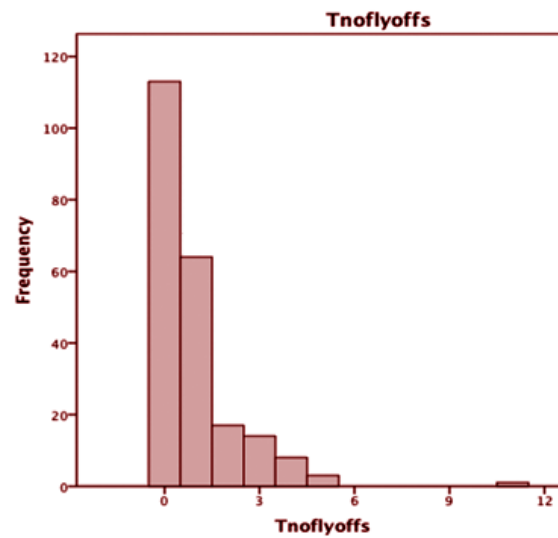
Figure 6.12: Histogram of variable means *Tnoflyoffs* illustrates a positively skewed result.

	Coff	Csq	Ctr	Soff	Sci	Str	Toff	Tci	Tsq	Itci	Itsq	Ittr	nrig	Cnoflyoffs	Snoflyoffs	Tnoflyoffs	Cfldmvgme	Sfldmvgme	Tfldmvgme
Coff	1																		
Csq		1																	
Ctr		.280	1																
Soff				1															
Sci				-.209	1														
Str					.269	1													
Toff							1												
Tci						.275		1											
Tsq		-.308	.415						1										
Itci	-.237			-.395						1									
Itsq							-.239				1								
Ittr												1							
nrig	-.226			-.307		-.330		-.219	-.308		-.383		1						
Cnoflyoffs		-.347	-.375		-.299			-.227					.501	1					
Snoflyoffs					-.392	-.450		-.247	-.277				.540	.336	1				
Tnoflyoffs			-.295		-.252			-.370	-.447				.645	.354	.345	1			
Cfldmvgme				-.287	-.211		-.263	-.231	-.295	-.284			.757	.377	.308	.509	1		
Sfldmvgme	-.329					-.263		-.277			-.318		.770	.402	.456	.400	.597	1	
Tfldmvgme				-.278		-.280		-.254	-.372			-.241	.808	.385	.433	.449	.657	.669	1

Figure 6.13: Correlation matrix for all variable means with sample n=117, where *nrig* >7-round games. Red-brown colour shows 25 correlations with defensive behaviour, yellow colour indicates correlations with variables that are specific to physical activity, pink colour pertains to correlations with offensive behaviour scores and gray colour indicates correlations with game length. Only statistically significant correlations at p<.05 are shown in this correlation matrix.

ables. A Pearson's bivariate correlation matrix in figure 6.13 was conducted with the derived data set variables and the new sample size ($n_7 = 117$). The correlation coefficient table in figure 6.13 was prepared by deleting non-significant coefficients. Remaining correlation coefficients are significant at least at $p < .05$.

The correlation matrix in figure 6.13 shows 63 significant correlations. Of the total of 63 correlations, 25 mostly negative correlations involve defensive play, determined by variable means of *Csq, Ctr, Sci, Str, Tci* and *Tsq*. These are followed by 18 mostly positive correlations of corporeal variables *Cnoflyoffs, Snoflyoffs, Tnoflyoffs, ltci, ltsq, lttr, Cfldmvgme, Sfldmvgme* and *Tfldmvgme*. We see an even split between negative and positive correlations with the variable *nrig* as bivariate partner. Finally, an all-negative cast of correlations is indicated with offensive behaviour scores via variables *Coff, Soff* and *Toff*.

In the next stage we pursue defensive behaviour scores in more detail, because of the dominance of defensive behaviour scores engendering correlations in this correlation matrix. In section 3.3.2.1 we stated that 'token shape placement', which is essentially strategic behaviour, is considered to play a more sophisticated role in creative participation because of combining physical and conceptual aspects. Therefore, the dominance of defensive behaviour scores at this stage is suggestive of an emergent pattern that warrants further investigation.

6.3   Stage 2: Honing in on defensive behaviour play

In the second stage of this analysis, we further investigate defensive behaviour scores produced by Sim-Suite participants. In the previous stage, we saw that strategic variables, specifically defensive behaviour, produced the largest number of correlations as bivariate partners. In this stage we take steps to further investigate this phenomenon by creating two groups of defensive behaviour scores. We achieve this by computing a composite variable of defensive behaviour scores which we split at the median. Scores below the median form the group of low defensive behaviour scores, scores above the median form the group of high defensive behaviour scores. With each group of defensive behaviour scores we perform cluster analysis and determine cluster groupings to gain perspective on possible attributes of defensive behaviour scores in game-play. Each generated cluster grouping shall be further investigated by creating correlation matrices. Here we locate a number of attributes, such as panoptic correlations, symmetry and full symmetry correlations, token axes activity, and self-referential correlations. All these attributes are explained in due course throughout this stage.

Before we proceed with the next step, we demonstrate how the previously introduced pictograms, illustrating variables, are utilised to visualise interactions between variables. To do so, we draw on an example from the correlation matrix in figure 6.13 in stage one. Let us turn to figure 6.14, here we show an excerpt from the correlation matrix in stage one with two red highlighted boxes, singling out two correlations for this demonstration. From each box we see an arrow leading to another red-outlined box. In both boxes, the tokens illustrated in the pictograms are arranged in the manner that reflects their position in physical space, details on that were explained in chapter three, figure 3.9. Specifically, we see pictograms of variables depicted with
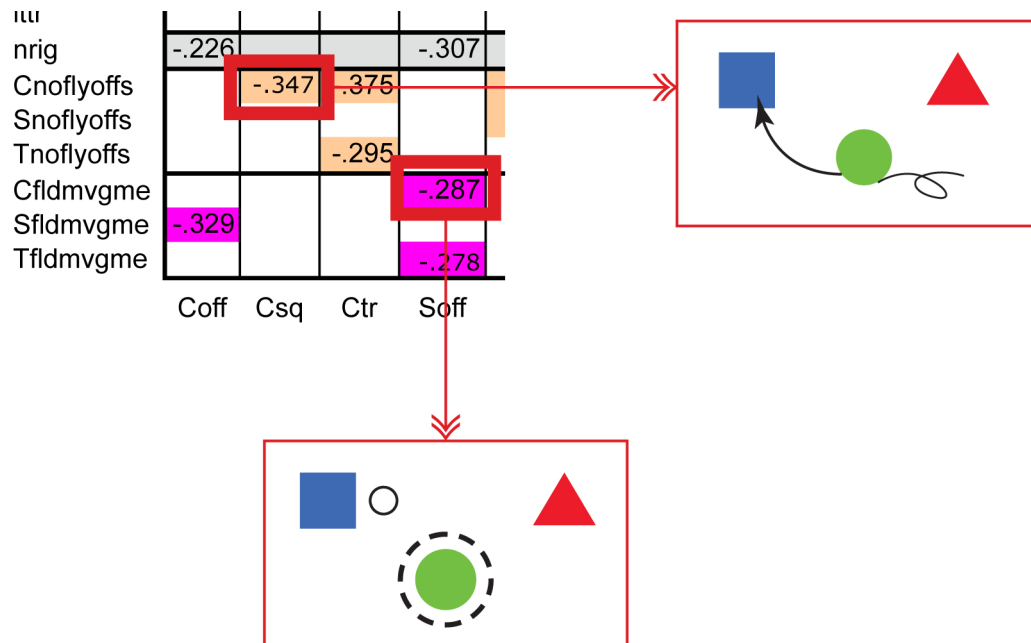
Figure 6.14: Demonstration of pictograms visualising two correlations excerpted from the correlation matrix in figure 6.13.

their bivariate correlation partners. The correlation with coefficient -.347 shows the depiction of variables, *Cnoflyoffs* correlating with *Csq*. In the box below the excerpt the correlation coefficient -.287 shows variables, *Cfldmvgme* correlating with *Soff*. We compose pictograms similar to forming words from letters in language. To illustrate how variables interact together, we assemble pictograms of specific variables, as introduced in the beginning of this chapter, and place them together in the context of all three token shapes. We shall use this format to enhance discussions on statistical findings in the remainder of this chapter.

6.3.1 Standardisation of scores

Let us resume stage two. Before we can create a composite variable of defensive behaviour scores, we first standardise the units of scores in the derived data set. Cluster analysis is best performed on standardised variables (Romesburg, 2004). With standardisation the occurrence of arbitrary effects caused by units chosen for measuring data attributes, or similarities among cases such as Euclidean squared distance, can be eliminated. Standardisation recasts data sets into dimensionless units which remove the possibility for arbitrary effects. Standardisation equalises attributes among cases which is desirable for example, when ranges of values vary greatly and thus larger ranges carry more weight in determining similarities among objects.

Milligan and Cooper (1988) conducted a study that investigated eight standardisation functions centred on Z scores. In concluding their study they recommended two types of Z score equations that involve using the variable's range as the best solution to standardise scores. They sum up that "division by range (Z_4 and Z_5) offer the best recovery of the underlying cluster structure. This result holds across error conditions, separation distances, clustering methods and coverage levels"

```
20
21
22    COMPUTE Coffz=Coff / (8.33 - 1.00).
23    EXECUTE.
24    COMPUTE Csqz=Csq / (5.00 - 0.43).
25    EXECUTE.
26    COMPUTE Ctrz=Ctr / (5.00 - 0.43).
27    EXECUTE.
28    COMPUTE Soffz=Soff/ (8.71 - 1.25).
29    EXECUTE.
30    COMPUTE Sciz=Sci/ (4.9 - 1.1).
31    EXECUTE.
32    COMPUTE Strz=Str/ (5.14 - .38).
33    EXECUTE.
34    COMPUTE Toffz=Toff/ (8.50 - 1.43).
35    EXECUTE.
36    COMPUTE Tciz=Tci/ (5.44 - 0.94).
37    EXECUTE.
38    COMPUTE Tsqz=Tsq/ (5.00 - 0.90).
39    EXECUTE.
40    COMPUTE Cnoflyoffsz=Cnoflyoffs / (6 - 0).
41    EXECUTE.
42    COMPUTE Snoflyoffsz=Snoflyoffs / (7 - 0).
43    EXECUTE.
44    COMPUTE Tnoflyoffsz=Tnoflyoffs / (11- 0).
45    EXECUTE.
46    COMPUTE ltciz=ltci / (11064.62- 3070.30).
47    EXECUTE.
48    COMPUTE ltsqz=ltsq / (9759.00- 2906.25).
49    EXECUTE.
50    COMPUTE lttrz=lttr / (8459.86- 3401.71).
51    EXECUTE.
52    COMPUTE Cfldmvgmez=Cfldmvgme / (190- 12).
53    EXECUTE.
54    COMPUTE Sfldmvgmez=Sfldmvgme / (177- 14).
55    EXECUTE.
56    COMPUTE Tfldmvgmez=Tfldmvgme / (165- 34).
57    EXECUTE.
58    COMPUTE nrigz=nrig / (24-7).
59    EXECUTE.
60
61
62
63    compute zdefensvar = Csqz + Ctrz + Sciz + Strz + Tciz + Tsqz.
64
```

Figure 6.15: Screenshot of SPSS syntax illustrating the computation of variable *zdefensvar*.

(p.202).

For the purpose of this thesis' investigation we convert the derived data set to Z scores using equation Z_4 as recommended by Milligan and Cooper (1988).

$$Z_4 = \frac{X}{\max(X) - \min(X)} \tag{6.3}$$

The composite variable *zdefensvar* was created from variable means of *Csqz, Ctrz, Sciz, Strz, Tciz* and *Tsqz* as shown in figure 6.15 using the equation shown in figure 6.3.

We have now established the variable *zdefensvar* and conduct descriptive statistics to determine central tendencies for *zdefensvar* which includes the median.

In figure 6.16 we see that *zdefensvar's mean* accounts for 3.3426 and the *median* adds up to 3.3437. Calculating two groups of defensive behaviour scores, we split the main sample with

Statistics

zdefensvar

N	Valid	117
	Missing	0
Mean		3.3426
Median		3.3437
Mode		2.19
Std. Deviation		.53049
Variance		.281
Range		2.42
Minimum		2.19
Maximum		4.61

Figure 6.16: Central tendencies of variable *zdefensvar*. This variable is computed from variable means of *Csqz, Ctrz, Sciz, Strz, Tciz* and *Tsqz*.

sample size (n=117) at the *median* of defensive behaviour scores. This results in the following: Group 1 low-defensive behaviour = *zdefensvar* $\leq$ 3.3437 with sample size:

$$n_{lz} = 58 \tag{6.4}$$

Group 2 high-defensive behaviour = *zdefensvar* $\geq$ 3.3437 with sample size:

$$n_{hz} = 59 \tag{6.5}$$

In the derived data set, to indicate that variables have been standardised, we add the letter 'z' to the end of each variable name as shown in figure 6.15.

6.3.2 Hierarchical cluster analysis procedure

We now have two groups of defensive behaviour scores and are in the position to conduct cluster analysis to explore data structure of these groups and identify possible shared and/or dividing characteristics. Hierarchical clustering procedure (Tan et al., 2005, Ch.8) is appropriate for this thesis' cluster analysis because the numbers of clusters to be generated are not pre-specified and can be permitted to emerge from the (exploratory) cluster analysis. Also, hierarchical clustering procedure is preferred when the number of cases is limited, which it is with the current split sample into low and high defensive behaviour scores.

Hierarchical clustering procedure is subdivided into agglomerative and divisive methods. An agglomerative method is conventionally used in the context of diagrammatic data display such as dendrograms or nested cluster diagrams. For this thesis' analysis an agglomerative method is deployed which is based on fusion or a 'bottom-up' approach, joining at each level the two clusters that are most similar. Agglomerative methods further distinguish types of linkage between clusters. For this thesis' analysis we administer Ward's linkage because of its efficiency and robustness (Hair, Anderson, Tatham, & Black, 1998). This linkage evolved from single, complete and average linkage with the main idea to minimise information loss associated with each cluster

grouping. Ward's linkage quantifies information loss in that merger rules evaluate at each step the kind of union every possible cluster pair offers, combining only with those that introduce least increase of information loss.

For interval data used by this analysis it is further appropriate to measure distance between two cases quantitatively using the Euclidean squared distance metric. Like the Euclidean distance metric, it measures distance between two cases in a straight line or as the 'crow flies'. Dendrograms generated by the afore-mentioned cluster analysis are shown in figures 6.17 and 6.18.

The first dendrogram illustrated in figure 6.17 displays clustering of low defensive behaviour scores. The variable *gameset*, listing each game in these clusters, is indicated on the left side of the dendrogram. Pink rectangles highlight cluster groupings that will be useful in the context of this analysis and will be pursued further, they are labeled 1, 2, and 3. Figure 6.18 shows the dendrogram for high defensive behaviour scores. Similarly, this dendrogram lists the games belonging to each cluster along the left side via the variable *gameset*. It also highlights cluster groupings that are meaningful for further analysis with labels 1, 2, and 3.

6.3.3 Pearson's correlation matrices for cluster groupings in low and high defensive behaviour scores

While it is helpful to have produced statistically generated groups of meaningful and shared characteristics in low and high defensive behaviour scores, we take it a step further to examine the interrelationships between variables within each game cluster. In this fashion, significant relationships will actually be spelled out through correlation coefficients and variable classes. To do so we have produced 6 correlation matrices, one for each cluster grouping which was previously highlighted pink in both dendrograms.

In figures 6.19, 6.20 and 6.21 we display coefficient matrices showing significant correlations in each of the three cluster groupings of low defensive behaviour scores. Similarly, figures 6.22, 6.23 and 6.24, show significant correlation coefficients in each of the three cluster groupings of high defensive behaviour scores. The six correlation matrices are colour-coded to create a link to the overview tables introduced in the next paragraph. Variable classes in each correlation matrix are symbolised by the following colours. The pink outline demarcates strategic variables; the purple outline describes corporeal variables; the orange line, located within the purple outline, discriminates mixed from corporeal variable classes; and the turquoise outline delimits timeline variable. Colour codes further extend to the actual coefficient fields, separating negative from positive correlations. Coefficients underlaid with light brown coloured fields highlight negative correlations, and coefficients underlaid with yellow coloured fields highlight positive correlations. These colour conventions are consistent throughout all six correlation matrices. We return to these correlation matrices throughout the remainder of stage two.

In addition, we have constructed two tables that create an inventory of variable classes and their negative and positive correlations from each correlation matrix. Tables 6.1 and 6.2 show that cluster groupings in high defensive behaviour scores produced 15 additional correlations to those produced by low defensive behaviour scores. Low defensive cluster groupings rank mixed variable
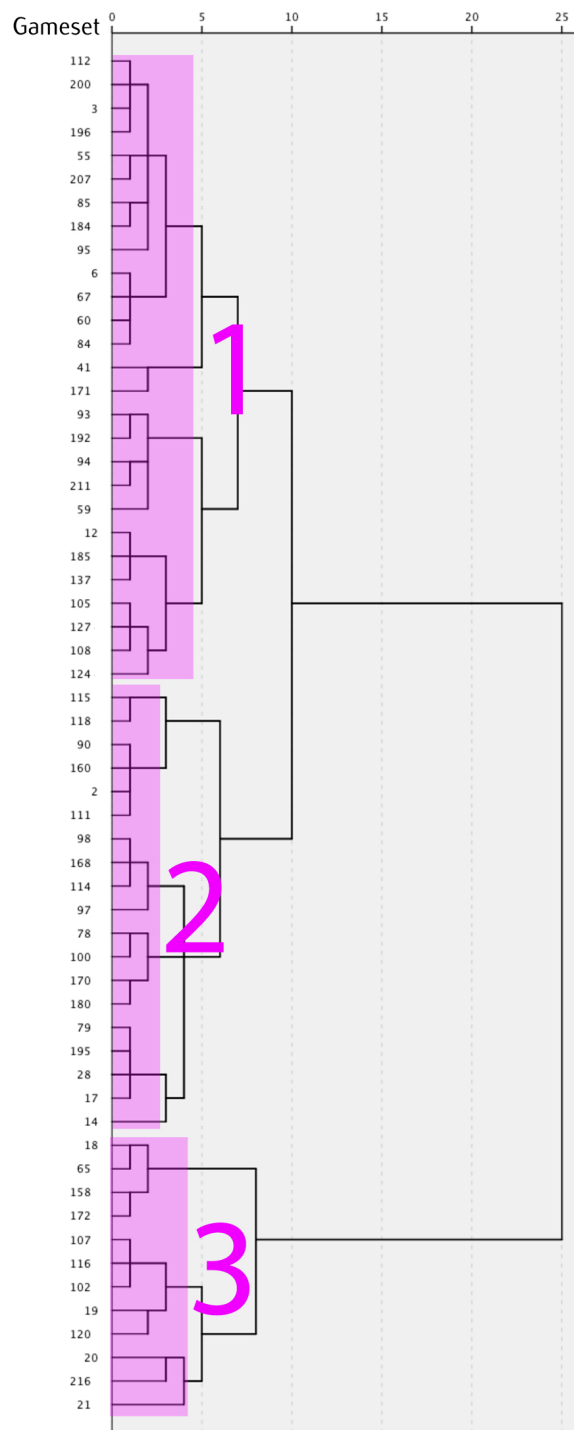
Figure 6.17: Low defensive behaviour dendrogram, indicating three cluster groupings of games.
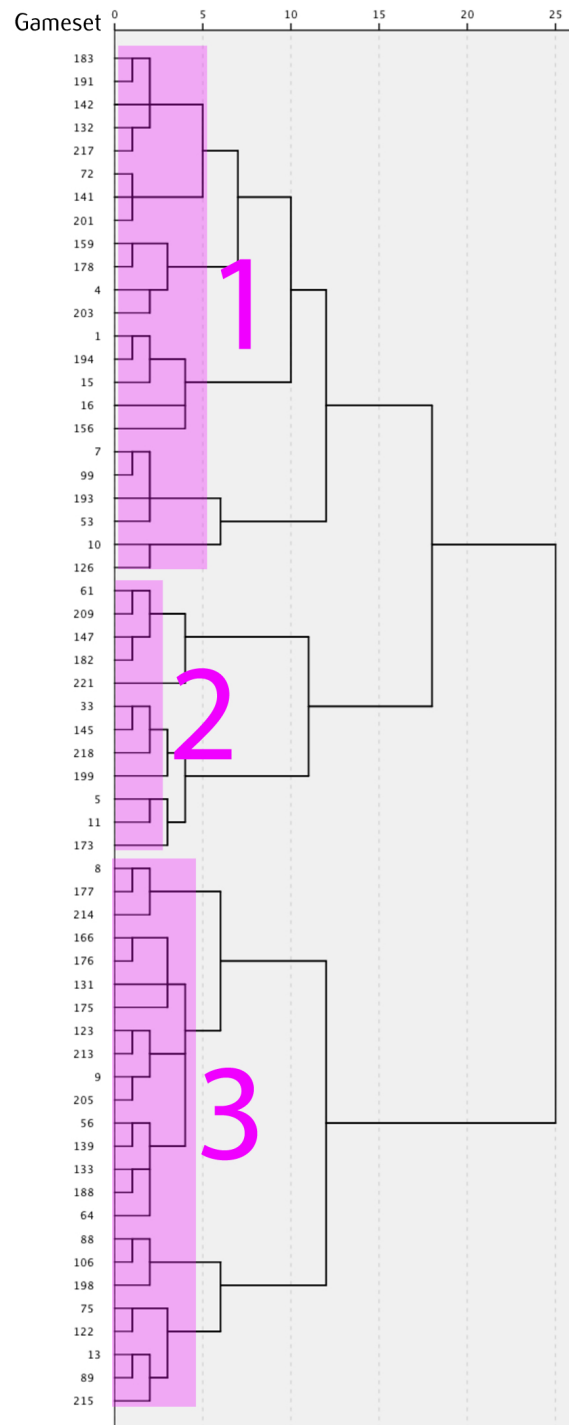
Figure 6.18: High defensive behaviour dendrogram, indicating three cluster groupings of games.
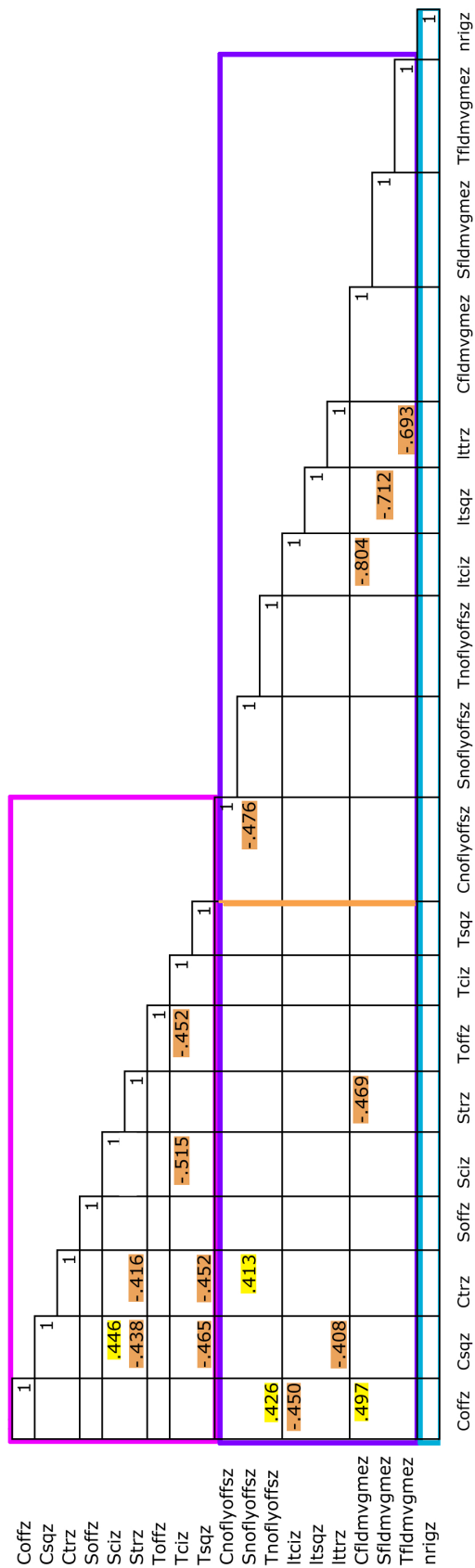
Figure 6.19: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping I in low defensive behaviour scores.
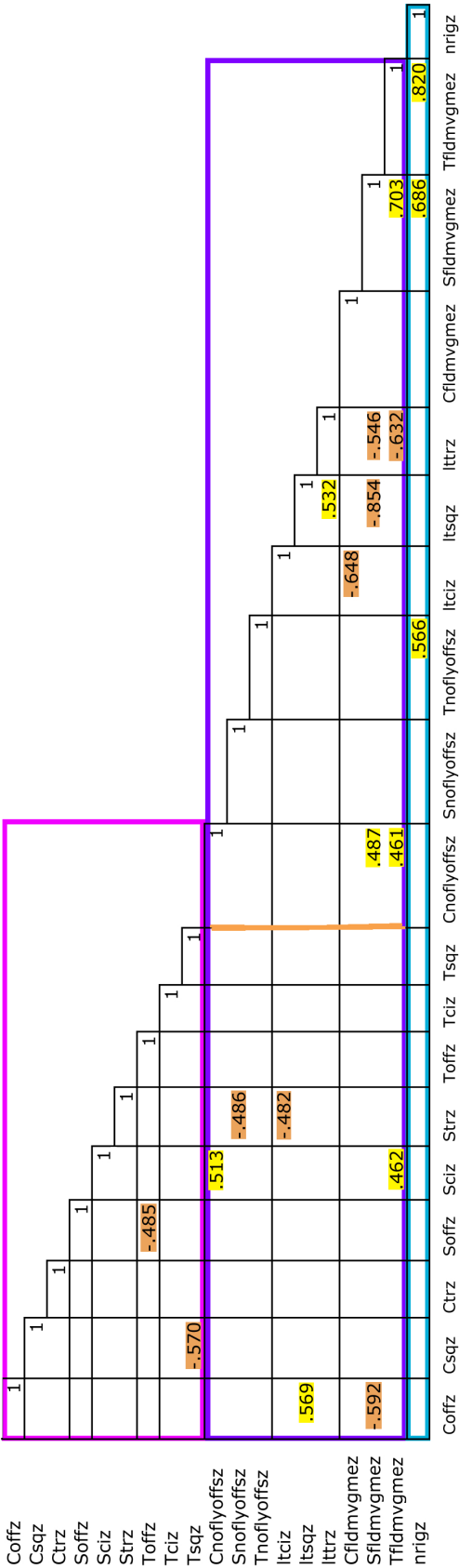
Figure 6.20: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping II in low defensive behaviour scores.
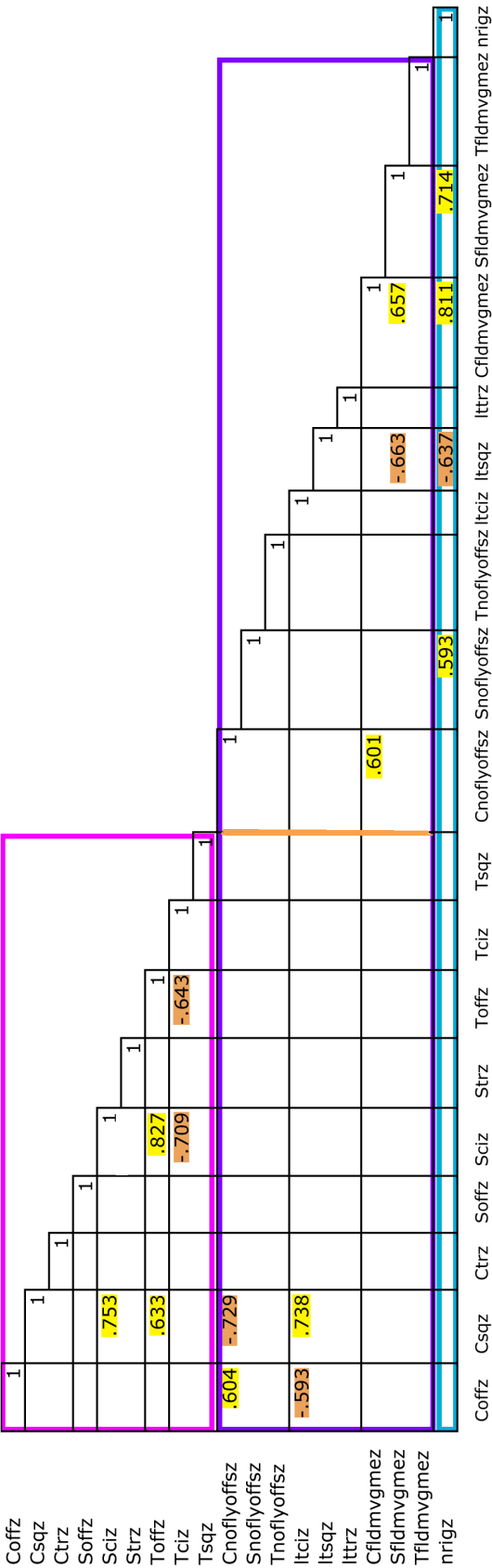
Figure 6.21: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping III in low defensive behaviour scores.

Figure 6.22: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping I in high defensive behaviour scores.

Figure 6.23: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping II in high defensive behaviour scores.

Figure 6.24: Pearson's correlation matrix with correlations p<.05, derived from cluster grouping III in high defensive behaviour scores.

Table 6.1: Correlation overview by variable class of game cluster groupings I, II, and III in low defensive behaviour scores in figure 6.17. 'N' is the total number of games in each cluster grouping.

cluster grouping	N=	variable class	total correlations	negative	positive
I	27	Strategic	7	6	1
I		Mixed	6	3	3
I		Corporeal	4	4	0
I		Timeline (mixed)	0	0	0
II	19	Strategic	2	2	0
II		Mixed	6	3	3
II		Corporeal	8	4	4
II		Timeline (mixed)	3	0	3
III	12	Strategic	5	2	3
III		Mixed	4	2	2
III		Corporeal	3	1	2
III		Timeline (mixed)	4	1	3

Table 6.2: Correlation overview by variable class of game cluster groupings I, II, and III in high defensive behaviour scores in figure 6.18. 'N' is the total number of games in each cluster grouping.

cluster grouping	N=	variable class	total correlations	negative	positive
I	23	Strategic	4	3	1
I		Mixed	8	5	3
I		Corporeal	5	3	2
I		Timeline (mixed)	4	0	4
II	12	Strategic	2	1	1
II		Mixed	5	5	0
II		Corporeal	7	3	5
II		Timeline (mixed)	6	3	3
III	24	Strategic	3	2	1
III		Mixed	10	7	3
III		Corporeal	9	4	6
III		Timeline (mixed)	6	2	4

classes highest with 16 correlations, followed closely by corporeal variables with 15 correlations, then strategic variables with 14 correlations and finally timeline variable with 7 correlations. The order of 16, 15, 14 correlations is seamlessly consecutive with mixed, corporeal and strategic variable classes nearly equally represented.

In high defensive behaviour scores, cluster groupings rank in the first place, mixed variables with 23 correlations, followed closely by corporeal variables with 21 correlations. Then a gap appears between corporeal variables and the next ranking variable class which is timeline variable with 16 correlations, followed by an even larger gap with strategic variables sporting 9 correlations.

There are some quantitative differences between groups of defensive behaviour scores. The group of high defensive behaviour scores has one additional game than the group of low defensive behaviour scores. The group of high defensive behaviour scores generated 15 additional correlations than the group of low defensive behaviour scores. Both tables show that negative correlations prevail when totalling correlations in both groups. In high defensive behaviour scores, each of the three cluster groupings shows higher numbers of negative correlations than positive ones. In low defensive behaviour scores, two out for the three cluster groupings are dominated by positive correlations but in total, when adding up all correlations, negative correlations prevail over positive ones.

In both groups across cluster groupings, correlations with strategic variables are dominated by negative coefficients. The proportion between negative and positive correlations with strategic variables in cluster groupings of low defensive behaviour scores shows 10 to 3. In high defensive behaviour scores, cluster groupings show the proportion between negative and positive correlations to be 6 to 3. Negative correlations with strategic behaviour variables might imply that strategic behaviour impacts participants' performance by diverting the participants' attention and ability to participate in the game fully. We also observed that aspects of strategic behaviour, such as defensive play, can have a wide-reaching effect on all three participants at the same time. We discuss this phenomenon in the next subsection.

6.3.4   Panoptic correlation

The phenomenon described in this subsection has been labeled panoptic correlation, it was observed in correlation matrices produced from cluster groupings in low and high defensive behaviour scores. Panoptic correlations centre on active strategic variables, they are negative correlations which include variables *Csqz, Ctrz, Sciz, Strz, Tciz* and *Tsqz*. Conventionally, bivariate correlations involve a relationship between two variables, but in panoptic correlations the nature of two active strategic variables engages all three token shapes and for the thesis' investigative purposes these have been called panoptic correlations.

The chart in figure 6.25 introduces all possible types of panoptic correlations, however only subsets of these correlation configurations appear in the low and high defensive game clusters. Moreover the subsets differ in interesting ways and are theoretically revealing, inter alia, assymmetries in token shape axis interaction. In this chart, we utilise pictograms introduced in stage
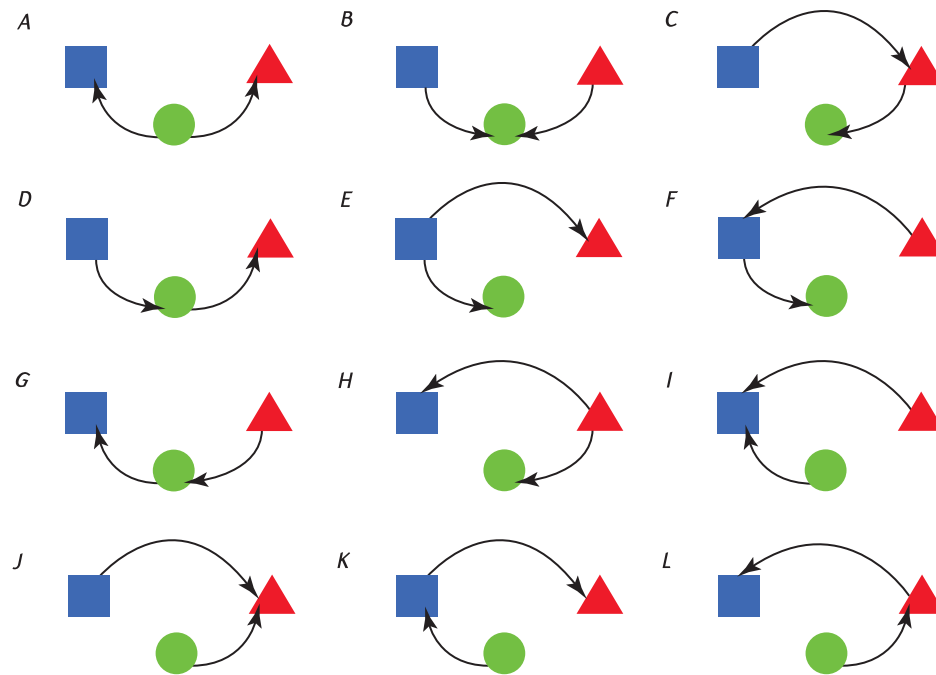
Figure 6.25: Pictograms of panoptic correlations. This chart shows all possible configurations of the panoptic phenomenon. Letters *A*, *B*, *H*, *I*, *J*, *K* and *L* are relevant for this thesis' investigation, they denote the subset found throughout cluster groupings in both groups of defensive behaviour scores.

one. Each panoptic correlation is composed of two variables from active strategic variables.

In table 6.3 we have created an overview of panoptic correlations as they occur in each cluster groupings of low and high defensive behaviour scores. The table shows that cluster groupings in low defensive behaviour scores produced more than double the number of panoptic correlations than those in high defensive behaviour scores. In other words, there is much active strategic interaction in cluster groupings of low defensive behaviour scores but because these panoptic correlations turn out negatively, their relationship conveys a defensive struggle by one token's variable over another.

Furthermore, in the overview table 6.3 we see that in cluster groupings I and II of low defensive behaviour scores, the panoptic correlation letter *I* manifests twice. In the cluster groupings I and II in high defensive behaviour scores we see the panoptic correlation letter *H* appear twice as well. If we refer to the chart that visualises these correlations via pictograms in figure 6.25, we notice that letters *I* and *H* depict opposing forces in strategic engagement. In letter *H* we see Triangle token's strategic variables *Tsqz, Tciz* correlate with each other against both opponents. Loosely interpreted, Triangle token's variables are 'attacking' both opponents at the same time. In panoptic correlation letter *I*, we interpret Square token's variable as being 'attacked' by both opponents, Triangle token's variable *Tsqz* and Circle token's variable *Csqz*. There is an interesting axial dynamic coming forward between Square token's variables and Triangle token's variables. In the next subsection we investigate this 'axis' notion further.

Table 6.3: Panoptic correlation for all cluster groupings in low and high defensive behaviour scores.

	letter in fig. 6.25	**var 1**	**var 2**	**coefficient**
low behaviour scores:				
cluster grpng I	*J*	*Ctrz*	*Strz*	-0.416
	K	*Csqz*	*Strz*	-0.438
	L	*Ctrz*	*Tsqz*	-0.452
	I	*Csqz*	*Tsqz*	-0.465
	A	*Ctrz*	*Csqz*	-0.515
cluster grpng II	*I*	*Csqz*	*Tsqz*	-0.570
cluster grpng III	*B*	*Sciz*	*Tciz*	-0.709
high behaviour scores:				
cluster grpng I	*L*	*Ctrz*	*Tsqz*	-0.450
	H	*Tciz*	*Tsqz*	-0.481
cluster grpng II	*H*	*Tciz*	*Tsqz*	-0.605
cluster grpng III	-	-	-	-

6.3.5 Axial relations between variables

In the previous subsection we noticed a possible dynamic that might be related to axes on which players interact with each other. In essence, the data gathered for this analysis is produced by Sim-Suite players, whose bodies were physically located in space, moving stationary on wobble-boards and interacting in relative position with each other. The chart in figure 6.26 reflects and abstracts player positions relative to each other as they come into being in the actual installation. For this thesis' investigation we look at respective variables by each token from the point of spatial configuration, and describe these as token axes.

In table 6.4 we have summarised token axis interaction and show how this interaction is distributed among axes: Square-Triangle token axis, Circle-Triangle token axis, and Circle-Square token axis. These three axes are two-directional, therefore Square-Triangle token axis is also Triangle-Square token axis and so forth. The table shows a category "no axes", here we have singled out correlations that do not pose a clear sense of token axis interaction. The category "no axes" defines types of correlations which have as one bivariate partner an active strategic variable which is directed towards one specific token shape. But the other bivariate variable in this correlation is a token shape that is not addressed by the strategic bivariate partner. Let's look at an example. Variable *Csqz* is Circle token's defensive behaviour variable acting against Square token's variable. If the corresponding other bivariate partner is not Square token but for example Triangle token, then there is no clear sense of axis between Circle token and Square token. To continue with the example, Circle token's strategic variable plays defensively against Square token's variable but the correlating bivariate partner is Triangle token's variable that describes the longest time a token is being held stationary on a field of the game-board. This would not be considered
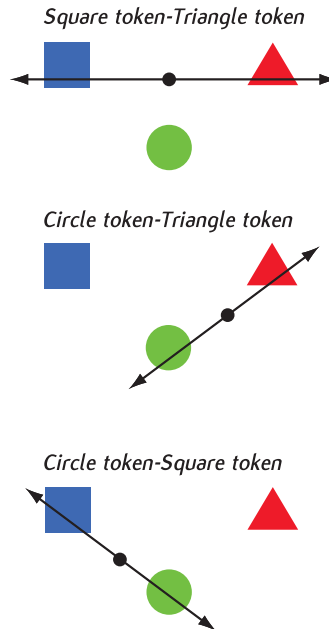
Figure 6.26: Chart of token axis interaction, tokens interact in both directions.

token axis interaction, but on the other hand if the other bivariate partner were Square token's variable that describes the same behaviour, namely the longest time Square token was held on a field of the game-board, this correlation would be considered participating in token axis interaction.

The table 6.4 displays that Circle-Square token axis is strongly represented throughout all cluster groupings in both low and high defensive behaviour scores. This situation is contrasted by Square-Triangle token axis interaction which is sparsely represented throughout cluster groupings in low and high defensive behaviour scores. In cluster groupings of low defensive behaviour scores we note that cluster groupings I and III have no Square-Triangle token axis although a high percentage of interaction between tokens takes place with "no axis". Recall that cluster grouping I in low defensive behaviour scores had the largest number of panoptic correlations which do not favour token axis interaction, because here all three token shapes are implicated at the same time. Although cluster grouping III in low defensive behaviour scores shows an evenly distributed cast between variable classes and correlations, this cluster grouping does not produce much interaction along the token axes. In cluster groupings of high defensive behaviour scores, this situation is much more balanced and token axis interaction is more evenly distributed among the three axes.

In addition to the "no axis" category composed from correlations of unrequited defensive behaviour bivariate partners, other correlations do not display an axis because the correlation's bivariate partners originate from variables of the same token shape. Recall the double appearance of letter H, panoptic correlations with Triangle token's defensive behaviour variables *Tciz, Tsqz*. This is such an example, a correlation that has the same token shape at its origin. We call these types of correlations self-referential.

To probe the "no axis" category, we briefly turn to table 6.5, where we look at token axis and bivariate partners from the perspective of the variable "fly-off" which describes a token flying

Table 6.4: Axis distribution in correlation matrices of all cluster groupings in low and high defensive scores

Low defensive behaviour scores cluster groupings

Square-Triangle	Circle-Triangle	Circle-Square	no axis
I			
-	1	2	3
II			
4	1	4	2
III			
-	-	2	2

Square-Triangle	Circle-Triangle	Circle-Square	no axis
% per total correlations - I			
-	6%	12.5%	18%
% per total correlations - II			
21%	5 %	21%	10.5%
% per total correlations - III			
-	-	12.5%	12.5%

High defensive behaviour scores cluster groupings

Square-Triangle	Circle-Triangle	Circle-Square	no axis
I			
2	2	2	2
II			
2	1	6	1
III			
4	2	3	4

Square-Triangle	Circle-Triangle	Circle-Square	no axis
% per total correlations - I			
9.5%	9.5 %	9.5%	9.5%
% per total correlations - II			
10.5%	5 %	31.5%	5%
% per total correlations - III			
14%	7 %	11%	14%

off the game-board and essentially out of the game at a particular round in the game. In table 6.5 we have labeled in the "axis" category "no axis" correlations which have been described in last paragraphs, the remainder in the "axis" category is labeled "none" to indicate that these correlations are self-referential. From the perspective of "fly-off" variables, we note that in cluster groupings of low defensive behaviour scores each token axis interaction comprises Circle token, and we see a total absence of Square-Triangle token axis interactions. In cluster groupings of high defensive behaviour scores, we count 5 correlations with Circle-Square token axis, 3 correlations with Square-Triangle token axis, and 2 correlations with Circle-Triangle token axis interactions, which in principle is confirming the overall result on token axis interaction. 'Weak' token axis interactions are centred on Triangle token, 'strong' token axis interactions are centred on Square token.

In table 6.6 we have created an additional perspective of self-referential correlations, we have listed variables that refer to token shapes and their number of participation in self-referential correlations. We see that variables of strategic behaviour attributed to Circle and Square tokens (*Ctrz, Soffz, Sciz, Strz, Tsqz*) have no self-referential correlations in low defensive behaviour scores and few in high defensive behaviour scores. At the same time we notice a high number of self-referential correlations with corporeal variables, for example variables describing the number of fields traversed on the game-board, and variables describing the longest time a token is held stationary on a field of the game-board. This is discussed in more detail in the next section.

6.3.6 Symmetry and full symmetry correlations

Earlier we saw that corporeal variables were foregrounded as the preferred variables in self-referential correlations. When tracing these correlations to their source, in correlation matrices of cluster groupings in low and high defensive behaviour scores, we note the phenomenon of symmetric correlations.

In tables 6.7 and 6.8 we list all correlations throughout low and high defensive behaviour scores that display symmetric correlations in their respective cluster groupings. The Greek meaning of symmetry is "measuring together". In spotting symmetry between cluster groupings, we recognised that correlations were composed of synchronised corporeal and timeline variables. In other words in a cluster grouping, a correlation's variable configuration repeats multiple times over two or three token shapes. Therefore we called this phenomenon "symmetry" as shown in table 6.7. It describes two symmetric correlations with two token shapes. It is called a "full symmetry" as shown in table 6.8, when all three token shapes are implicated in symmetric correlations. In figure 6.27 we depict a full symmetry correlation as pictogram from cluster grouping II in high defensive behaviour scores for visualisation purposes.

The primary variables present in full symmetry correlations are related to physical movement, conveying participants' movement of similar type and speed over time. For example, the most prolific corporeal variables in full symmetry correlations are variables *Cfldmvgmez, Sfldmvgmez* and *Tfldmvgmez* with timeline variable *nrigz*. Symmetric correlations with these variables foreground a player's physical action traversing a similar number of fields per game-round. This variable

Table 6.5: Total number of correlations with the "fly-off" variable listed by token

	"fly-off" token	**bivariate**	**axis**	**neg. / pos.**
low cluster grpng	Circle	*Snoflyoffsz*	Circle-Square	neg.
	Square	*Ctrz*	none (no axis)	pos.
	Triangle	*Coffz*	Circle-Triangle	pos.
	Circle	*Sciz*	Circle-Square	pos.
	Square	*Strz*	none	neg.
	Circle	*Sfldmvgme*	Circle-Square	pos.
	Circle	*Tfldmvgme*	Circle-Triangle	pos.
	Triangle	*nrig*	none	pos.
	Circle	*Coffz*	none	pos.
	Circle	*Csqz*	none	pos.
	Circle	*Cfldmvgme*	none	pos.
	Square	*nrig*	none	pos.
high cluster grpng	Circle	*Ctrz*	none	neg.
	Square	*Soffz*	none	neg.
	Square	*Toffz*	Square-Triangle	pos.
	Square	*Tciz*	none (no axis)	pos.
	Triangle	*Cnoflyoffsz*	Circle-Triangle	neg.
	Square	*ltciz*	Circle-Square	pos.
	Square	*ltsqz*	none	pos.
	Circle	*nrigz*	none	pos.
	Square	*Csqz*	Circle-Square	neg.
	Square	*Cnoflyoffsz*	Circle-Square	neg.
	Circle	*ltsqz*	Circle-Square	neg.
	Circle	*Coffz*	none	neg.
	Circle	*Soffz*	Circle-Square	pos.
	Square	*Strz*	none	neg.
	Triangle	*Strz*	Square-Triangle	neg.
	Triangle	*Cfldmvgme*	Circle-Triangle	pos.
	Triangle	*Sfldmvgme*	Square-Triangle	pos.
	Triangle	*Tfldmvgme*	none	pos.
	Triangle	*nrig*	none	pos.

Table 6.6: Total number of self-referential correlations depicted by variables

variables

	Coffz	Csqz	Ctrz	Soffz	Sciz	Strz	Toffz	Tciz	Tsqz
low def. clstr grpng	4	2	-	-	-	-	2	2	-
high def. clstr grpng	2	1	1	1	-	3	3	-	3
	Cnofly.	Snofly.	Tnofly.	ltciz	ltsqz	lttrz	Cfld.	Sfld.	Tfld.
low def. clstr grpng	3	1	1	5	4	2	4	5	3
high def. clstr grpng	2	3	2	2	3	2	7	5	8

Table 6.7: Symmetry correlations for all cluster groupings in low and high defensive behaviour scores

symmetry correlations

var 1	var 2	coefficient	low defensive - cluster grouping
Tfldmvgmez	*nrigz*	0.820	
Sfldmvgmez	*nrigz*	0.686	**II**
Cnoflyoffsz	*Sfldmvgmez*	0.487	
Cnoflyoffsz	*Tfldmvgmez*	0.461	**II**
Cfldmvgmez	*nrigz*	0.811	
Sfldmvgmez	*nrigz*	0.714	**III**

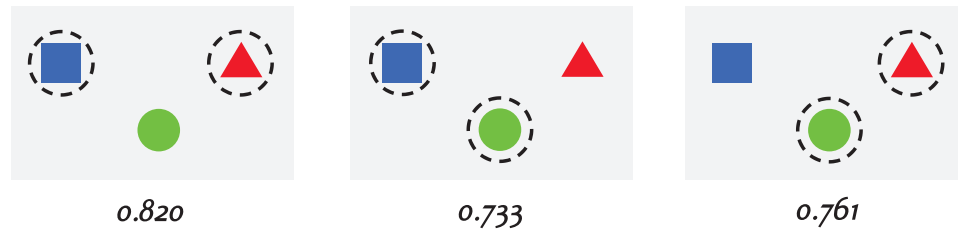| var 1	var 2	coefficient	high defensive - cluster grouping
Sfldmvgmez	*ltsqz*	-0.708	
Tfldmvgmez	*lttrz*	-0.674	**I**
Snoflyoffsz	*Tciz*	0.475	
Tnoflyoffsz	*Sciz*	0.874	**I**
Cfldmvgmez	*Sfldmvgmez*	0.532	
Cfldmvgmez	*Tfldmvgmez*	0.577	**III**

Figure 6.27: Pictogram demonstrating a full symmetry correlation in cluster grouping II in high defensive behaviour scores. Coefficient values show strong positive correlations.

class as part of positive full symmetry correlations marks a consistent engagement by participants. The game-board builds up with more tokens after each game-round, requiring participants in the current game-round to increase their search for an optimal field to settle on, while maintaining effectiveness in context of their game-play. Full symmetry correlations in cluster groupings of high defensive behaviour scores show that even when participants are not symmetrically correlating with increasing number of rounds via timeline variable *nrigz* they will engender symmetric correlations with each other's stepping movements and speed as demonstrated in cluster grouping II in table 6.8. These results suggest that participants in these games manifest a collective sense of group 'rhythm' which is self-sustaining and self-supporting as group dynamic.

Comparing symmetry and full symmetry correlations from the point of negative and positive correlations as well as classes of variables, we see distinct trends in cluster groupings of low and high defensive behaviour scores. We turn to table 6.7 and cluster groupings with low defensive behaviour scores. We note an all positive cast of symmetry correlations. We also note a unique variable combination (*Cnoflyoffsz, Sfldmvgmez* and *Cnoflyoffsz, Tfldmvgmez*) in cluster grouping II. Albeit a 'weak' coefficient, this symmetry correlation divulges some of the earlier observed tendencies related to axial token shape interaction. It shows that Square token's variable *Sfldmvgmez* and Triangle token's variable *Tfldmvgmez* increase their travels across the game-board symmetrically while Circle token's variable *Cnoflyoffsz* increasingly flies off the game-board. This suggests that Square and Triangle tokens' play-dynamic impacts Circle token's performance in what may be considered a detrimental manner. This variable relationship steadily prevents Circle token's participation in a game-round or even game. This should be further evident when we look at variable means in the next stage.

Furthermore, the afore-mentioned symmetry correlation may also be a key element in elucidating the reasons behind the fact that there are no positive full symmetry correlations in low defensive behaviour cluster groupings as shown in table 6.8. It might be that axial play-dynamics between two token shapes, such as Square and Triangle tokens, prevents a 'rhythmic' participation by all three token shapes. Recognising that all full symmetry correlations in cluster groupings of low defensive behaviour scores are negative and self-referential variable combinations further supports this point.

A last point to be made in stage two involves looking at common correlations. Here we are

Table 6.8: Full symmetry correlations for all cluster groupings in low and high defensive behaviour scores

full symmetry correlations

var 1	var 2	coefficient	Low defensive - cluster grouping
Cfldmvgmez	*ltciz*	-0.804	
Sfldmvgmez	*ltsqz*	-0.712	**I**
Tfldmvgmez	*lttrz*	-0.693	
Cfldmvgmez	*ltciz*	-0.648	
Sfldmvgmez	*ltsqz*	-0.854	**II**
Tfldmvgmez	*lttrz*	-0.632	

var 1	var 2	coefficient	High defensive - cluster grouping
Cfldmvgmez	*nrigz*	0.493	
Sfldmvgmez	*nrigz*	0.670	**I**
Tfldmvgmez	*nrigz*	0.552	
Cfldmvgmez	*nrigz*	0.781	
Sfldmvgmez	*nrigz*	0.874	**II**
Tfldmvgmez	*nrigz*	0.944	
Cfldmvgmez	*Sfldmvgmez*	0.733	
Sfldmvgmez	*Tfldmvgmez*	0.820	**II**
Tfldmvgmez	*Cfldmvgmez*	0.761	
Cfldmvgmez	*ltciz*	-0.603	
Sfldmvgmez	*ltsqz*	-0.531	**III**
Tfldmvgmez	*lttrz*	-0.532	
Cfldmvgmez	*nrigz*	0.781	
Sfldmvgmez	*nrigz*	0.874	**III**
Tfldmvgmez	*nrigz*	0.944	

Group I	-0.712
Group II	-0.854
Group III	-0.663
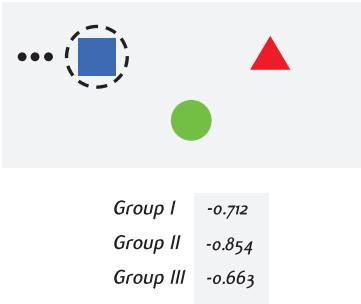
Figure 6.28: Negative variable configuration *Sfldmvgme, ltsq* common to all three cluster groupings of low defensive behaviour scores, it is also a self-referential correlation.

Group I	0.493	0.670	0.552
Group II	0.781	0.874	0.944
Group III	0.748	0.712	0.730
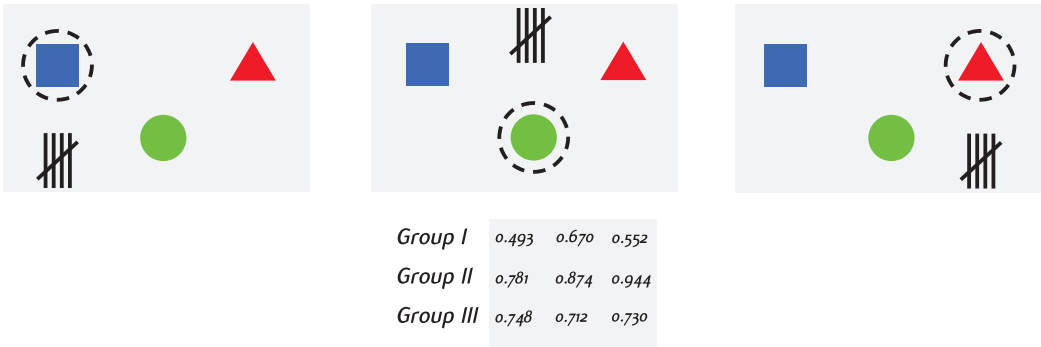
Figure 6.29: Positive variable configurations *Cfldmvgme, Sfldmvgme, Tfdmvgme* with *nrig* common to all three cluster groupings of high defensive behaviour scores. This variable configuration is considered a full self-referential symmetry correlation.

isolating correlations with variable combinations that are common to all cluster groupings in either low or high defensive behaviour scores. We have used pictograms to illustrate which variable combinations have manifested in cluster groupings of low and high defensive behavior scores. In figure 6.28 we see the self-referential variable combination *Sfldmvgme, ltsq* surfacing in all three cluster groupings of low defensive behaviour scores with varying negative but sequential coefficient strengths. In figure 6.29 we discern three positive correlations that are common to each cluster grouping in high defensive behaviour scores. Obviously these three correlations make up a full symmetry correlation, re-iterating that physical interaction by participants with high defensive playing strategies engender a more tightly focussed and synchronised coordination between players.

This completes perspectives on variable relations with each other. The next stage gives perspective on average differences.

6.4 Stage 3: Average difference in low and high defensive play

In this stage of this thesis' statistical investigation we focus on illustrating the magnitude of average difference between variables by using descriptive statistics to calculate central tendencies, specifically the variable means for all token shapes. We proceed with the derived data set of

variable means. In stage two it was necessary to standardise variable means because we were dealing with a number of different units that needed to be standardised to conduct cluster analysis in order to determine similarities across scores and variables. In stage three we are looking at variable means within the same variables by comparing low and high variable means in low and high defensive behaviour scores, therefore we are no longer in need to utlise standardised scores.

The chart in figure 6.30 introduces a number of variable means comparatively. Central tendency for each variable were generated in SPSS and further processed in Excel software to create a view of data that allows quick comparative access by placing the variable mean values of token shapes next to each other. The chart is divided into two parts, whereby the upper part illustrates variable means for low defensive behaviour scores and the lower part illustrates variable means for high defensive behaviour scores, both are indicated via a yellow highlight. To the left side of the chart two variable classes are listed, these are strategic and corporeal variable classes. Each variable class itemises a number of variables while their names are declared in a 'neutral' version. Token shape-specific variable names have been abbreviated to convey only the essence of that variable. To locate the token shape-specific variable mean, one also needs to refer to the horizontal header rows of the chart. For example, on the left side of the chart "defens" stands for variable names *Ctr, Csq, Sci, Str, Tsq* and *Tci*. In order to ascertain which token shape belongs to the variable mean value in the chart, one needs to read the horizontal header row together with the 'neutral' variable name on the left. For example, to find out the variable mean for Square token's defensive variable against Circle token, variable *Sci*, entails first locating the main column for Square token shape, which is placed in the centre between 'Circle' and 'Triangle'. Secondly, it entails locating the column header "circle opponent" and aligning the value in that column with the row that is indicated with "defens" on the left side of the chart, and where both row and column meet, we find the variable mean value for *Sci*.

The colours in the chart signal lowest and highest variable mean values for a respective token shape. Fields that are underlaid with green are the lowest variable mean values in that particular variable across all three token shapes. Likewise, fields that are underlaid with pink are the highest variable mean values in that particular variable across all three token shapes.

The task of stage three is to render a comparative view of variables and their means across token shapes as well as low and high defensive behaviour scores. In addition to the chart in figure 6.30, displaying the numeric values comparatively, we have created a visual version of lowest and highest variable means in both groups of defensive behaviour scores. This is demonstrated in the pictogram in figure 6.31. When looking at the chart in figure 6.30 and the pictograms in figure 6.31 we can profile lowest and highest variable means for each token shape in the following fashion:

6.4.1 Circle token variable means

Circle token's variable means show two consistent lowest and highest values throughout both groups of low and high defensive behaviour scores. Circle token's variables for active strategic variables *Csq, Csq,* or *defens* in the chart, are the lowest means of all three token shapes' active strategic variables, they are 4.14 in the group of low defensive behaviour scores and 5.4 in the

low defens.		CIRCLE square opponent	triangle opponent			SQUARE triangle opponent	circle opponent			TRIANGLE square opponent	circle opponent
defens		4.17	4.37			4.37	4.14			4.17	4.14
offens	4.39	4.63	4.3		4.63	4.3	4.39		4.3	4.63	4.39
flyoffs	2.02	1.97	2.02		1.97	2.02	2.02		2.02	1.97	2.02
fldmvgme	80.72	78.1	78.21		78.1	78.21	80.72		78.21	78.1	80.72
lt	5823	5816.26	5927.85		5816.26	5927.85	5822.93		5927.85	5816.3	5822.93

high defens.		CIRCLE square opponent	triangle opponent			SQUARE triangle opponent	circle opponent			TRIANGLE square opponent	circle opponent
defens		5.48	5.47			5.47	5.4			5.48	5.4
offens	4.75	4.35	4.6		4.35	4.6	4.75		4.6	4.35	4.75
flyoffs	0.83	0.97	0.73		0.97	0.73	0.83		0.73	0.97	0.83
fldmvgme	66	59.8	63.14		59.8	63.14	66		63.14	59.8	66
lt	5532	5833.15	5513.39		5833.15	5513.39	5531.66		5513.39	5833.2	5531.66

Figure 6.30: Variable means of low and high defensive behaviour scores. Variables are shown in the left column of the chart. Fields underlaid with colour signal lowest and highest variable mean values across token shapes. Green highlights lowest variable mean values across all three token shapes and pink highlights highest variable mean values across token shapes.
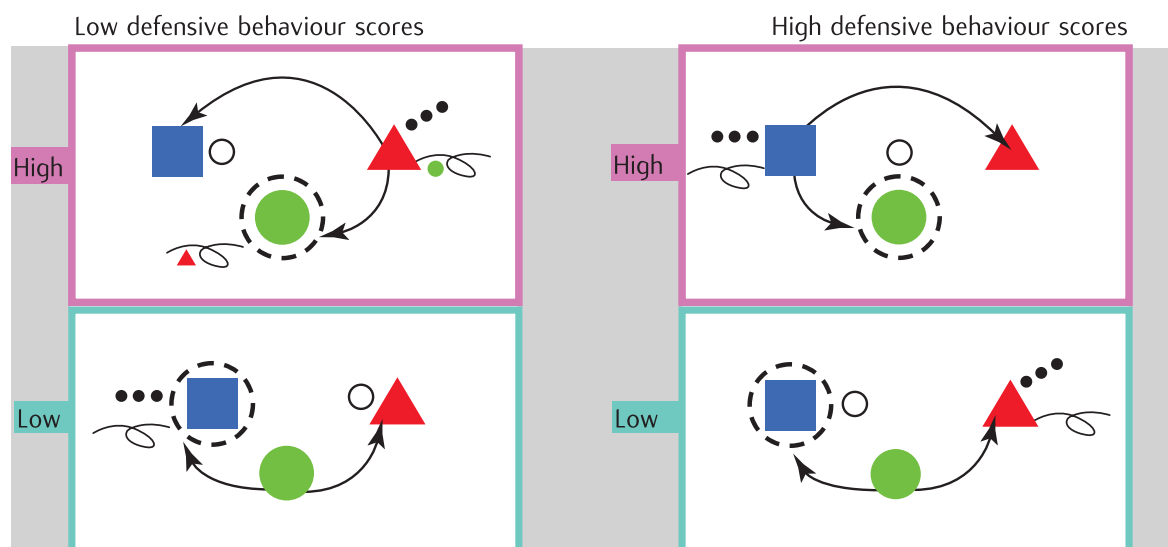

Figure 6.31: Pictograms representing variable means of low and high defensive behaviour scores. Left pictogram displays lowest and highest variable means for low defensive behaviour scores, right pictogram exhibits lowest and highest variable means for high defensive behaviour scores.

group of high defensive behaviour scores. Also, Circle token's variable mean for fields traversed on the game-board, variable *fldmvgme*, is the highest variable mean across all three token shapes in both low and high defensive behaviour scores. They are 80.72 for the group of low defensive behaviour scores and 66.0 for the group of high defensive behaviour scores.

Furthermore, Circle token's variable mean for variable *flyoffs* is the highest mean in the group of low defensive behaviour scores but this is a shared position because Triangle token's variable mean for the same variable is identical to that of Circle token, both token shapes have the variable mean of 2.02. In the group of high defensive behaviour scores, Circle token's variable means for *Coff*, or *offens* in the chart, is highest across all token shapes with 4.75.

6.4.2   Square token variable means

Square token's variable means also show one consistent variable mean that is lowest across all token shapes in both groups of low and high defensive behaviour scores. Square token's variable mean for *fldmvgme* is the lowest variable mean across all token shapes in low defensive behaviour scores with 78.1, and lowest in high defensive behaviour scores with 59.8. In the group of low defensive behaviour scores, across all token shapes, Square token's variable means are the lowest with 1.97 for *flyoffs* and 5816.26 for *lt*. In the same group, Square token's variable means are highest across all token shapes for the passive strategic variable *Soff*, or *offens* in the chart, with 4.63.

In the group of high defensive behaviour scores, Square token's variable mean for variable *Soff*, or *offens* in the chart, is lowest across all token shapes with 4.35. In the same group, Square token's variable means that are highest across token shapes are *flyoffs* with 0.97, *lt* with 5833.15, and for active strategic variables *Sci, Str*, or *defens* in the chart, with 5.48.

6.4.3   Triangle token variable means

Unlike Circle and Square tokens, Triangle token does not have one or more consistent lowest or highest variable means throughout both groups of low and high defensive behaviour scores. In the group of low defensive behaviour scores, Triangle token has the lowest variable mean for *Toff*, or *offens* in the chart, with 4.3. It has the highest variable means for active strategic variables *Tci, Tsq*, or *defens* in the chart with 4.37, and of course the shared position of highest variable mean for *flyoffs* together with Circle token's variable mean of 2.02. In the same group, Triangle token's variable mean for *lt* is the highest across token shapes with 5927.85 milliseconds.

In the group of high defensive behaviour scores, Triangle token's variable means are lowest across all token shapes for *flyoffs*, and *lt*. There are no highest variable means for Triangle token in the group of high defensive behaviour scores.

6.4.4   Observation of opposition patterning in lowest and highest variable means

Overall, the results for this stage regarding token shapes' variable means support what has previously been discussed in stage two. They suggest that a physical positioning in the installation presupposes a set of playing strategies. On average, Circle token's variables show an extremely

consistent position with the lowest defensive behaviour playing strategy and the highest number of fields traversed on the game-board, irrespective of division into low or high defensive behaviour scores. Although, Circle token's variable means for defensive play are lowest, in contrast they are the highest in offensive play where, on average, Circle token's variable exhibits the best token placement of all token shapes. Similar to Circle token's variable means, Square token's variable means also shows some consistency regardless of defensive behaviour score division in traversing on average the lowest numbers of fields on the game-board. Triangle token's variables show none of this type of 'consistent throughout groups' behaviour.

Other observations that can be made by looking at average differences is the repeated opposition between lowest and highest variable means between Square and Triangle tokens with respect to low and high defensive behaviour scores. For example, Triangle token's variable means for *lt* are highest in the group of low defensive players, and lowest in the group of high defensive players. Square token's variable means for the same variable are lowest in the group of low defensive players, and highest in the group of high defensive players. In a similar fashion we note this criss-crossing of variable means for variables *flyoffs*. With one distinction, Circle token's variable mean for *Cnoflyoffs* is shared with that of Triangle token's variable mean for *Tnoflyoffs*, because both have the same value. In essence it is the same principle: Square token's variable mean for *flyoffs* is lowest in the group of low defensive players and highest in the group of high defensive players. Furthermore, Triangle token's variable mean for the same variable is highest (and shared with Circle token) in the group of low defensive players, and lowest in the group of high defensive players. Lastly, the opposing pattern dynamic repeats one more time with active strategic variable means, where Triangle token's variable mean in *defens* is highest in the group of low defensive players, and Square token's variable mean for the same variable is highest in the group of high defensive players. In case of variable mean for *offens*, the pattern is started by Square token's variable means for being the highest in the group of low defensive players, and lowest in the group of high defensive players. Triangle token only matches the lowest variable mean for the same variable in the group of low defensive players, in the group of high defensive players Circle token's variable mean ranks highest as discussed earlier.

6.4.5 Frequency distribution for variable *winningshape*

So far the focus of this stage has been on interval data. In this subsection we briefly examine nominal data with the variable *winningshape*. We performed descriptive statistics to determine the frequency of token shapes winning games in both groups of low and high defensive behaviour scores.

In tables 6.9 and 6.10, we see a tendency for Triangle and Circle tokens to win games in both groups of low and high defensive behaviour scores. Square token's variable *winningshape* ranks lowest in winning games in both groups of low and high defensive behaviour scores. This pattern is commensurate with panoptic correlations in stage two, when we characterised phenomena that appeared in cluster groupings of low and high defensive behaviour scores. Here Triangle token's active strategic variables produced the same panoptic correlations twice, indicated with letter *H*

Table 6.9: Frequency distribution of variable *winningshape* in low defensive behaviour scores

token	frequency
CIR	20
SQU	16
TRI	22

Table 6.10: Frequency distribution of variable *winningshape* in high defensive behaviour scores

token	frequency
CIR	22
SQU	14
TRI	23

in the panoptic chart in figure 6.3. Square token's active strategic variables also procured two identical panoptic correlations, indicated with letter *I* in the panoptic chart in figure 6.3.

In Square token's panoptic correlations with letter *I*, the central theme was reception of defensive (and struggling because panoptic correlations are negative) 'attacks' from both Triangle and Circle tokens via variables *Tsq, Csq*, which was contrasted by the central theme of Triangle token's panoptic self-referential correlations as the 'attacker' with variables *Tsq, Tci*. Loosely interpreted, the frequency distribution of variable *winningshape* suggests this theme is carried over in the win and lose situation of game-play.

For the final stage in this thesis' analysis we investigate variables over time by making use of the 'raw' data set.

6.5   Stage 4: Corporeal variables over time

In the last stage of this thesis' statistical analysis we concentrate on corporeal variable classes and take a look at their values on a game-round basis. Here we utilise the 'raw' data set where data are sampled over rounds within games. We continue to investigate low and high defensive behaviour groups, and maintain the same game sets in each group as in stage two and three of this analysis. The 'raw' data set which samples game-rounds, provides the following sample sizes for low defensive behaviour scores:

$$n_{lr} = 624 \tag{6.6}$$

and high defensive behaviour scores:

$$n_{hr} = 507 \tag{6.7}$$

The variance between both samples is due to differing game lengths in both groups of defensive behaviour scores. In figure 6.32 the histogram shows that the group of low defensive be-

Figure 6.32: Frequency distribution for number of rounds in games that make up the group of low defensive behaviour scores.

haviour scores maximises 24-round games, whereas the group of high defensive behaviour scores maximises 13-round games as seen in figure 6.33.

In this stage we are investigating how the values of corporeal variables unfold over time by analysing them through cross tabulation and case summaries conducted in SPSS and charts produced in Excel software. Because of the varying game lengths in both groups, we have approached variable values as percentages together with deciles to normalise data and compensate for varying game lengths. We present statistical results of this approach in the form of line graphs. Each line graph is classified and grouped by low or high defensive behaviour scores, while all three token shapes' trajectories are displayed together so that these line graphs may be viewed comparatively.

6.5.0.1   Corporeal variable class, pictograms and definitions

The chart in figure 6.34 briefly reviews token shape-specific corporeal variables by their pictograms and definitions.

Cnoflyoffs

This variable indicates the number of times Circle token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.

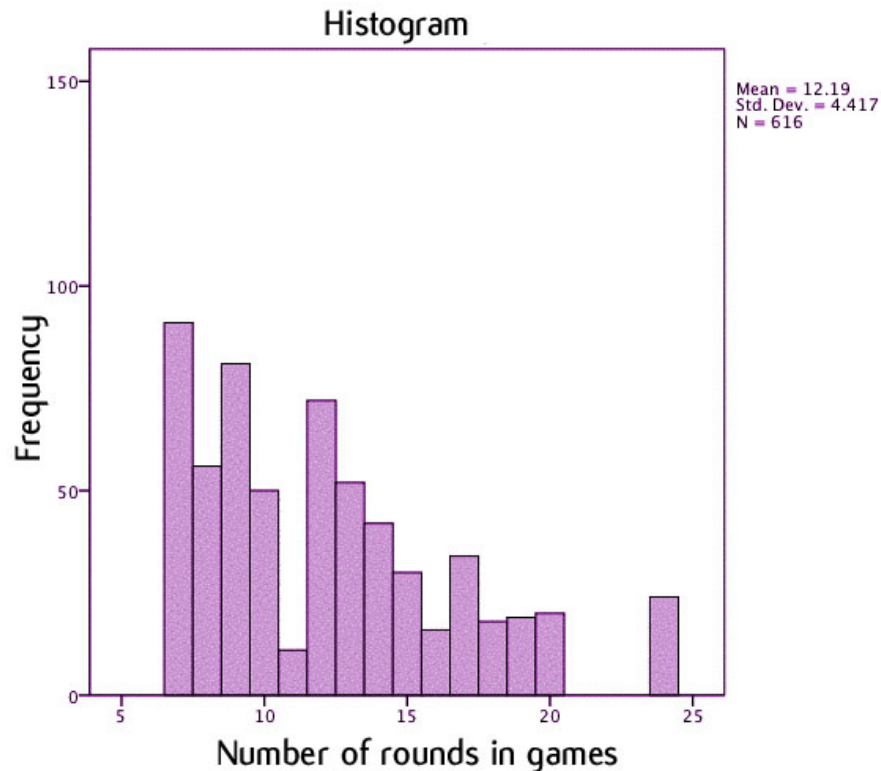The pictogram for this variable is demonstrated in figure 6.34a.

ltci

Figure 6.33: Frequency distribution for number of rounds in games that make up the group of high defensive behaviour scores.

This variable indicates Circle token's longest-held position in milliseconds on a field of the game-board.

The pictogram for this variable is demonstrated in figure 6.34b.

    Cfldmvgme

This variable indicates Circle token's number of fields traversed on the game-board per round.

The pictogram for this variable is demonstrated in figure 6.34c.

    Snoflyoffs

This variable indicates the number of times Square token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.

The pictogram for this variable is illustrated in figure 6.34d.

    ltsq

This variable indicates Square token's longest-held position in milliseconds on a field of the game-board.

The pictogram for this variable is illustrated in figure 6.34e.

    Sfldmvgme

This variable indicates Square token's number of fields travelled on the game-board per round.

The pictogram for this variable is illustrated in figure 6.34f.

    Tnoflyoffs

(a) *Cnoflyoffs* (b) *ltci* (c) *Cfldmvgme*

(d) *Snoflyoffs* (e) *ltsq* (f) *Sfldmvgme*

(g) *Tnoflyoffs* (h) *lttr* (i) *tfldmvgme*
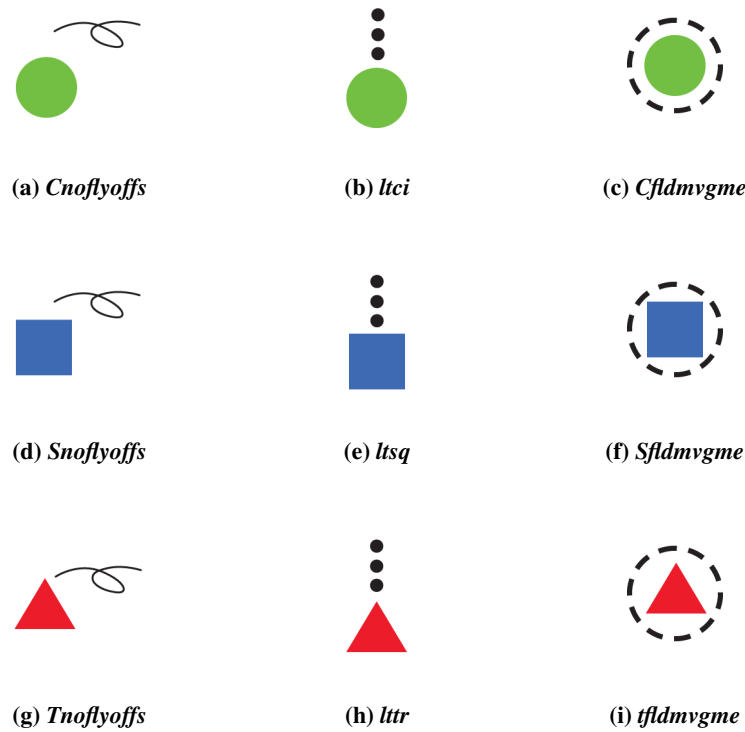
Figure 6.34: Pictograms of corporeal variables for each token shape

This variable indicates the number of times Triangle token flies off the game-board and out of the round. This variable is counted per game-round because each round has one token, therefore tokens are lost per round.

The pictogram for this variable is illustrated in figure 6.34g.

 lttr
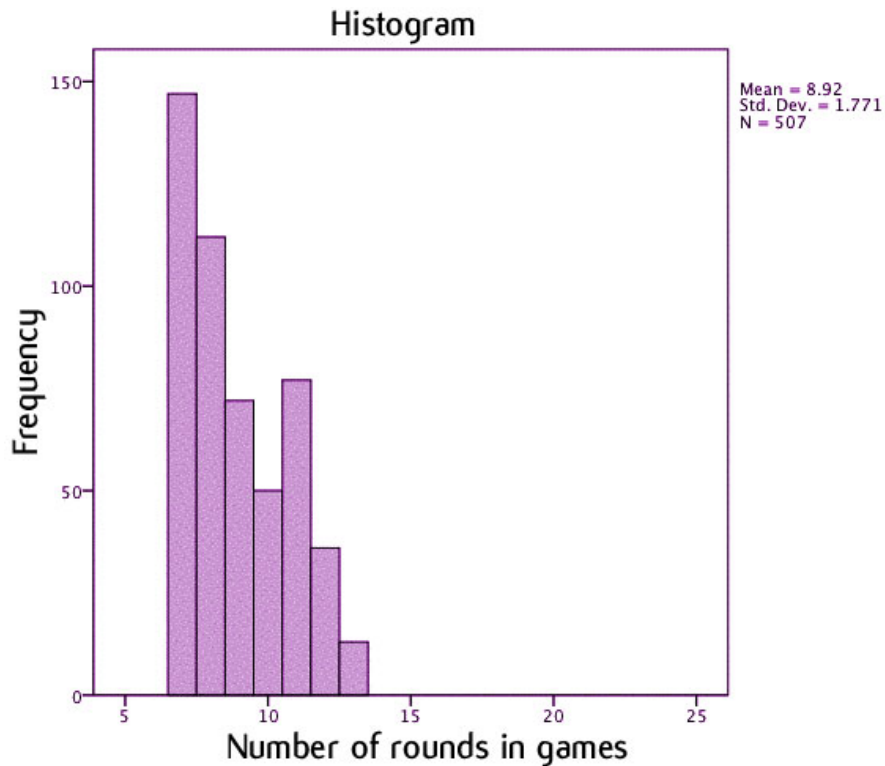
This variable indicates Triangle token's longest-held position in milliseconds on a field of the game-board.

The pictogram for this variable is illustrated in figure 6.34h.

 Tfldmvgme

This variable indicates Triangle token's number of fields traversed on the game-board per round.

The pictogram for this variable is demonstrated in figure 6.34i.

In the section we plot and layout each corporeal variable's data over time.

6.5.1 Values for corporeal variables *Cnoflyoffs*, *Snoflyoffs*, *Tnoflyoffs* over time

The corporeal variable discussed in this subsection describes a token shape flying off the game-board in a particular game-round which is measured as a binary value per game-round, either 1 for "fly-off" or 0 for none. We proceed by demonstrating how we calculated average values over time, using Circle token as an example token shape to exemplify the procedure we applied to all token shapes in both low and high defensive behaviour scores. We first used SPSS to generate cross

		Cflyoffs * round Crosstabulation											
		round											
		1	2	3	4	5	6	7	8	9	10	11	Total
Cflyoffs	0 Count	28	28	26	27	24	24	28	14	7	3	1	210
	% within Cflyoffs	13.30%	13.30%	12.40%	12.90%	11.40%	11.40%	13.30%	6.70%	3.30%	1.40%	0.50%	100.00%
	1 Count	0	0	2	1	4	4	0	1	0	0	0	12
	% within Cflyoffs	0.00%	0.00%	16.70%	8.30%	33.30%	33.30%	0.00%	8.30%	0.00%	0.00%	0.00%	100.00%
Total	Count	28	28	28	28	28	28	28	15	7	3	1	222
	% within Cflyoffs	12.60%	12.60%	12.60%	12.60%	12.60%	12.60%	12.60%	6.80%	3.20%	1.40%	0.50%	100.00%

Figure 6.35: Cross tabulation for variable *Cnoflyoffs* in the group of low defensive behaviour scores. This output was generated in SPSS, it was further processed in Excel.

Figure 6.36: This screenshots demonstrates the conversion formula used to convert ranking rounds to percentages in Excel.

tabulation, counting frequencies of "1" and "0" for the binary value of "fly-offs" per round. We conducted cross tabulation per token shape in each *gameset* of low and high defensive behaviour scores. SPSS syntax for cross tabulation reads:

```
CROSSTABS
    /TABLES=Cflyoffs BY round
    /FORMAT=AVALUE TABLES
    /CELLS=COUNT ROW
    /COUNT ROUND CELL.
```

Each cross tabulation generated a table in SPSS, seen in figure 6.35, which was imported into Excel software. We extracted the row of variable percentages, e.g. "1 count % within *Cflyoffs*" and transposed values in a spreadsheet. We then converted ranking rounds to percentages by using a standard formula, seen in figure 6.36. Once all token shapes had been processed in this manner, we created line graphs for each group of defensive behaviour scores with Excel's line chart function. In figure 6.37 we display the line graph for the group of low defensive behaviour scores and in figure 6.38 we illustrate the line graph for high defensive behaviour scores.

The difference in "fly-off" behaviour by both groups is notably peaking in height and length. The group of players' with low defensive behaviour scores portrays maximum peaking height

Figure 6.37: The group of low defensive behaviour scores: Line graph for variables *Cflyoffs* (green), *Sflyoffs* (blue) and *Tflyoffs* (red), x-axis denotes game-rounds converted into percentages, y-axis shows percentages of total 'flyoffs' scores per round.
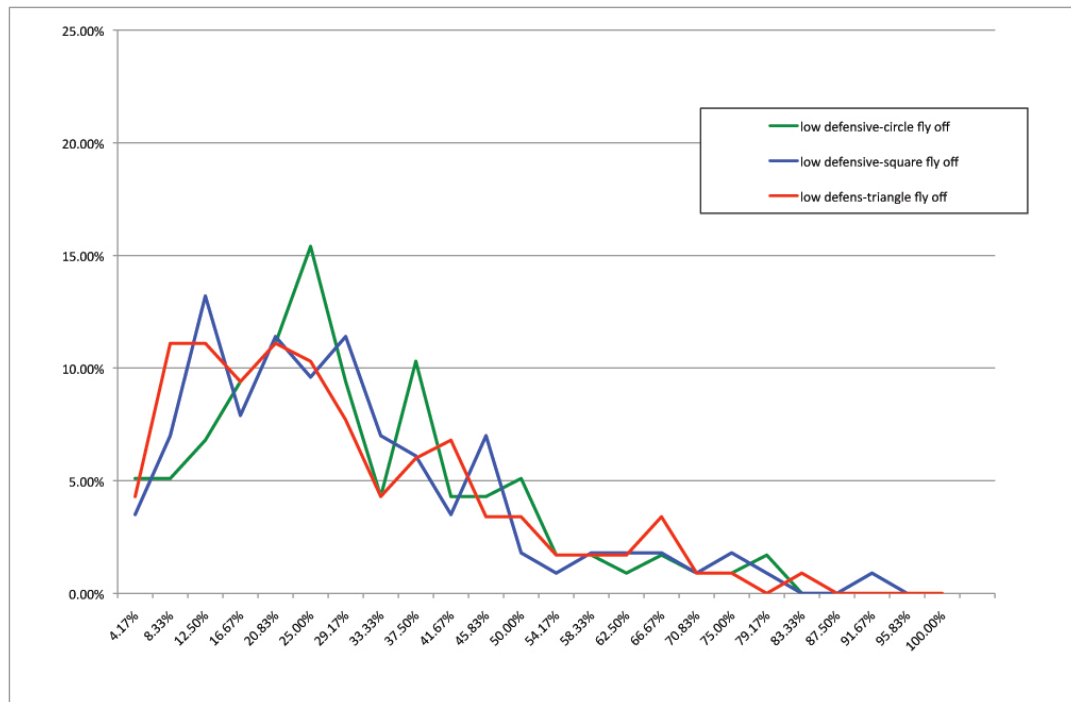

Figure 6.38: The group of high defensive behaviour scores: Line graph for variables *Cflyoffs* (green), *Sflyoffs* (blue) and *Tflyoffs* (red), x-axis denotes game-rounds converted into percentages, y-axis shows percentages of total 'flyoffs' scores per round.
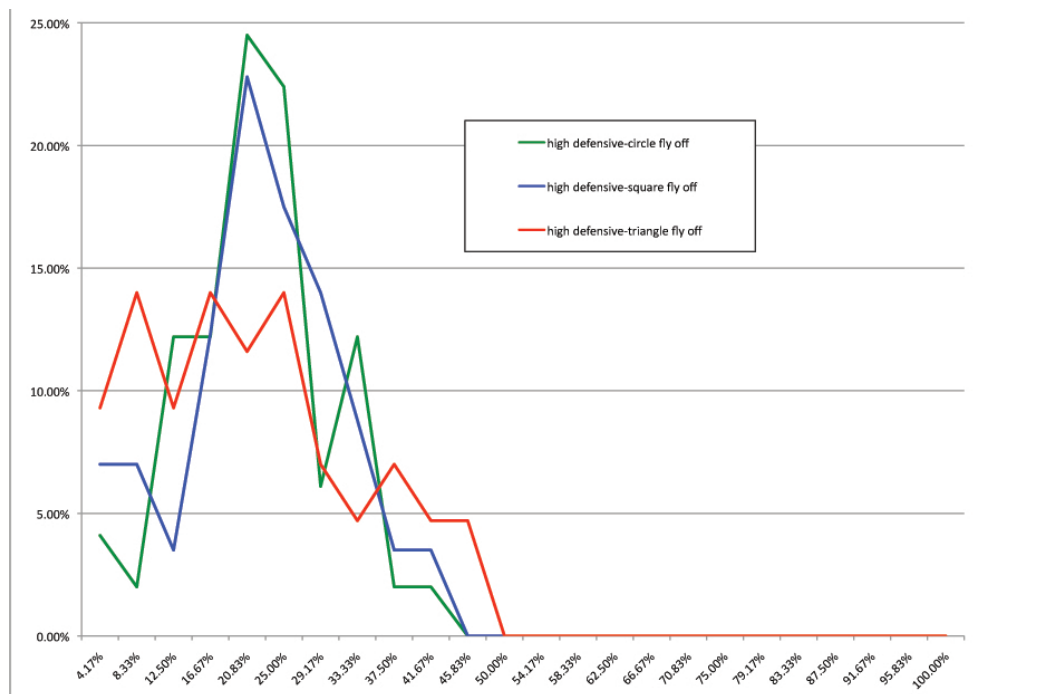
between 10-16%, with the highest peak at 16% recorded at approximately 27% into the game. On average Circle token's variable dominates highest peaks, followed by Square and Triangle tokens. This group of players gradually tapers off their "fly-off" activities over the course of the game.

The group of players with high defensive behaviour scores demonstrates maximum peaking height between 20-24%. Circle token's variable peaks highest with 24% at approximately 24% into the game. Circle token's and Square token's variables' highest peaks are in alignment. Triangle token's variable shows a much shallower peaking trajectory compared to that of Circle and Square tokens. In this group, at about 50% into the game "fly-off" activities come to a complete stop.

Already in stage two of this thesis' analysis we observed a strong axial relationship between Circle token's variable and Square token's variable. In figure 6.38 we see indicators of this notion with Circle and Square tokens' variables related and intertwined trajectories. On average Triangle token's "fly-off" pattern shows little interactional relationship with Circle and Square tokens. For example when observing the first 10% of game-play in figure 6.38, Triangle token's variable peaks where Circle token's variable dips. When Circle and Square tokens peak highest at about 23% into the game-play, Triangle token's variable dips again at that time.

Overall, players in the group of low defensive behaviour scores have a steady approach to flying off from the fields of the game-board over the course of the game length. In contrast, players in the group of high defensive behaviour scores show an acute approach to flying off from the fields of the game-board that lasts 50% into the entire game length, the remaining 50% are free from "fly-offs". Although both groups' highest peaks are in proximity, within 10%, high defensive players seem to master more easily the activities involved in keeping one's token shape in the game.

6.5.2   Values for corporeal variables *ltci*, *ltsq*, *lttr* over time

In this subsection, the variable under inspection describes the longest time a token shape has been held stationary on a field of the game-board. Here we investigate how this variable's values spread over time in both groups of defensive behaviour scores. We demonstrate our procedure on one token shape to serve as explanatory example. This procedure was applied to all token shapes in both groups of defensive behaviour scores. The variable discussed in this subsection is measured in milliseconds and values represent the highest number of milliseconds a token shape was kept stationary in a particular game-round. To obtain an even spread of data points throughout 100% game length, independent of number of rounds per game, we first divided number of rounds and multiplied by 100 to create the variable *pcthrugame*.
The syntax in SPSS reads:

$$\text{compute } pcthrugame = ((round/maxrnd) * 100). \tag{6.8}$$

An additional step was taken to normalise the variation of game lengths in each group, e.g. 8-round games have a higher frequency than 24-round games. With the help of deciles we distributed data points evenly across 100% so that each game length is equally represented at any

given percentage point. The syntax in SPSS reads:

```
if(pcthrugame le 10)decile=1.
if(pcthrugame gt 10 and pcthrugame le 20)decile=2.
if(pcthrugame gt 20 and pcthrugame le 30)decile=3.
if(pcthrugame gt 30 and pcthrugame le 40)decile=4.
if(pcthrugame gt 40 and pcthrugame le 50)decile=5.
if(pcthrugame gt 50 and pcthrugame le 60)decile=6.
if(pcthrugame gt 60 and pcthrugame le 70)decile=7.
if(pcthrugame gt 70 and pcthrugame le 80)decile=8.
if(pcthrugame gt 80 and pcthrugame le 90)decile=9.
if(pcthrugame gt 90 and pcthrugame le 100)decile=10.
```

Next, we conducted statistical analysis computing the mean with case summaries on the basis of the data subset for each token shape's variable, plotted against the grouping variable *decile* in each group of low and high defensive behaviour scores. In SPSS the syntax reads:

```
SUMMARIZE
    /TABLES=ltci BY decile
    /FORMAT=NOLIST TOTAL
    /TITLE='Case Summaries'
    /MISSING=VARIABLE
    /CELLS=MEAN.
```

SPSS outputs demonstrated in figure 6.39 were imported into Excel software where line graphs were computed with Excel's chart function. The line graph showing trajectories for the group of low defensive behaviour scores is illustrated in figure 6.40, and for the group of high defensive behaviour scores it is illustrated in figure 6.41.

In the group of low defensive behaviour scores, variables' trajectories feature, to varying degrees, periodic performance. Circle token's variable trajectory exhibits periodic characteristics with four intervals. By contrast, Triangle token's variable trajectory exhibits only weak periodic performance and Square token's variable trajectory shows no periodic performance.

The group of high defensive behaviour scores features weak periodic performance but exhibits overall more confluence between variables' trajectories. Especially after *decile* marker 7, all three trajectories are focussed in the same direction, making a sweeping downward curve. There is also some similar confluence visible in the group of low defensive behaviour scores, towards the last *decile* marker 10.

In stage three of this thesis' analysis we observed symmetry and full symmetry correlations.

Case Summaries Mean	
decile	ltci
1	6455.73
2	6097.07
3	6508.57
4	6862.2
5	5898.99
6	5942.46
7	5976.3
8	6136.84
9	5930.98
10	4271.78
Total	5926.74

Figure 6.39: SPSS output table for case summaries of the corporeal variable *ltci* grouped by variable *decile* for the group of low defensive behaviour scores.

Figure 6.40: Line chart of corporeal variables *ltci* (green) *ltsq* (blue) and *lttr* (red) in low defensive behaviour scores.
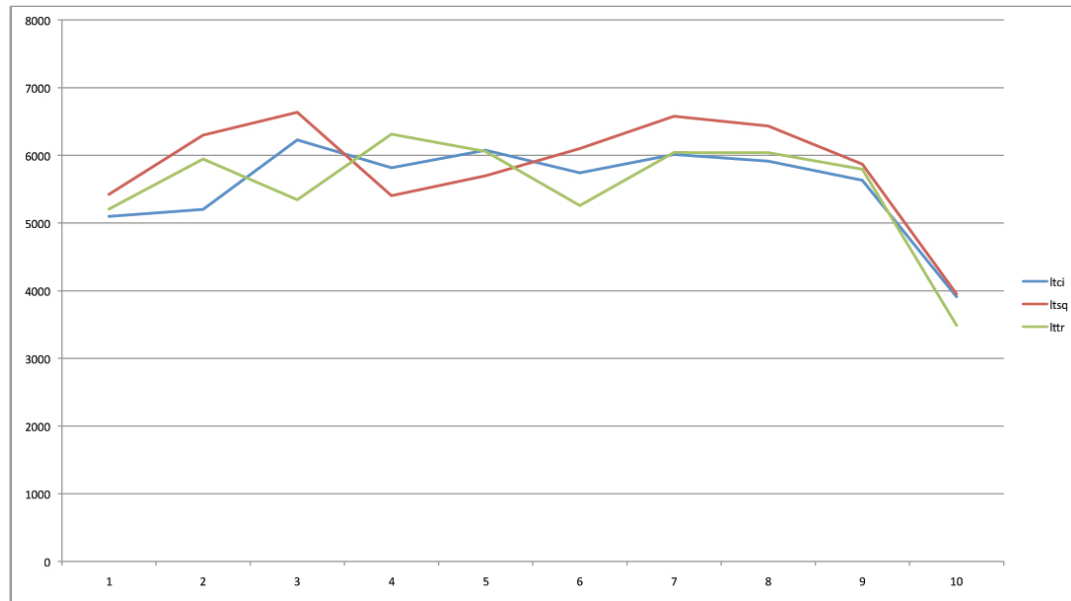
Figure 6.41: Line chart of corporeal variables *ltci* (green) *ltsq* (blue) and *lttr* (red) in high defensive behaviour scores.

In the previous stage we saw that the variable discussed in this subsection forms mostly negative symmetry and full symmetry correlations. Evidence for negative symmetric correlations might be found here in the token shapes' trajectories, which are confluent with a downward sweeping tendency.

6.5.3 Values for corporeal variables *Cfldmvgme*, *Sfldmvgme*, *Tfldmvgme* over time

In this subsection we show how corporeal variables, describing number of fields traversed by a token shape during game-rounds, unravel over time. As in subsection 6.5.2, we first computed *pcthrugame* in SPSS and then neutralised game lengths via 10 deciles, also computed in SPSS. We already detailed these aspects of the procedure in the foregoing subsection.

SPSS outputs were in the form of tabulated case summaries exemplified in figure 6.42, which computed the mean from a data subset, pertaining to each token shape's variable, plotted against the grouping variable *decile* in each group of low and high defensive behaviour scores. In SPSS the syntax reads:

```
SUMMARIZE
    /TABLES=cfldmvgme BY decile
    /FORMAT=NOLIST TOTAL
    /TITLE='Case Summaries'
    /MISSING=VARIABLE
    /CELLS=MEAN.
```

Case Summaries Mean	
decile	cfldmvgme
1	6.43
2	6.96
3	7.41
4	7.63
5	8
6	7.39
7	7.72
8	8.11
9	8.66
10	6.38
Total	7.5

Figure 6.42: SPSS output table for case summaries of the corporeal variable *Cfldmvgme* grouped by variable *decile* for the group of low defensive behaviour scores.
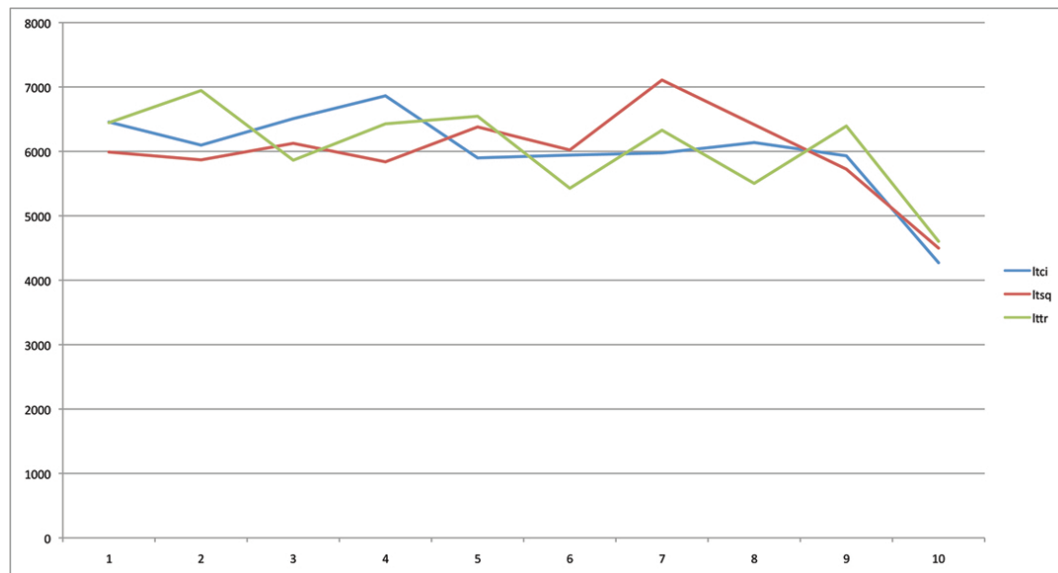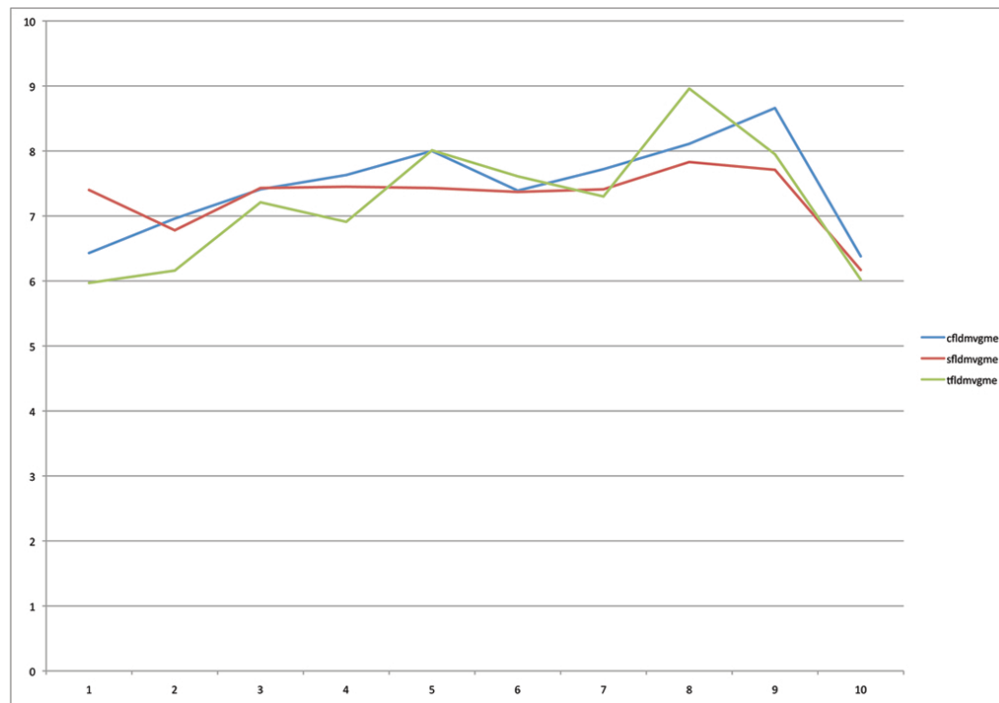

Figure 6.43: Line chart of corporeal variables *cfldmvgme* (green), *sfldmvgme* (blue) and *tfldmvgme* (red) in low defensive behaviour scores
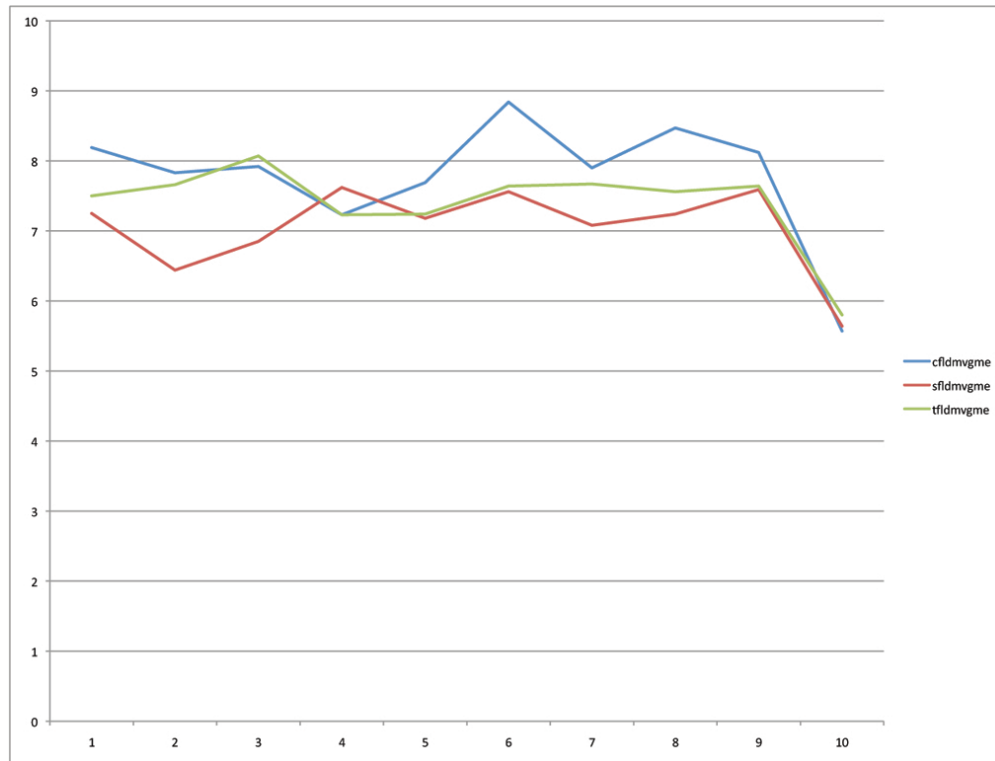
Figure 6.44: Line chart of corporeal variables *cfldmvgme* (green), *sfldmvgme* (blue) and *tfldmvgme* (red) in high defensive behaviour scores

Tabulated case summaries for this variable were imported into Excel software where we calculated line graphs in both groups of low and high defensive behaviour scores using Excel's chart function. The line graph for the group of low defensive behaviour scores is shown in figure 6.43, and for high defensive behaviour scores in figure 6.44.

On average, Circle token's variable trajectory exhibits the most activity in traversing fields on the game-board in both groups of defensive behaviour scores. In stage three of this thesis' analysis, we also observed that Circle token's variable procured the highest-ranking mean for traversing fields on the game-board in both groups of defensive behaviour scores. Here, Circle token's variable extensive trajectory may reflect this variable's highest ranking mean. Also, Circle token's variable performance exhibits some periodicity with three intervals in the group of low defensive behaviour scores. Also in the same group, there is a collective upward trend with Circle and Square tokens variables' trajectories peaking between *decile* marker 8 and 9.5, and reaching between 8.6 and 9 fields of average coverage on the game-board at this stage in the game-play. This trend is only faintly visible in Triangle token's trajectory but at *decile* marker 9 all three trajectories descent collectively.

General remarks on both groups of defensive behaviour scores are that the group of low defensive behaviour scores is associated with more harmonised trajectories and seems overall more evenly tempered when compared with the group of high defensive behaviour scores. The trajectories in the group of high defensive behaviour scores display more extreme collective dipping

and peaking of trajectories, asserting a more energetic inclination in their movements, while both groups approximate a similar span of average field coverage on the game-board.

In the second stage of this thesis' statistical analysis we saw that the variables discussed here produced a prolific number of symmetry and full symmetry correlations in both groups of defensive behaviour scores. In figure 6.44 when examining trajectories of the group of high defensive behaviour scores we observe strong confluence between trajectories in several parts of the line graph. Between the 3rd and 4th deciles, Circle token's variable trajectory aligns closely to that of Square token's variable trajectory, and again between decile marker 5 and 6, Circle token's variable trajectory is closely aligned with that of Triangle token's variable trajectory. Towards the end of the line graph, from decile marker 9 to 10, all three variables' trajectories are closely coordinated in their downward movement. These observations strongly suggest that these trajectories affiliations are indicative of stage two's symmetry and full symmetry correlations.

In the next section we conclude our findings for this statistical analysis.

6.6   Conclusion

For this thesis we conducted an exploratory analysis of Sim-Suite participants' game-play. The question guiding the research described in this chapter centred on embodied cognitive aspects that are expressed as creative participation in the 'field of artistic communication' within short-term and immersive engagement. Over the course of four stages we investigated games generated from log file data for patterns of game-play. Initially we started off applying descriptive statistics to the derived data set, to disclose initial insights. This revealed that we needed to eliminate games with marginal interchange between participants. After we removed games that were less than 7 rounds and created a correlation matrix overview with strategic, corporeal and timeline variable classes, defensive behaviour was foregrounded as a possible emergent pattern of game types.

The next stage investigated active strategic behaviour scores by splitting the total sample into groups of low and high defensive behaviour scores, and producing cluster analysis for each group of defensive behaviour scores. From six identified cluster groupings in low and high defensive behaviour scores we computed correlation matrices with an array of support charts, tables and visualised renderings in the form of pictograms to draw out variable relationship features and to make these more comprehensible. In this process, our findings led us to characterise specific features of variable relationships by developing concepts of panoptic correlations, symmetry and full symmetry correlations, and self-referential correlations. Also, we analysed axial interactions by tokens throughout these relations.

In a complementary approach we evaluated token shapes variable means of low and high defensive behaviour scores supplemented by visual representations with previously introduced pictograms. In the final stage we investigated the 'raw' data set by highlighting corporeal variables' in-game trajectories in low and high defensive behaviour scores.

From the perspective of embodied cognition, the results from this study first need to be contextualised with Sim-Suite as an *in situ* installation for cultural settings where participants step onto wobble-boards to competitively interact in a group of three persons. The focus of interaction

between participants is shared visually and physically. Each participant is standing on a wobble-board in fixed orientation with the other two participants in sight. Participants are gathered around a horizontal area concentrating their gaze on a screen display and bringing their attention to digitally displayed events. Spontaneous and natural full-body movements channel communication on the basis of creative engagement with familiar social and conceptual elements. Sim-Suite thrusts participants into a context which is composed of elements that are physically, socially, and conceptually familiar. Sim-Suite's game-play entails that participants actively reconfigure these elements through creative engagement.

When participants step onto wobble-boards they align their intent by directing it to the objective of game-play. Sim-Suite then becomes the context of joint attention with defining sensorimotor and attentional activities toward the goal of winning the proposed competition (Sebanz et al., 2006; Tomasello, 1995). Digital events on the virtual 'playing' board supply shared perceptual input. The playing objective makes it relevant for all participants to be informed about the whereabouts of other participants with token placement and bodily movement. In coordinated joint attention, participants cast their gaze downwards onto the ground area where digital events proceed and provide input for participants' responses.

In this scenario participants are both actors and observers of bodily movements in joint action. Bodily movements required to participate are simplistic, they are balancing and stepping movements, practically innate human abilities. Action observation necessitates knowing what the other person will do. Observer and actor share the same underlying action goal and this leads to action prediction which is the underpinning of successful interaction. Predicting what another is about to do and planning one's own actions accordingly is formed from shared task representation (Gallese et al., 1996; Blakemore & Decety, 2001; Knoblich & Jordan, 2002).

For Sim-Suite participants task sharing entails playing strategically against each other to win the game. Strategic play is composed of offensive and defensive play, selecting the optimal field for token placement and looking for ways to stop others from advancing their optimal token placement. While offensive play is overt and mandatory, defensive play is covert and optional. This leaves some room for participants to decide on their level of involvement with defensive play which has repercussions on participants' action prediction and action planning.

Part of the results we obtained in this exploratory study may be in regard to this aspect of action observation and task sharing. High defensive behaviour scores comprised positive full symmetry correlations with variables that record tokens that are longest held stationary on a field, and variables that record stepping on the wobble-board to navigate one's token around the game-board. These findings were reiterated when unrolling corporeal variables over time showing coalescing trajectories over game-rounds. Unintended synchronised movements in action observation and task sharing are well documented in research literature, and they even come into being when circumstances are not in support of synchronisation (Goodman et al., 2005; M. J. Richardson et al., 2005; Shockley et al., 2003; Schmidt et al., 1990). One explanation for this result of synchronisation by those with high defensive behaviour scores is that participants' task objective is fulfilled. This enables timely action prediction and planning, leading to action coordination and

synchronous movements. In low defensive behaviour scores the shared task objective was not fulfilled. The participants' defensive engagement was not equal and consistent, this caused interference anticipating action prediction and planning on behalf of each participant as observer. It prohibited action coordination.

Further results obtained from analysis of game-play data showed outcomes relative to spatial orientation of participants to each other and axes of play between participants. Spatial orientation produced a specific locale for each token shape. The two main locales were Square token and Triangle token, functioning as dividing locales between low and high defensive behaviour scores. Participants standing in Square token's locale tended to be highly defensive players, participants in Triangle token's locale were those who played less defensively. Participants in Circle token's locale tended to be in a neutral position, which accommodated defensive efforts by the other two participants when playing along their axes.

Participants play against each other along three axes. This is expressed in a series of triads. Joint attention takes place between two participants and digital events as object of attention, one axis at the time. Participants shift from one axis to the next, although the locale of low defensive behaviour scores, Triangle token, showed less axis activity with Circle token and only moderate activity with Square token. Square token's locale together with that of Circle token demonstrated the strongest axis of interaction. These results may imply divided and selective attention due to simultaneous introduction of target stimuli via simultaneous turn-taking. As mentioned earlier, task sharing depends upon knowing other participants' token placement. Each participant is confronted with two stimuli as token placement by other participants, these have to be evaluated in the context of one's game-play and may necessitate countering with appropriate moves. However, Sim-Suite's game-play only grants response, via token placement, to one of two target stimuli.

The case may be that specific participant orientation to each other facilitates better coping with simultaneous target stimuli, therefore strengthening axis engagement. In spatial orientation to each other, Square token participants and Triangle token participants are faced with a direct opposition. Triangle token participants are also facing Circle token participants diagonally to their left. Square token participants' additional opponent, Circle token, is situated diagonally to their right. This may influence defensive playing techniques where action observation is less accessible on the diagonal. Circle token participants have two opponents opposing in the same degree, possibly the most difficult locale of all because both opponents are diagonally opposed to the left and right.

Our results included observations of three types of corporeal variables with varying implications for game-play. These variables captured three levels of physical activity, and highly defensive players displayed a more energetic picture in several of these variables. In the first instance we measured participants 'losing' their token from a particular game-round. This could happen for a number of reasons all of which having to do with inattention towards aspects of game-play and failing to adjust one's movement according to the demands of the game. Here, highly defensive players learned quickly, at about half-time, to avoid losing one's token. In the second instance, physical activity was part of the game-play challenge, a compulsory physical activity committing

the body to resolve conflictual demands of game-play. This entailed finding a point of resonance between stepping or moving on the wobble-board and maintaining one's token shape on a field of the game-board until a particular round comes to an end. Both of these types of physical activities actualised synchronous movements between participants, engendering symmetric representation in correlated data either between two or all three token shape variables. Nevertheless, production of synchronous movements was dominated by the third instance of measured physical activity where we recorded fields traversed on the game-board per game-round.

When considering the nature of these physical activities in Sim-Suite's game-play while recognising the outcomes of synchronous movements in game-play activity, we may recall from section 4.2.1.3 that dancing promotes a similar pattern of physically coupled movements between agents. It may be construed that these synchronous movements show similarities to dance steps. Specifically, alternating dance steps between stepping on the wobble-boards to hold one's token still, and stepping on the wobble-boards to navigate the game-board. In addition, participants were possibly assisted by auditory feedback from wooden surfaces hitting each other.

This concludes chapter six. In chapter seven we look at the wider implications of joint attention, action prediction and observation, as well as synchronous movements and the effects of spatial orientation of Sim-Suite players. In the next chapter these topics are reviewed in the context of empirical findings in embodied cognition research, the theoretical lens from chapter four and creativity research.

Chapter 7

Sim-Suite and the creative process continuum

7.1   Introduction

In this thesis we have been concerned with the contemporary developments in artistic creativity. In chapter one we explained that these developments have unified creators and audience in the engagement of a 'field of artistic communication'. The embodied creative processes involved in the active experience of the 'field of artistic communication' are part of a continuum. At the end of chapter one we proposed two questions about the creative process continuum to be investigated via the case study research strategy advocated by this thesis. The questions centred on embodied cognitive aspects and their relevance and relation to the creative process continuum. Each question was ascribed to a different procedural and temporal parameter, such as long-term, collaborative engagement versus short-term, immersive, cooperative engagement. These parameters spurred two investigations, each with its own methodological approach for data collection and analysis. We contextualised our findings from the perspective of embodied cognitive processes at the end of chapters five and six.

The micro and macro structural features of the creative process continuum dictated the necessity of two investigations, determining methodologies prepared with either qualitative or quantitative data. For example, the real-time trail of technological artefacts created by participants obliged the use of methodologies that exploited and applied the numeric, algorithmic component of these artefacts. At this stage, we are no longer bound by these necessities and are able to look at the creative process continuum from a coherent, expansive perspective.

Up until now, the investigations in chapters five and six were treated as separate entities. We conducted each study independently, and contextualised findings from the perspective of embodied cognition without associating findings from both chapters. In this chapter we relate the findings from chapters five and six to one another. We refer to them also as relational findings. Throughout this chapter we compare how these sets of findings relate to the same topic in embodied cognition. We proceed in this approach by referring back to the theoretical lens established in section 4.2, and by bringing empirical research from embodied cognition into the discussion. Where relevant
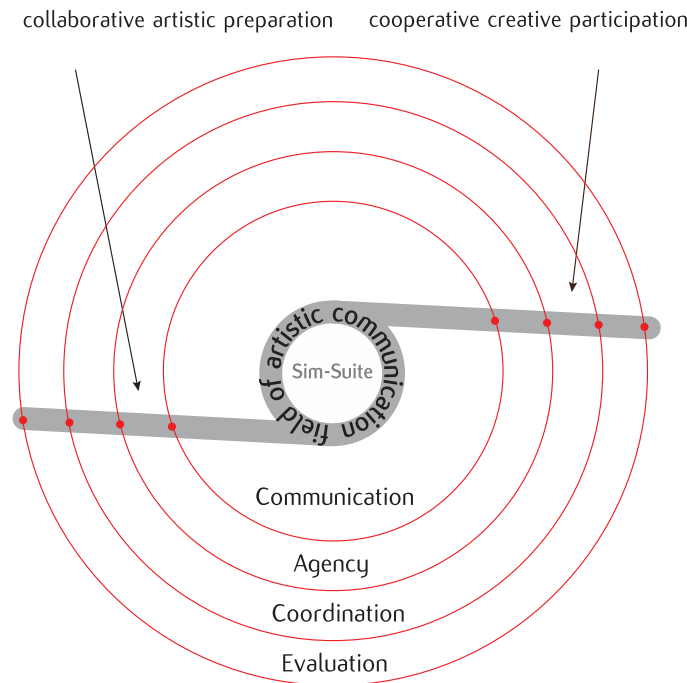
Figure 7.1: This figure demonstrates the main themes on embodied cognition we have uncovered via our research. *Communication, agency, coordination* and *evaluation* are depicted in hierarchical fashion. However, individual components are not strictly separated from each other. We have indicated with concentric circles that all components are interlinked and interrelated.

we draw on chapter two and contextualise findings in creativity research with our results.

In chapter one we asked the question: How are related cognitive processes expressed in two instances in the creative process continuum? We present our answer to this question via a series of themes in embodied cognition. In each theme we discuss related cognitive aspects that have been identified through our investigations and findings. Before we lay out these themes, let us recall how we characterised the creative process continuum in chapter one:

The 'field of artistic communication' engenders procedural creative processes defining the multi-dimensionality of a continuum. Creative processes involved in collaborative preparation of the 'field of artistic communication', and creative processes involved in cooperative and creative participation in the 'field of artistic communication' operate cognitively on a continuum via embodiment.

Accordingly, these creative processes can be probed to exhibit underlying embodied cognitive processes, because we know from creativity research that creative cognition is constitutive of cognitive processes that build on extant knowledge structures. Figure 7.1 graphically depicts the main four themes bridging 'collaborative artistic preparation' and 'cooperative creative participation'.

Themes in figure 7.1 form concentric circles around Sim-Suite's 'field of artistic communication'. The creation of artistic communication begins with basic communication because the processes involved are collaborative and cooperative. The graphic further reflects the conduct of actions is through autonomous behaviour or agency. Here we discuss the understanding that cog-

nition and embodiment are inseparable from autonomy as put forth by the enactive perspective. With the theme *coordination* we have reached action-specific processes that are coupled, which can mean coupled to others, coupled to materials, or the environment. The theme *evaluation* makes up the last circle in the graphic, because evaluative processes are regulatory and directive. Evaluative processes not only move the process forward in time, they comprise aspects of all other components that have to occur first for evaluation to take place.

In this chapter we discuss each theme and its process properties on the preparatory side and the participatory side of the 'field of artistic communication'. Each main theme has a number of sub-themes that are listed in table 7.1. These sub-themes are discussed within their main themes. In section 7.2 we discuss *communication* where we revisit the communication model introduced in chapter four under the embodied-embedded approach to cognition. We explain how 'signal cost' relates to the two perspectives on the creative process continuum.

The next section, 7.3 deals with the cognitive process of *agency*. We draw parallels to intrinsic motivation explained in chapter two. Here we also refer back to agency in the enactive approach in chapter four. This section is supported with additional research from experiments in embodied cognition that have investigated agency. This helps us to pinpoint the exact aspects of agency that are at stake in our account of the creative process continuum.

In section 7.4 we tackle several sub-themes. We first introduce the overarching theme *coordination* with a number of experiments on social interaction conducted in embodied cognition. One aspect of coordination involves joint action. In triads, joint action and creative exploration are linked together through the exploitation of affordances with the material used for creative expression. Here we relate findings from the early cycle of our research to creative cognition experiments discussed in chapter two. We then introduce experiments in linguistic entrainment research. We make connections with entrainment through our findings, and the role of language in the creative process continuum. We review claims made about language in the embodied-embedded approach in chapter four, and map these to our account of the creative process continuum. Next, we move on to discuss a second form of coordination, interactional synchrony. We propose explanations for our findings on interactional synchrony within Sim-Suite's creative participation. The last sub-theme in this section takes a look at physical space and spatial orientation. We mention experiments in joint action and spatial orientation, and relate the resulting insights to our findings. We wrap up this section by pointing out the importance of physical space in artistic creation.

In the last section, 7.5, we focus on evaluation and empathetic foundation in the creative process. To do so, we link back to the communication model introduced in chapter four and elaborated upon in section 7.2. We identify the first level of evaluative processes as emergent from communication. This is a basic feature in collaborative and cooperative creative processes. We demonstrate the second level of in-process evaluation which centres on the action that is being performed. In creative collaboration this type of evaluation was foregrounded during the execution of an idea. In creative participation, it was coupled to navigational decisions on the game-board. In the third level, the above-process evaluation, team members evaluate their work from the perspective of a media artwork. Sim-Suite participants on the other hand perform above-process evaluation when

Table 7.1: Embodied cognitive processes identified in the creative process continuum.

Embodied cognitive processes by theme

Main themes	Sub-themes
Communication	- signal cost
	- 1st level of evaluative cognitive processes
Agency	- misattribution
	- undetected discrepancy between predicted consequences and actual sensory consequence of movement
Coordination	- joint action
	- affordances
	- linguistic entrainment
	- interactional synchrony
	- physical space and spatial orientation
Evaluation	- 2nd level (in-process)
	- 3rd level (above-process)
	- empathetic foundation

they make decisions on game strategy. In addition there is an unconscious factor, which we associate with the concept of the observer explained in the enactive approach in chapter four. Finally we close this section by noting that empathy, as it is understood from the enactive perspective, is the foundation for our account of the creative process continuum.

At the end of this chapter, we revisit creativity research and draw conclusions that directly speak to the content in section 2.3. We briefly discuss a number of themes in creativity research from the perspective of our findings: problem-finding, interdisciplinarity, motivation, art form, and evaluative processes. We contrast these with the much broader approach to creativity taken in this thesis. In the next section, we begin with our first sub-theme on 'signal cost' in communicative situations in the creative process continuum.

7.2   Communication: The signal continuum in 'the field of artistic communication'

In this section we first reconnect to the embodied communication model in section 4.2.1.1, and also section 4.2.1.5 where we discuss language as material symbols. Turning to Sim-Suite and forms of communication in the creative process continuum, we note that Sim-Suite's team members communicated verbally in both collaborations. The verbal stage was accounted for either as preceding physical action, or following action depending on issues that arose from the context of action. By contrast, Sim-Suite's participants were not specifically engaging in verbal communication as part of their gaming interactions (though some communication was taking place) but were

nevertheless communicating via their bodies in motion and the changing visual display as result of their actions.

From the perspective of Oberzaucher and Grammer's model, mutual cooperation transpired between Sim-Suite's team members and participants in the following fashion. Mutual cooperation was needed for the cooperation of Sim-Suite's team members to generate workable ideas, utilise their skill sets effectively and evaluate their work. The cooperation needed for the production of the installation impelled a wider range of analogue indexes from the signal continuum, including spoken words predicated by types of coupling with the environment. Enactively speaking, the collaborators' intention of constructing the artwork produced structural coupling with the environment in an open-ended manner, with motor contingencies and affordances contained only by the larger immediate, surrounding environment and cultural artefacts. In other words, tools, objects, locations, and people demarcated the collaborators' environment in which their embodied communication took place to construct the artwork.

On the other hand, the mutual cooperation entered into by Sim-Suite's participants when stepping into the installation was characterised by a narrowly defined environment. Sim-Suite's team members, who had prepared a 'field of artistic communication', intentionally limited structural coupling for the participants when they entered into the created 'cultural environment'. Sim-Suite as 'cultural environment' placed high attentional demands on its participants, and channelled attention to specific areas in the interface within the game-play context. It restricted participants' embodied communication bandwidth, centering it predominately on analogue indexes from the signal continuum that involved body motion, sound, gesticulation and other indicators of non-verbal mental processes. Sim-Suite's interface and game-play channelled the participants' attention that minimised spoken words and the reception of facial expressions.

The nature of mutual cooperation shown by Sim-Suite's participants was grounded in embodied communication with playful competitive behaviour. From the premise of Oberzaucher and Grammer's model, which we use to explain communication in the context of a situated and exhibited artwork that was analysed through the quantitative data, we are relating the game aspects of the artwork to cooperative communication invoked by the notion of competition. The model builds on evolutionary constraints of honesty, deception, and manipulation in communication. We see that the notion of competition may have encouraged adaptation of the various deceptive communication strategies, mentioned in the model, to ensure winning the competition. Adaptive behaviour demonstrated by the participants is tailored to the specific aspects of the 'cultural environment', such as standing and balancing in one place on a wobble-board as well as responding to the demands of the game-play, such as the movement requirements. In other words, participants had to be resourceful and use their creative potential to adapt deceptive communication strategies to the competitive situation presented by the artwork. From this perspective deception and competition can be seen as related phenomena that are shaped by the pursuit of self-interest. The participants' deceptive strategies were encouraged as part of the socially coupled game-play along with it a set of manoeuvres of encoding and decoding of deceptive signalling. Here, competitive behaviour expressed through physical coordination in coupled communication is form of gesticulating one's

strategies.

By contrast, the nature of mutual cooperation for Sim-Suite's team members was characterised by building trust via embodied communication. From findings in chapter five we learned that collaborators were spending time and effort, committing themselves to creative acts in the production of Sim-Suite over the course of many months. According to the embodied communication model, the indexes from the signal continuum were not only wider ranging but also more costly for Sim-Suite's team members. Referring to Zahavi's Signal Handicap theory (A. Zahavi, 1997, 2000), Oberzaucher and Grammer explain:

> Analog signals on the index level evolve to be reliable by a special selection process that differs from the process that selects all other characters other than signals: The evolution of a signal should impose a handicap (an investment) on the signaller because of the possible deception (p.156).

For the signal to be perceived as honest and hence trustworthy it must impose production costs on the sender. This production cost may be seen in Sim-Suite's team members' efforts to communicate effectively. These efforts made by individual team members ranged from adapting to different working styles, to the ability to overcome environmental constraints, and devise compromises during the idea implementation phase of Sim-Suite's game. We interpret these efforts as comparable to a display of the individual's 'fitness' factor, to be a reliable team member. From this comparative perspective both groups, Sim-Suite team members and Sim-Suite participants, had different signalling needs within their groups to communicate creatively. This suggests that embodied communication in the creative process continuum holds relative positions of signal cost depending on the content and commitment to the 'field of artistic communication', including varying ranges of analogue indexes from the signal continuum.

7.3 Agency

In chapter two we discussed that creativity researchers from social psychology found that creative behaviour without intrinsic motivation is most unlikely. This insight resulted from years of research and the formulation of the *Intrinsic Motivation Principle of Creativity*. The collaborations that created the artwork Sim-Suite were intrinsically motivated without external incentive. Team members were motivated to physically engage while adopting and tailoring their expert skills to the demands of the project. They had to become proficient with unaccustomed tasks; they had to surmount failed attempts at implementation, compromises and constraints induced by the environment; and transcend incompatibilities in working styles and interaction patterns due to interdisciplinary collaboration efforts.

Intrinsic motivation was equally important for Sim-Suite participants, who had to step out from their anonymity as audience members onto the platform where they became the centre point of audience attention. Here they were committing themselves to physically engage with an unfamiliar environment, within which they had to adapt their personal control to navigate the new territory (Bandura, 2001). In addition, findings in creative participation with Sim-Suite's game

from chapter six showed that corporeal variables in games with high defensive behaviour scores engendered more energetic trajectories than those of low defensive behaviour scores. This may point to diverging levels of motivation between participants of low and high defensive behaviour scores.

In both instances of the creative process continuum, in terms of team members and participants, agents created their experience causing events to occur through willed action of the internal self that acted as separate entity from the external world in order to establish social communication. But willed action is generated in tandem with the self-identified physical body because effective action is achieved through reciprocal interactions between perceptual cues and sensorimotor controls.

In section 4.2.2.3, we stated that agency is the core element in the first dimension of embodiment from the enactive approach to cognition. It is the starting point for autonomous systems. It is the active, intentional separation from the environment in pursuit of self-sustaining processes, whereby the agent proceeds with adaptive action in pursuit of self-preservation. In human agents body image and body schema have been conceptualised as attributes of agency. According to Gallagher (2005a, 2005b) the experiential continuity of a body part to the entire body is actively constructed when representing the body as a whole in the body image. By contrast, the body schema functions on the neurological non-conscious level where the body's capabilities for action are defined. The embodied-embedded approach to cognition postulates that cognitive niche construction with advanced technological means takes advantage of the brain's neurological plasticity where new bodily structures are integrated into the body schema. Enactive cognitive science on the other hand, points out that the body-body problem arises with a distinction between body image and body schema. Thompson (2007) stated that the approach is problematic because it does not account for pre-reflective bodily self-consciousness, our predominant bodily consciousness we experience most of the time.

To understand how agency affected the creative process of Sim-Suite team members and Sim-Suite participants, we first take a closer look at empirical research in the next section.

7.3.1 Experiments on agency supporting findings in Sim-Suite's creative process continuum

Building on section 4.2.1.4, where we noted theoretical approaches that detail perceptuo-motor systems understandings on agency, we now take a brief look at the empirical side of an embodied-embedded approach to agency by outlining three seminal experiments to support our research findings. These researchers who conducted these experiments work in the field of cognitive neuroscience and cognitive psychology. Their empirical work has been appropriated by several proponents of embodied cognition, among these are S. Gallagher, T. Ziemke, and A. Morse. There is currently a new research branch in the making which is funnelling this research work to understand 'joint action'. The starting point of 'joint action' shares the concept of minimal representation which is integral to extended mind theory.

Blakemore, Frith, and Wolpert (1999) investigated tickling by deploying a robotic device in the

production of tactile stimuli. The stimulus was induced on the palm of the right hand, either self-produced or externally produced. In the conditions in which the tactile stimulus was self-produced, subjects moved the arm of a robot with their left hand to produce the tactile stimulus on their right hand via a second robot. Temporal relationships were explored by creating a delay between the initiated movement of the left hand and the ensuant movement of the tactile stimulus on the right hand. Spatial relationships were investigated by implementing trajectory perturbations and varying the direction of tactile stimulus as a function of the left hand movement. Ticklishness ratings climbed proportionally with an increase of temporal delay and spatial deviation between self-produced movements and tactile stimulus. This suggested that the experience of ticklishness was in proportion to the discrepancy between the predicted and actual tactile feedback that followed the hand movement.

Knoblich and Kircher (2004) conducted studies that asked subjects to perform circle drawing tasks with a stylus on a writing tablet. In four experiments the researchers investigated continuous actions to understand: whether movement velocity moderates conscious detection of changes in visuomotor coupling; whether conscious change detection can be affected by an external signal guiding the circle drawing movement; whether induced spatial and asymmetrical changes are more likely to be detected than spatial and symmetrical changes; and finally, whether conscious detection of changes in visuomotor coupling is based on local or global discrepancies. The main finding by this study was the systematic relationship between the extent of change in relative velocity and the conscious detection rates which remained consistent across different initial velocities. Knoblich and Kircher suggest that the "signal for conscious change detection was generated by a system that integrates visual and motor information and that the signal was proportional to the discrepancy between these two sources of information" (p.664). Signals are recognised and regulated by the organism as one coherent unit of sensorimotor functions.

The previously mentioned research investigations into attributes of agency were centred on the individual's self-instigated actions. Recently research on agency was conducted from the perspective of social interaction and self-recognition. Van den Bos and Jeannerod (2002) build on a research setup by Daprati et al. (2002) with a version of the alien hand phenomenon. The research setup involved subject and experimenter sitting across each other at a table with their right hand on the table wearing a glove to avoid morphological cues of identity. The subject's hand was hidden under a table-mounted flat screen display angled at 45°. On the backside of the flat screen display a mirror was mounted reflecting both hands which were filmed by a video camera and displayed on the screen. For the subject, this created an impression of looking directly at the table with both hands placed on it. The trials began with both persons holding their hand in a fist and the screen switched off. An auditory signal indicated to the persons to move either thumbs or index fingers. The screen was switched on and after a second auditory signal the persons initiated their movements simultaneously. In a different condition where experimenter and subject moved at different times, different fingers were moved as well. After a one second on-screen appearance of the hands, the screen was switched off and on again, this time displaying an arrow indicating a former hand position, which had to be identified by the subject as belonging to self or the experi-

menter. Other conditions of discreet actions included temporal onset and spatial image rotation of 90°, -90°, and 180°. The results showed that "same movement" conditions with ambiguous action cues produced error rates but these were lowest when the hand orientation was congruent with the subject's body orientation. Generally, the study results suggest that bodily cues and action cues are part of self-recognition, and that action cues can overrule bodily cues.

7.3.2   Agency in Sim-Suite's preparatory and participatory creative processes

In chapter five we laid out findings for the collaborative creative processes by Sim-Suite's team members. In both collaborations, team members engaged in discreet as well as continuous actions with the artwork-in-progress[1], such as the construction of wobble-board encasements and platform; creating animations; writing programming code; and designing graphics and producing sound samples. In section 5.3.1, and more specifically for Sim-Suite's game creation section 5.3.2.3, we illustrated via quotes from reflection sessions how collaborators depended on contributions by others via social interactions with their work-in-progress. The collaborators had arrived in places which made it impossible to perceive possible interaction bottlenecks for potential participants who would be engaging with the artwork-in-progress for the first time. The collaborators were making iterative changes while performing repeated physical engagement with their work-in-progress, for example when creating interaction mechanisms where game events had to be coordinated with movements on the wobble-board and token shape movements traversing the game-board. These activities created discrepancy in the collaborators' sense of agency between predicted consequences of movements, or the intentional changes implemented in the artwork to improve interaction, and their actual perception as consequences of movements after implementation. These actual consequences were no longer recognisable because the collaborators were expecting the desired state of changes. It made the perception of unadulterated movements, as they would be experienced by participants coming to the artwork without prior knowledge of it, impossible to perceive.

On the other hand, the collaborators noted that participants engaging with the artwork were frequently misattributing agency to their respective token shapes in Sim-Suite's game. The participants were navigating their token shape remotely by stepping and balancing on wobble-boards where the token shape to be navigated could be located anywhere on the game-board, either further or closer away from the edge of the wobble-board they were standing on. This might have had effects on spatial perception and consequently influenced the sensorimotor system and action execution (Jordan & Knoblich, 2004). To remedy this situation graphic support was implemented, such as highlights on tokens when they are first placed into a new game-round. The idea here was to create visual cues that would facilitate persistent identification with a particular token shape, or help reinstate it in the beginning of each game-round. However, the situation could not be contained completely, compensating for misattribution or non-attribution of participants' respective token shapes, because of the nature of the artwork where collective social interaction takes place

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[1]In chapter five, it was also pointed out that some of these actions might have been epistemic. At this time, we do not have a sufficiently fine-grained analysis of Sim-Suite participants' engagement, and are therefore unable to review them in conjunction with findings from Sim-Suite's team members collaborate creative process.

in an enclosed visual field on a game-board[2]. In addition, digital material was used to represent the participant in Sim-Suite's game. This representation was a two-dimensional shape which simulated the participant's movement, or put in another way, through movements on the wobble-board Sim-Suite participants remotely navigated on the virtual game-board. In section 2.3.3.1 we discussed some of the issues that arise from the dimensional difference between physical and digital materials which may affect a person's comprehension with associated interaction mechanisms.

Creative acts and agency have important connective links to idea generation and the perceived manifestation of ideas in the physical world. In the case of Sim-Suite, we saw that the creative process continuum is permeated with issues of agency which are located between idea generation, the implementation of ideas, and social interaction and participation. We assume that issues of agency are not specific to the creation of Sim-Suite, but that media artists in the course of their work develop strategies that cope with artistic intention and the unconscious detection of changes in their agency when iterating over artworks-in-progress. Unlike non-interactive art forms, artists working with interactivity propose a physical commitment to their audience as gateway to the artwork. If interactivity is not supported by a transparent mechanism, the artwork becomes inaccessible.

7.4   Embodied coordination

In chapters five and six, we touched upon joint action by thematically discussing shared dialogue, action prediction and observation in the conclusion of each chapter. In this section we elaborate on the broader theme of joint action from the overarching embodied-embedded cognitive perspective. Traditionally joint action has been attributed to language research but recently researchers who pursue embodied cognition have begun to investigate the perceptual, motor and cognitive activities of two or more individuals organised in coordinated and joint action (Galantucci & Sebanz, 2009). These investigations have been sparked by advances in cognitive psychology and cognitive neuroscience research. They demonstrate that people's bodies are interlinked beyond symbolic communication, that communication relies on the individual's motor system in the perceptions of other people's actions.

7.4.1   Experiments on social interaction supporting findings in Sim-Suite's creative process continuum

In section 4.2.1.2 we discussed the nature of affordances from the perspective of the embodied-embedded approach to cognition as relational dynamics between organism and environment. In this context M. J. Richardson et al. (2007) compared biological flexibility to the physical extension via tools and objects in the exploitation of relational affordances. M. J. Richardson et al. conducted experiments based on predicting that the extension of one's own body via tools is equally true for interpersonal activity, where cooperating individuals join together in the actualisation of interpersonal affordances "much in the same way as two limbs come together to actualize intrapersonal affordances" (p.847). To test assumptions in terms of the organism-environment-action system

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[2]Similar observation in enclosed visual fields have been made in surgery situations when multiple hands operate together in a dense and narrow visual area.

regarding the body, the body-tool and the body-body levels of affordances, four experiments were designed. These required that subjects (1) make judgments about graspability of wooden planks and (2) actually grasp and move wooden planks of different lengths using either one hand (1H); two hands (2H); two hands with grasp-extending tool in one hand (TH); or with another subject in assistance with each subject holding one end of the wooden plank (2P). Of particular interest was the transitioning between "the action-scaled ratio at which individuals or pairs of individuals transitioned from 1H to 2H, 2H to TH, and 2H to 2P grasping" (p.847). 1H, 2H, TH, 2H and 2P were calculated in regards to an action-scale ratio such as plank length/hand span for 1H grasping, plank length/arm span for 2H grasping.

The overall results for the first two experiments with individual subjects examined in afore-mentioned conditions showed that individual subjects perceived grasping boundaries between conditions properly. They also perceived action-abilities with the unfamiliar (TH) tool accurately. In experiments three and four with subjects in pairs, the results showed that transitions from 1H, 2H, TH, to 2P proceeded in a similar manner as in the solo experiments. This suggests that the "spontaneous emergence of joint or tool-based activity results from the perception of action-scaled animal-environment relations" (p.856). It further suggests that there is functional equivalence of body, body-tool and body-body action systems, which support the understanding that body-tool and social action systems are constitutive of a single synergy.

The researchers noted that when the "dynamical pressure of a previous trajectory of action was not present, the pull to cooperative action appears to have been stronger than the pull to solo action" (p.857). This suggests that affordances operating on the interpersonal level are preferred to self-similar affordances enabled by individual action systems with inanimate tools. Therefore the social unity offers a more global change in the affordance spectrum, extending embodiment through joint activity and socially embodied cooperation and affecting dynamics with others through emergent entitativity (groupness) (K. L. Marsh et al., 2009).

K. L. Marsh et al. (2009) recognise three major principles stemming from the understanding that movements and actions are constraints via interaction with others. This understanding implies that dynamic principles underpin and unify components of a system in social and non-social action, and that the linkages between the components are mechanical and informational. The perceived information strongly affects human behaviour equally to mechanical linkages, and how others "moor" us in time and space affects behaviour temporally (past, present and future).

In the last subsection of chapter two, 2.3.3.2 we mentioned that artistic collaborations in the genre of media art require for the collaborators to reconfigure their expert knowledge and use that knowledge to innovate. Beyond this, collaborators have to behave cooperatively predicated by social skill. This enables the informational and mechanical linkage K. L. Marsh et al mention above. Social skill is the meta level of this type of engagement which is a prerequisite for the successful unfolding of the creative process. Collaborative creative processes such as the one that delivered Sim-Suite occur over many months, where the collaborators during the creation of the artwork engage in situations that require an adaptive predisposition by all involved individuals to guide the various types linkage in the context of innovation. This is not comparable to the carrying

of planks in a lab study, and has already been mentioned in section 2.3.3.2. Here we stated that collaborative creative processes by originating artist, who are innovating the artwork as well as the process (unlike film-making where the process is pre-determined) are in a creative process together that "encompasses relationship-based interaction patters" (quoted from section 2.3.3.2, pg 38), and these represented the corner stone on which the production of the artwork Sim-Suite was accomplished.

7.4.2 Affordances and triads in Sim-Suite's creative process continuum

These afore-mentioned principled approaches, empirical observations and suggestive results are relevant to the creative process continuum. Specifically from the perspective of this thesis' case study as social interaction in the form of triads. Triads have been defined as "unity of action that embraces the participants and the common object" (Asch, 1952, quoted in K. L. Marsh et al., 2009). Both sides of 'the field of artistic communication' rely on the triad to create a common ground between Sim-Suite creators and Sim-Suite participants. This common ground of joint activity, embedded in relational affordances and social embodied cooperation, can be seen as part of the multi-dimensionality of 'the field of artistic communication'. It unifies the creator and participant groups within themselves: the group of creators working as triads in the preparation of the artistic 'field' with tools and materials, and the group of participants that collectively engages with the artistic 'field' via computer-mediated artefacts.

Sim-Suite creators' action systems actualised body-body and body-tool relational affordances in the joint endeavour of creating the artwork. For example, when constructing the wobble-board encasements and the timber platform, one of the collaborators operated a power tool and was assisted by the second collaborator. Many of the actions involved were performed ad hoc, which meant that both collaborators had to make persistent physical adjustments in different ways to accommodate each step in the creative process. The collaborator who operated the power tool had to continually restore body synergies with the tool, specifically the trunk-leg and arm movements (Bongers et al., 2004). The second collaborator had to physically adjust to the changing body-body relational affordances when assisting the other. Assisting meant further that the collaborator had to not only respond to the changing body posture of her power tool operating collaborator but also coordinate synergies (trunk-leg and arm movements) within herself when handling the construction material in different body postures. This type of coupling is provoked by the immediacy of the creative process, in absence of any planning or the conventional use of expert knowledge. It requires a just-in-time orchestration of one's physical extension through the use of materials and physical corporation with the interaction partner. From the perspective of the extended mind theory, this may be seen as operating along the seam of *continuous reciprocal causation* and relational affordances, because the linking of brain, body and world is more precisely expressed as linking brain, body and body-body (the two collaborators) and the body-tool (for example, the various carpentry tools) relational affordances.

Sim-Suite participants entered into actions that extended their action repertoire in conjunction with the 'playing' tool, the wobble-board. Participants were motivated to exploit body-tool rela-

tional affordances in their creative application to utilise resources that would provide an advantage over their opponents. One example for such resourcefulness is the fast and repetitive alternating of left and right steps on the wobble-board. This simple dynamic maintains the token in place on the game-board while also satisfying the movement requirements to avoid one's token flying off the game-board. In other words, the participants exploit the inertia of the (technological) system by stepping swiftly left and right on the wobble-board, which does not update in time to displace the token therefore keeping it stationary on the field of the game-board.

7.4.2.1 *Collaborative beginnings as triad with preinventive forms*

In chapter five, the early cycle demonstrated how the lead artist moved from the thematic selection of the artwork forward through a series of cognitive processes involving social interaction that consummated with the acquisition of an object, the wobble-board. At this point, the first collaboration started up between the lead artist and MF, the artisan furniture maker. From the beginning of the first collaboration the collaborators were set on a route of discovery without any preconceived ideas to work from in pursuit of their collaborative artistic creation. They were merely guided by the directive to facilitate some form of interaction by standing on a wobble-board.

Similarly, in experiments conducted in support of the Geneplore model, discussed in section 2.2.1.6, the researchers emphasised the aspect of discovery in creative achievements. Here, the research design set up for experiments in conceptual synthesis started off with two-dimensional drawings of preinventive forms. These preinventive forms are comparable to the starting point of the first collaboration because the wobble-board is a simple construction of two forms coming together: a wooden disk placed on the flat side of a hemisphere while the round side rests on the ground.[3]

In creative cognition, experiments conducted in lab settings did not take collaborative efforts into consideration. By contrast the findings in this real-world case study showed that the selection of the wobble-board as starting point presented opportunities for idea generation through collaborators' action systems triggered via the wobble-board's relational affordances. The dynamic aspects of the collaborative process, such as the physical handling of the object by the collaborators, were matched with the dynamic affordances, forming the conceptual foundation for embodied communication. The pursuit of artistic creativity in a natural setting gravitated to an object to establish a triad, the two collaborators and the wobble-board. The 'creative' triad supported the exploitation of the full potential of creative physical engagement via embodied communication and relational affordances.

7.4.3   The creative process continuum and forms of coordination

In this subsection we build on aspects of *continuous reciprocal causation* discussed in section 4.2.1.3, where we looked at various forms of coordination. Specifically, in this section we discuss linguistic entrainment and interactional synchrony in relation to our findings. Before we do so let us discuss the interdisciplinarity factors which were among our findings in chapter five.

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[3]For more information on the visual appearance of a wobble-board see diagrammatic illustration 3.6 in chapter three

The collaboration with the lead artist and MF, the artisan furniture maker, featured more similarities in working styles than the second collaboration, where the lead artist collaborated with JR, the engineer. Types of interdisciplinary team collaboration can be distinguished between narrow and broad interdisciplinarity (Dusseldrop & Wigboldus, 1994). Narrow interdisciplinarity shares methods (including working styles), paradigms and a similar knowledge culture in contrast to broad interdisciplinarity which involves disciplines with different methods, paradigms and knowledge culture.

From the perspective of working styles, the first collaboration presented a narrow collaboration because both collaborators had a similar working style but a broad collaboration regarding the collaborators' respective skill set. MF's skills placed him in a leading position in the execution of ideas for Sim-Suite's timber construction whereby the lead artist was working in a supportive role. In the second collaboration with the lead artist and JR creating the Sim-Suite game, differences in working styles made it a broad collaboration but because both collaborators were working with digital tools, it was also a narrow collaboration where both were using their skill sets equally. In sum, in both cases of Sim-Suite's artistic collaborations a simple division between narrow and broad interdisciplinarity does not render an accurate picture.

In section 4.2.1.1, we explained that mirror neurons might play a role in embodied communication and perception. The behaviours of Sim-Suite's collaborators were affected by the mutual perception of each other's action that dealt with different ways of engaging with the wobble-board. For example, the collaborators who constructed the wobble-board encasements where focused on physical aspects of the wobble-boards such as the tipping angle, whereas the collaborators who implemented the game were concerned with bridging stepping and balancing movements with game dynamics. During both collaborations the team members were informing each other's concurrent performance of related actions, and perceptually judging the action performance by the other collaborator from the current state of one's own motor system (Sebanz & Knoblich, 2009).

In the collaboration with the afore-mentioned divergent skill sets, working with power tools and learning to execute simple construction tasks may well have been influenced by the lead artist's mirror neuron system. Although the collaborators did not share specific "learning session", the production of the artwork from the position of lead artist requires intrinsic motivation (as discussed in section 2.2.1.3) which may have been a strong factor in grasping the necessary construction tasks supported by the mirror neuron system for just-in-time learning.

7.4.3.1 Linguistic entrainment and the role of language

Earlier in this chapter we discussed that Sim-Suite teams were creating and functioning within a wider spectrum of embodied communication because their environment was less constrained, physically and temporally, than that of Sim-Suite participants. This wider spectrum of communication means was characterised by spoken dialog bridled by aspects of interdisciplinarity. Adaptive spoken dialog is understood as coordinated behaviour in joint action, where linguistic choices and temporal processing are adapted by both interlocutors (Brennan & Hanna, 2009).

From the embodied-embedded perspective, Brennan and Hanna researched the language-as-action tradition. This tradition sees language as collaborative behaviour which is determined by

interpersonal coordination. Here, interpersonal coordination is constitutive of a cumulative progression of utterances, grounded in moment-by-moment feedback, which shapes the interaction partners' social identity. This view also incorporates the understanding that language adaptation can be fallible.

Through convergent or complementary behaviour, dialogs are tailored as "audience design" by speaker and addressee. Underlying adaptive dialog is timing and the use of functional words but more importantly the "conceptual pact", as "flexible and temporary agreement to conceptualize a referent according to a particular perspective" (p.280). In their research and that of their colleagues, Brennan and Hanna found that this "conceptual pact" is a jointly achieved perspective that is partner-specific and commences in the early moments of language processing between interlocutors. Studies that tested "conceptual pacts" were building on entrainment, which is the phenomenon that "people in conversations tend to use the same terms when they refer repeatedly to the same objects".

In chapter five we discussed that collaboration partners, the lead artist and the engineer, experienced in the beginning of their collaboration linguistic confusion on terminology. The content of this terminology described game properties and other conventions pertaining to the shared digital environment of their work. It may have been that confusion on terminology was caused by the lead artist using words that she had utilised before entering the "conceptual pact" with her collaborating partner, because she was already involved with Sim-Suite before entering the second collaboration. Therefore she might have coined terminology that existed outside the "conceptual pact", which led to failure in communication with JR, the engineer, because he was not part of the project prior to the second collaboration.

Concurrently, in the early stages of their collaboration they had to adapt to a common working style, which was channeled and guided by linguistic entrainment. In the collaboration that created Sim-Suite's game, linguistic entrainment functioned further as directive in forming effective relational action patterns. Throughout Sim-Suite's game development collaborators continued to entrain by forming their own terminology that referenced game events, for example[4] "wrap around", "draw graphic" and other partner-specific vocabulary that helped coordinate their actions and span interdisciplinary constraints.

From the perspective of the theoretical lens in chapter four, language as consensual domain is seen as dynamic and emergent from shared behaviour, which formed the starting point for the verbal stage in Sim-Suite's collaborations and paved the way for linguistic entrainment. At the same time, language became the "scaffolding" for collaborative action for Sim-Suite's team members in the implementation of ideas for the artwork. Language as "material symbols" instructed and informed Sim-Suite participants' behaviour in the game-play. Language was used by Sim-Suite's team members as a prescriptive element in the form of instructions (see figure 3.4) that participants received in words and images during the tutorial screens. Beyond that language was coupled to real-time behaviour that, if ignored, had cascading consequences on the participants' activities.

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[4]This terminology is composed of common words. Here we just mention a few examples, the reflection sessions showed many more instances of linguistic entrainment.

One such an example is the flashing word "move" which would display in the participant's screen area as a reminder to fulfil the movement requirements of the game. If he or she would then chose to ignore making adjustments to his or her behaviour, the participant's token would simply fly off the game-board leaving him or her without token to continue playing in that particular game round. This also impacted the participants' strategic play in constructing the winning token configuration because the loss of a token had repercussions throughout the remainder of the game. Thus a single word on-screen could instigate behaviour and the resulting real-time physical consequences, impacting all subsequent game-play developments of a particular round.

In section 4.2.1.5, we mentioned Clark's (2008) three claims that explain how language as embodied symbols aid in the construction of cognitive niches. In the following paragraphs we demonstrate how these claims can be applied in the context of Sim-Suite's creative process continuum.

First claim: We demonstrated that Sim-Suite's team members, who created the game first labelled their collaborative world through linguistic entrainment. These team members then labelled the 'cultural environment' they had created with instructions for participants to navigate the game.

Second claim: Sim-Suite's team members were using verbal exchange to adapt, frame and channel their actions in the making of the artwork. This was shown in chapter five in the first model on the common stages of both collaborations. In the same chapter it was also discussed that Sim-Suite's team members were reconfiguring their expert skills to fit the context of the project which was accompanied by shared verbalisations. Similarly, during game-play Sim-Suite participants were using and adapting their expert skill of maintaining themselves upright while standing on a 'moving' ground. They were engaging in this activity based on instructions that were given to them in the form of displayed words (and pictures).

Third claim: Sim-Suite collaborators were constructing a niche for problem solving using verbalised concepts that only had a mental basis at the time of utterance. The spoken words enabled the collaborators to define the problem space of the artwork. With the material implementation of ideas, collaborators created feedback loops between the artwork-in-progress and the mentally residing concepts. Since the material counter part of these ideas were steeped in physical reality with all the physical contingencies, the verbalisations created a bridge between thought (concepts) and the physical manifestation of these in form of the artwork-in-progress.

For the Sim-Suite participants the linguistic structures within the 'cultural environment' prompted for real-time decision making on conducting one's behaviour during the game-play. This was coupled to strategic play and, as already mentioned in one of the previous paragraphs of this subsection had actual repercussions for the development of the game.

Next, we discuss another form of temporal coordination, interactional synchrony, observed among Sim-Suite participants and elaborated upon in chapter six. Findings revealed that the group of high-defensively playing participants synchronised their movements as a form of physical coordination. Timing in motor control is a precise matter and is considered, for example, the reason why we cannot tickle ourselves because if our action proceed as predicted or planned, the actual sensory consequences of the performed action match and lead to "sensory cancellation" (Sebanz

& Knoblich, 2009; Blakemore et al., 1999).

7.4.3.2 *Interactional synchrony and highly-defensive playing Sim-Suite participants*

In section 4.2.1.3, we discussed M. J. Richardson et al.'s (2005) experiments investigating limb coupling with wrist pendulums. Results obtained provided evidence for interactional synchrony through informative visual interaction between two subjects causing unintentional coupling of rhythmic wrist movements. We echo these research findings in chapter six with the group of high-defensively playing Sim-Suite participants. In the absence of, or extremely minimal, verbal communication and eye contact, participants were problem-solving Sim-Suite's game-play via visual information and bodily movements while producing synchronised data for corporeal variables. Synchronised movements occurred when participants were engaged in competitive behaviour similarly to M. J. Richardson et al.'s study with competitive game-play behaviour in a cartoon character 'guessing' game.

M. J. Richardson et al. explain that minimal conditions for rhythmic coordination between two people is "mere interactional presence, mere sufficient visual information about the other person's movement" (p.76). This is seemingly not dependent on whether this constitutes a dyad or triad configuration. In M. J. Richardson et al.'s study subject pairs were dyads because the informational interaction was on the basis of an image and not on the basis of a shared 3D object. Interactions with Sim-Suite on both sides of the 'field of artistic communication' are considered triads. Even on the participatory side of the 'field' this was the case because our results showed that participants were interacting as serial triads. The computer-mediated objects that Sim-Suite's participants navigated with their feet and whole body were inter-linked to each other's performance similar to objects handled between interactors using their hands.

Results from chapter six showed that the group of high defensive players in Sim-Suite's game produced symmetric correlations which propagated interactional synchrony. As mentioned in section 4.2.1.3, coordination as in-phase synchrony is often observed when frequency of movement increases but this was not the case with the high-defensively playing Sim-Suite participants. A higher frequency of movement would have caused more fields to be traversed on the game-board, but both groups, the low-defensively playing and high-defensively playing participants, produced closely related values for the average means of that variable.

In the conclusion of chapter six we reasoned from the point of joint action and the fact that high-defensively playing participants were engaged with a collective attentional focus on the task objective of the game. A joint task objective created the structural backdrop for action observation to precipitate timely cues in predicting and planning of actions, thus generating coordinated movements in a synchronised fashion. This reasoning is further supported from the perspective of neuroscience and the activation of mirror neurons where the degree of mirror neuron activation depends upon the motor expertise of the observing individual (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006). Although, the types of stepping and balancing movements necessary to play the Sim-Suite game were not expertise-driven other than the human expertise as bipedal primate maintaining themselves upright. This is a learned skill in childhood. Thus, movement expertise in playing Sim-Suite was basic therefore creating equal conditions for the majority

of participants in observation-induced mirror neuron activation.

We should say at this point that research into joint action investigated from the current perspective, regarding general human adult interactions, is a fairly recent development (Galantucci & Sebanz, 2009). In a study published this year, Kourtis et al. (2010) designed a research setup that mirrored that of Sim-Suite's spatial orientation of participants positioned to each other, while forming a triangle in space. Their research aimed at understanding if social relations between individuals modulate action observation. The researchers built their investigation on established research findings that the mirror neuron system activation modulates gaze direction and body orientation. The setup of the study arranged subjects around a table forming an equilateral triangle in space. The task involved an object in the middle of the table that had to be lifted and returned to the same position (individual action) or passed onto the next subject (joint action). Alternating between subjects, all three subjects were performing 'partner' in joint action, and 'loner' in individual action. The study results "indicate that motor activation during action anticipation depends on the social relation between the actor and the observer, formed during the performance of a joint action task" (p.760).

Interactional synchrony between high-defensively playing Sim-Suite participants may have been the result of a better balance in their social relations during interactions. This may in part explain why low-defensively playing participants did not manage to produce interactional synchrony. Levels of cooperation with others in establishing social relations, especially in creative endeavours are subject to motivation and intersubjectivity. Empathetic understanding of other's intentions and the grasping of one's own intentions in relations to others, may have played a role in supporting interactional synchrony in Sim-Suite's high-defensively playing participants. We may also consider these players as more creative in their expression compared to participants of low-defensively played games. In this section we aimed to demonstrate that entrainment, underpinned by joint action, is part of the spectrum of the creative process continuum. We showed that different aspects of joint action are highlighted depending on task objective and constraints imposed by the environment.

7.4.4 Creative interaction and physical space

The findings reported in chapters five and six included an important role for physical space in support of the creative act, in linking objects and spatial orientation with action. Both collaborations involved in the creation of Sim-Suite were dependent upon physical space in a number of ways. The workshop, where the installation structure was build from timber, was a resource of just-in-time materials because well-worn workspaces are physical spaces that accumulate materials from preceding productions and projects. The Sim-Suite collaborators who were working on the game with digital tools were equally making use of physical space in form of a temporary studio. Here, they roughly set up the wobble-boards in their encasements with sensors attached and connected to a provisional screen display placed on the floor. This setup was instrumental in building and developing the game because every game event that was implemented had to be physically tested and incrementally altered, to reach a workable version before collaborators could move on with

the next step in the development.

During game development, collaborators were working with digital tools which was more flexible regarding the use of physical space than when working with power tools in the workshop. The findings in chapter five mention that when working away from their temporary studio, at their respective homes, on larger bits of the game that demanded specific expert skills by either collaborator, improvisation of the creative task was necessary. Improvising during task execution compensated for the missing physical links with the installation components, such as real-time, physical engagement when testing a game event under development.

In section 4.2.2, we introduced the enactive perspective on structural coupling with the environment which constitutes the basic form of embodiment, the extension of the organism into the greater body of the environment where both mutually specify each other. From this perspective, the game development situation as operational closure of a network of creative interactions was disrupted when switching work environment. Structural coupling without physical references had to be accommodated in some other way. Here, we refer to enactivism's phenomenological basis where mental acts are described as being intrinsically anchored in intentionality. When collaborators were improvising in their creative tasks, they had to rely on their object-directed experience and imagine, or remember, the installation setup to align their actions and execute their tasks. This was made possible because of the already inculcated rapport with the installation, from having developed a close action-system relationship in previous sessions and grasping of relational affordances. This kind of improvisational task completion was limited in that it can only function within tightly established parameters of a task.

In chapter six, findings pertaining to physical space and creative participation with Sim-Suite's game illustrated that the spatial orientation and positioning within the installation in relation to other players engendered types of playing 'styles'. Sim-Suite's installation set up arranges three people in an equilateral triangle, two people play directly across from each other while the third person is oriented between the other two. The third person's view of the other two players is at 45° angle and askew rather than in a straight line. The third person looks out straight in to the audience, while the other two players are facing each other flanked by the audience on the right and left side. Participants remain fixed in the same position during the entire game-play, they only move their feet within the circumference of the wobble-board they are standing on. Findings showed that participants playing across from each other had opposing playing 'styles', this was revealed by statistical central tendencies and correlations. The third person appeared to be playing in a style that 'alternated' interactions with the other two players.

7.4.4.1   *Experiments in joint action and spatial orientation support findings in Sim-Suite's creative process continuum*

Research literature in joint action investigating human spatial orientation to each other with regards to effects on cognition and social interaction is quite limited at this time. We know that the presence of another person impacts joint action via coordination. For example D. C. Richardson et al. (2008) refer us to Shockley et al.'s (2007) experiments that were able to show that "speech similarities influence interpersonal postural coordination, [but] the presence of another individual

invites interpersonal coordination beyond that coordination resulting from utterance similarities" (p.83). In other words, the sheer presence of two subjects has foundational relevance for coordinated postural sway.

Kilner et al. (2006) recently investigated action observation from the perspective of the mirror neuron system. The researchers tested the hypothesis that action observation evokes activity in the observer which mirrors the observed actions but should be independent of the observer's viewpoint of action. The mirror neuron system should function in the same way irrespectively of whether someone is observing another person from the front or back. The study recorded cortical activity while subjects watched a series of videos of actors performing simple movements from different viewpoints. The results suggested that subjects "did not modulate their spatial attention when the actor's back was turned, despite the fact that the subject's task was identical in all conditions and the visual stimuli were broadly the same, an arm moving in either the left or right of the visual scene". The researchers further suggest "that the different patterns of α-oscillations in the forward facing and backward facing conditions reflects a process that is modulated by the social relevance of the person being observed" (p.147). Therefore the researchers "speculate that this modulation reflects a mechanism that filters information into the mirror neuron system, allowing only socially relevant information to pass" (p.143).

A study by Kaminski et al. (2004) investigated with two experiments apes begging for food from a human observer. In the first experiment the human either stared at the ape, faced the ape with her eyes closed, sat with her back towards the ape, or left the room. In the second experiment the observer's body and face orientation was crossed over so that she could have her body and/or face oriented either towards or away from the ape. Results showed that apes generated more behaviour when being watched in the presence of the human, but demonstrated sensitivity to the observer's face and body orientation separately. Researchers suggest that these results on face and body orientation indicate two different types of information encoding. Face orientation encodes perceptual access, and body orientation encodes the observer's disposition to transfer food, which was also the primary response while face orientation was secondary. The state of the observer's eyes (either closed or open) seemed to have little signification to spatial orientation.

7.4.4.2   *Physical space and orientation in Sim-Suite*

From the experiments described in the previous subsection, we can speculate that spatial orientation of Sim-Suite's participants in the installation shaped the participants' game-play behaviour by virtue of action observation and subsequent filtering of information. Action observation may have instigated attentional priorities between axes of interactions of one opponent participant versus another. There are several factors that support this speculation. For example, interaction partners came from a broad demographic of age, gender and body types. All participants were placed in whole-body view to each other. Due to the simultaneous stimuli that participants had to cope with during game-play, relatively little verbal exchange took place, and also not much eye contact. The consistency of this finding, of different types of playing 'styles' in each wobble-board location of the installation, throughout the four stages of the statistical analysis suggests that information encoding was linked to spatial orientation and the resulting neurological processes.

Physical space is a vital component in the creative process continuum, it has an important role that affects objects, procedures, tools, intentionality and spatial orientation and location. As we saw in the preceding subsections, physical space enhances the creative process by furnishing access to materials. It facilitates procedural body-object interactions which unfold the actual process of creation. It channels attention and focus which further depends on physical orientation relative to others. In sum, these findings impact creativity and pattern creative achievements specific to each art form. With each art form the notion of physical space will differ by probing and highlighting aspects that might not coincide with the ones mentioned here. Regardless of this difference, the importance of physical space in art-making and participation will always be the same even on the most fundamental level.

7.5   Evaluation and intersubjectivity

In this section we take a look at the concepts of evaluation and appraisal in creative situations as they pertain to findings elaborated in chapters five and six. Briefly, in section 2.2.1.4, we reviewed creativity research literature and explained that evaluative thinking in idea generation is thought to be either deferred judgement, meaning after ideas are generated they are evaluated at some later stage, or as happening 'online', closely linked to idea generation.

From the perspective of this thesis, we speak about applied artistic creativity as a 'field of artistic communication' underpinned by embodied communication. Therefore we start this section by referring back to section 4.2.1.1 but also to the beginning of this chapter, where we first explained Oberzaucher and Grammer's (2008) model of embodied communication. The model proposes that communication is dynamic with engagement and synchrony but also breakdown and repair as detailed throughout this chapter. What has not been mentioned yet is that the model is grounded in the concept of tonic communication developed by Schleidt (1973). He summarises that "discrete signs (signals, symbols, key signs) are repeated by the transmitting animal in more or less regular intervals, and in that way have a continual effect on the receiving animal, reflected in a gradually changing or steadily maintained behavioral output" (p.378).

It is important to understand that the signal sending and decoding occurs over time where the reception intervals depend on the signalling rate. The receiver "uses a signal-time filter to extract the contextual meaning of the signal" (Oberzaucher & Grammer, 2008). This process is accumulative with discreet content meanings building up over time. Drawing on tonic communication, the model suggests that both interaction partners continuously adjust their communication flow through an appraisal or evaluation process which, analogous to Schleidt's concept, is not always consciously conducted. By virtue of communicating with another, evaluative cognitive processes are present. This constitutes the first level of evaluative thinking in creativity, which we explain in more detail in the next subsection.

7.5.1   The three levels of evaluative processes in Sim-Suite's creative process continuum

A close-up view on the linguistic aspect in embodied communication demonstrated that interlocutors established a "conceptual pact" with shared communication goals (Brennan & Hanna, 2009).

They create a common, overlapping world together. On the level of the brain and neurological functioning, we referenced study results suggesting that motor activation in action anticipation depends on social relation, such as performing a joint task (Kourtis et al., 2010). Common world boundaries are subject to agency and neurological processes. In Sim-Suite, this common world understanding is centred on the artwork as primary goal for communication efforts between creators and participants. Throughout their creative process and participation, signal evaluation ensured communication flow between partners and motivated ongoing creative practice. We posit that there are three levels of evaluative thinking and acting in the creative process continuum. Evaluative cognitive processes in communication constitute the first level, because embodied creativity is situated and embedded in behavioural procedures within the context of the social and material environment. We saw that the collaborative creative act in applied artistic creativity is held together by dialog. Likewise, creative participation promotes cooperative engagement via non-verbal indexes into the signal continuum that are equally underpinned by evaluative cognitive processes.

To explain the second level of evaluative thinking and acting we turn to findings in chapter five on the collaborative creative process by Sim-Suite team members. Every idea communicated between collaborators was evaluated within the course of their dialog. Ideas had to be evaluated for their creative value and feasibility of execution, including projecting down-the-line ramifications within the artwork as a whole. In this process, one idea was selected for an execution process and during execution more decisions took place because a mentally conceived idea was never fully substantiated. Adjustments and alterations had to be made in-action which meant re-evaluating aspects of the idea either collaboratively or individually[5]. To summarise, the second level of evaluative thinking is constitutive of the procedural creative act. It is the connective link between thought and action that moves the process forward.

The third level of evaluative thinking and acting is artwork-specific. The findings in chapter five detail Sim-Suite's team members' creative behaviour during game development where they assess the artwork-in-progress from the above-process perspective. Previously we described habitual in-process evaluation. Now we describe complementary artwork-specific evaluation, entailing the objective of creating an interactive environment, or a 'field of artistic communication' for participatory creative action. On this level there is also an unconscious element as well as a focussed and excogitated approach to the evaluation of interaction mechanisms in the artwork. The unconscious element arises from the dispositional observer status that underpins all human interaction. We discussed this in chapter four under the enactive cognition paradigm which takes as a starting point the subjective observer status of an agent.

The observer status is fundamental to all human communication and includes evaluative cognitive processes. The reason for this aspect to be mentioned on the third level is that the collaborators received insights on the artwork's less than perfect interaction functionality without consciously participating in evaluative thinking. Insights were received during the first exhibition of Sim-Suite which took place in a noisy and crowded environment. The team members were moving around

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[5]Solo work took place during game development, when working away from the studio space. The timber construction was produced in its entirety in collaboration.

in the same space while engaging with other artworks that were on display. However, we are unable to provide details on possible insights in this situation due to limitations of retrospective data collection.

The focussed evaluation process on the third level was based on action observation in both collaborations. The team members working on the construction of the wobble-board encasements and the game development deliberately engaged in the act of observing others interact with the artwork-in-progress. The other aspect of focussed evaluation was solitary and introspective. It took place during the construction of wobble-board encasements and the game development. When implementing a particular game event, collaborators physically 'tested it out' once it was integrated in the game environment. When doing so they appraised functionality, appearance and creative value of their work. But as already elaborated in section 7.3 in this chapter, this was not a reliable approach because of undetected discrepancies in action prediction and actual sensory consequences of movements. Thus, errors in the interaction mechanisms were not apparent to the collaborators.

The first level of evaluation in Sim-Suite's creative participation as embodied communication has already been discussed earlier. On the second level, evaluative cognitive processes were addressing in-process activities. These entailed making decisions within milliseconds, where to move one's token next on the game-board in a dynamically changing virtual environment, provoked by simultaneous turn-taking of all three participants. On the third level, the game-specific level, participants' evaluative cognitive processes were focussed on strategically playing the game. Evaluation therefore contributed to decision-making and action planning that were goal-oriented and took into account the competence (or threat) of other players. These decisions were projected to time frames of game-round length or similar, in any case greater than the milliseconds constraint of the second level.

7.5.2 Empathetic foundation in Sim-Suite's creative process continuum

In contrast to Sim-Suite's rich communication backdrop, Galantucci (2005) stripped all conventional communication references from being accessed by subjects in a study with a novel medium where subjects played a video game. In this video game players are forced to "totally reinvent new forms of communication" without any prior inventory, "not even a prior set of signs to build from"(Galantucci & Steels, 2008, p.232). In this video game subjects succeed if they manage to communicate successfully. The video game consists of a set of rooms located on a grid marked with icons. Players have to come together in the same room with minimal room changes. They only have a local view and cannot see where the other player is located. Therefore they need to know where the other player is located to make their next move. Their means of communication is a digital scratchpad, which "moves vertical as one draws on it, so that drawing a horizontal line results in a diagonal line with a slant that reflects the velocity profile of the drawing motion" (p.232).

Galantucci et al. report that in successful pair players tightly coupled behavioural procedures were exhibited that coordinate actions between partners from which the communication system

emerged with features typical of creative expression such as innovation, alignment and variation. On the other hand, the researchers also observed an entirely different scenario:

> However, not all pairs in the study manage to bootstrap a communication system. Besides obvious requirements such as pattern-recognition abilities, memory, enculturation, etc., the challenge seems to require a cooperative attitude, a particular type of social intelligence. Some players behave like Humpty Dumpty. They just assume that others see the world in their way and use symbols the way they decide. They fail to realize that their communication is ambiguous and do not have the social inclination to negotiate repairs. Frustration can run very high. A task that some pairs manage in 10 minutes, takes others 3 hours before they give up (p.232).

The point that is made here is that successful communication is grounded first and foremost in empathy. Empathy is a key factor in the enactive approach to cognition and is derived from two parallel perspectives, empirical and phenomenological. Empirical research on affect underpins embodiment and emergence because affect is a multi-dimensional binding force acting upon all aspects of the organism: "the psychosomatic network of the nervous system, immune system and endocrine system; physiological changes in the autonomic nervous system, the limbic system, and the superior cortex; facial-motor changes and global differential motor readiness for approach or withdrawal; subjective experience along a pleasure-displeasure valence axis; social signalling and coupling; and conscious evaluation and assessment and the superior cortex" (Watt, 1998, quoted in Thompson, 2001).

For enactivists, affective states presuppose a two-organism self-other event. These states connect to the phenomenological capacity of intentional self-regulation through perceptuo-motor capacities of the body (Thompson, 2001). Taking these connections a step further, we refer back to two enactive standpoints on consciousness and types of empathy, especially the third type of empathy, which was termed *reiterated empathy* in chapter four. Consciousness is 'intersubjectively open', meaning it is structurally open to the 'other' ahead of any concrete encounter of self and other. Self-awareness as embodied agent in the world depends on empathy, specifically on understanding the other's empathetic grasp of oneself as other for him or her (D. Zahavi, 1999, 1997, 1996, quoted in Thompson, 2001).

Research into artistic creativity found that empathy plays a role in problem-finding. In section 2.2.1.2 we discussed Wakefield's (1994) qualitative experiment with stories told in response to black and white pictures on cards. The findings showed that artistically inclined students bore stronger reference to their empathetic capacities in relation to idea generation. Self-awareness affects the creative process throughout. Empathetic capacity profoundly impresses the translation of personal experience into material for artistic expression.

The creation of and participation in Sim-Suite took place firmly embedded in the world through social and material interactions. Here, the creative process continuum was a journey of discovery through passion and motivation. Many aspects of the continuum evolved and emerged from each situation that gradually built up the project on one hand, and delivered ad hoc encounters in the participation of it, on the other hand. To that extent an interactive artwork relies on empathetic

capacities by its creators. They have to be able to put themselves into the shoes of potential participants, in terms of functionality of interaction mechanisms. Yet, their work must also motivate creative engagement and enjoyment for potential participants. The premise of this artwork is social interaction. Participants were dependent on each other when creating their own experiences and enjoyment through human-to-human interaction. Sim-Suite's digital environment stimulated spontaneous action and undermined lengthy intellectual contemplation. In creating their experience, participants had to rely on their empathetic capacities in grasping the intentions of others and also one's realisation of the other's empathetic grasp of oneself as opponent player (background to this level of empathy is given in subsection 4.2.2.6).

7.6   Conclusion

The aim of this chapter was to integrate findings from chapters five and six. From the standpoint that cognition is embodied we demonstrated that the process of artistic creativity and creative participation is part of the spectrum of cognition that manifests a 'world' in terms of thoughts, social and material interactions.

This chapter started off by connecting back to chapter four's theoretical lens and extending Oberzaucher and Grammar's (2008) embodied communication model. This model builds on research findings from cognitive psychology and anthropology, psychophysics and biopsychology, social psychology and neuroscience. The model postulated that communication between humans is a matter of physical movement and motion quality. We saw the use of this model as beneficial, to create a base from which to build upon in the discussion of our research findings. This discussion was relative to the case study research strategy used to investigate the creative process continuum. In the first chapter we explained that media art as art form can comprise the creation of interactive environments, where a 'field of artistic communication' is the art 'object' and is emergent from a communicative process between creators and participants.

Creativity research operates from the assumption that creativity is a form of problem-solving. In this context, the problem-finding stage in artistic creativity takes on a special position in the development of original and socially-valued ideas. In our research defining a problem was not a singular stage, problem-finding was part of the on-going exploration which preceded every generated idea. This was a constitutive element permeating the process and incrementally building up the artistic creation. These observations fit some of the findings by researchers described in section 2.3.1.1, specifically Mace (1997), who redefined problem-finding and solving as problem manipulation. In the early cycle, where Getzels and Csikszentmihalyi (1976) located the problem-finding stage, the lead artist's creative process merely set the project on an ambiguous course via thematic selection. Throughout this chapter we have not used the term problem-finding because by definition there was no such stage in the creation of Sim-Suite. The constitutive elements of the collaborative creative process and cooperative participation were intrinsically dependent on agency, affordances, interdisciplinarity, coordination, joint action, evaluation and empathy.

We showed that embodiment in the creative process continuum meant that contingencies of real-time situations were regulated via visuomotor coupling with neurobiological parameters. In

particular we illustrated how fine-tuned neurobiological processes of agency imposed restrictions on the creative process, which were remedied by Sim-Suite team members via social interaction when they sought to observe others engage with the artwork-in-progress. In other words, in one way neurobiological processes created limits. In another way they created opportunity, as with this situation where team members were able to overcome limitations of agency by observing others interact with the artwork. Action observation facilitated through the mirror neuron system supported the team members in understanding the effects of their work on the participants. At the same time, action observation may have impeded participants in playing Sim-Suite's game from an equal predisposition because of spatial orientation to each other which locked participants into playing 'styles'. This demonstrates the intricate workings between the conscious mind and non-conscious body-bound reality.

As an instance of media art, Sim-Suite engendered a highly collaborative and cooperative process where each situation was filtered through several minds and bodies. In Sim-Suite, the collaborative creative process brought together people with different expertise which shaped the end product of their creative efforts. Expert skill is acquired over time. It cultivates a way of perceiving affordances that might not be available to novices. In the creation of Sim-Suite a variety of divergent expert skills were necessary to integrate into an artwork that was consistent in structure, appearance, functionality and enjoyment. However expert skill is not sufficient to exploit affordances to their optimum. Sim-Suite's team members had to be collectively motivated in the communication of their knowledge and ideas so that they were in the position to enable creative synergy. We illustrated that linguistic entrainment and adaptation to working styles hurdled communication discrepancies.

Motivation may have also contributed to interactional synchrony in high-defensively playing Sim-Suite participants which was not observed in the group of low-defensively playing participants. Interactional synchrony by Sim-Suite participants could have multiple causes. Looking at it from a different viewpoint, interactional synchrony between Sim-Suite participants was made possible through non-verbal communication grounded in empathetic capacity. Recall Galantucci et al.'s (2008) report on creating a communication system without any familiar inventory. It was of paramount importance for subjects to put themselves into the other player's shoes to succeed in the experiment. Sim-Suite's team members were relating to others empathetically in the creation of the artwork. It was beyond mere action observation when they noticed where and how participants were struggling in the reception of the artwork. It was the empathetic interpretation of what had been observed that supported the conscious evaluation process.

We postulated that evaluation is a multifaceted aspect in the creative process continuum. The first level is formed by the evaluative process in communication as Oberzaucher and Grammar's model has shown. We established that art-making is composed of in-process evaluation which synchronises thought and action with the outcome. When we reviewed creativity research in section 2.3.2, in-process evaluative processes were demonstrated in the research of Yokochi and Okada (2005), who studied the hand movements of a Chinese ink painter. The researchers found that hand movements in the air marked the beginning of each drawing cycle. Here the painter

was evaluating what he had already painted before, making a decision where to put his brush down next. In-process evaluation applies equally to creative participation in Sim-Suite. When participants formed plans where to move on the wobble-board, they rapidly had to assess the state of the game-board against the decision on which field to move next.

Above-process evaluation procedure is art form specific. The procedure describes steps taken to evaluate the artwork as interactive installation. This is the highest level of the evaluation procedure. Unlike in-process evaluation, this level of evaluation could only take place once a substantial amount of the artwork had already been implemented. At this level, particular properties were evaluated such as interactivity and game-play. Comparatively, the Chinese ink painter was observed stepping back from the canvas after twenty minutes of continuous painting to evaluate the result before moving on. From the perspective of this thesis, these movements by the Chinese ink painter would qualify as third level evaluation, specific to the properties of drawing with ink.

The thematically contextualised results illustrated that with two probes into the process continuum different elements of the same embodied cognitive process were foregrounded. From this perspective, creativity is pervasively intertwined with cognition, social interaction, and cultural developments. The proliferation of evidence from neuroscience and the incorporation of recently developed, innovative research design centering on embodiment might progressively reveal how the body's role shapes artistic outcomes. By and large creativity research aims to quantify and systemise creative processes categorically without consideration of the body's role. On this case study, we have demonstrated that artistic and creative process form a web of cognitive aspects that are orchestrated together on a situation-by-situation basis channelled by the environment.

The main themes in embodied cognition raised by this research have bridged the micro and macro structures of the creative process continuum. The properties of the macro and micro structures may be different due to couplings in social interaction and couplings to the environment. But underlying both structures is the digitalisation of our age, which has enabled previous tools, materials and techniques to be applied through hybridisation, as we mentioned in chapter one.

Hybridisation plays a much greater role, one that has affected the evolution of the modern mind. Donald (1991) writes:

> Our modern minds are thus hybridizations, highly plastic combinations of all the previous elements in human cognitive evolution, permuted, combined, and recombined. Now we are mythic, now we are theoretic, and now we harken back to the episodic roots of experience, examining and restructuring the actual episodic memories of events by means of cinematic magic. And at times we slip into the personae of our old narrative selves, pretending that nothing has changed. But everything has changed (p.356)

Everything has also changed in the way we perceive and make art. The themes that have surfaced in our investigation do not reflect an 'outstanding' cognitive component indicating creative cognition. Rather, cognition regulates the creative process on both structural levels of the continuum, and questions can be raised in this context: Whether or not the themes that have been uncovered by this research could be elicited from any interactive media artwork, where interactions are social and shared between persons? If yes, how are the embodied cognitive processes

pertaining to *communication, agency, coordination* and *evaluation* modulated throughout the engagement with an artwork of this genre? Moreover, how do these modulated embodied cognitive processes relate to the hybridisation of tools, techniques and materials? Lastly, the overarching question from this research is what is creativity from the perspective of embodied cognition? Answers to these questions will have to come about from future work, we now turn to chapter eight to conclude this thesis.

Chapter 8

Conclusion

8.1 Introduction

Sixty years ago a combined effort was made to conduct research into the nature of human creativity. The initial outlook shaping this research trajectory sought to find comprehensive answers by understanding individual differences in creative thought. At the exclusion of everything else that surrounds creative thought, research was designed to test, quantify, and derive unequivocal categories of creative thinking. At that time, visual art was still understood as an activity reserved for the highly-gifted few, who produce unique and socially-valued products, admired by the public as artworks trapped between white walls in quiet museum halls. Slowly this began to change, the glass walls between artworks and audience began breaking down. Traditional authorities that determined the difference between good and bad art began to disappear. So much so, that today we celebrate the death of art history as mentioned in chapter three.

Much of this change was ushered in by the burgeoning digital age, providing new tools for new conceptualisations, new connectivity between minds and bodies, and new beginnings in the creation of visual experiences. Artistic expression became possible without having to operate in a traditional art world setting. Since the late 1990's, the exhibition of computer-mediated artworks is steadily integrating into cultural, societal life through self-organised efforts by those interested in artistic media generated with digital tools. Up until now creativity research, on the other hand, has chosen not to take notice of these parallel evolving cultural developments because it operates from a static view of creativity, largely unhinged from tools, body and environment. Outside of creativity research many theorists and academics, who also concern themselves with cognition, understand that in contemporary society to be human means to be engaged in a complex system of distributed cognition (Hayles, 1999). This undeniably affects creative performances, especially when considering art as a "specific kind of cognitive engineering", which arises from the context of human cultural and cognitive evolution, precipitating a continuous transformation of culture via self-reflection (Donald, 2006). Therefore, to understand artistic creativity through scientific research means paying close attention to these evolutionary mechanisms and the resulting cognitive

architectures that progress through body, art forms and environment.

In chapter one we introduced scholarly work from the humanities, where contemporary art forms have been recognised to change what constitutes a work of art. Specifically with computer-mediated artworks that promote interactivity, Kluszczynski (2007a) suggested that in these types of artworks the audience is actively participating in establishing a bridge between the object as artefact and the work of art through one's receptive-creative actions. It is this joint endeavour that becomes the final artwork. The artwork in the traditional sense no longer exists because it is the procedural engagement that forms the object of one's perception, which according to Kluszczynski constitutes a 'field of artistic communication'.

This thesis was motivated by these developments because the discrepancy between contemporary artistic developments and the state of creativity research are disconnected. Hence, creativity research is not in the position to promote an accurate account of contemporary artistic creativity. At this stage, the approach taken by this thesis is exploratory and not without limitations, which we discuss in this chapter. But first let us review our main contributions.

8.2 Thesis contributions

In this thesis we addressed a long overdue gap in creativity research. Creativity research has been largely disconnected from the contemporary development of computer-mediated art. In fact, as far as the author of this thesis is aware, creativity research has to this day not concerned itself with any computer-mediated art forms, simply because it has not paid attention to the tools which are used in artistic creativity. This thesis aimed to fill this gap with support from scholarly observations in the humanities. Unlike creativity researchers, cultural theorists and those, who study the origin of cognition acknowledge that technology is a reciprocal facilitator in the evolution of creative output. These two surrounding fields to creativity research framed one side of our research efforts. Relevant contributions by both fields were discussed in detail in chapter one, when discussing the history and current application of interactivity in creative achievements with computer-mediated tools. They were also discussed in chapter two when we pointed out the importance of art forms as carriers for symbolic technology in the network of distributed cognition.

Out of these conclusions, we summarised that the creative output with digital tools specific to interactive artworks constitutes the creation of a 'field of artistic communication', making the definition of a 'finished' art object obsolete. In the case of interactive artworks, creativity is understood as shared dynamic between those, who prepare the 'field of artistic communication' and those, who participate in it. From this standpoint, we argued that creative cognitive processes operate on a continuum which includes preparatory and participatory engagement with the 'field of artistic communication'. The redefinition of the creative process as continuum from the perspective of digital and interactive artistic developments in contemporary culture is the first contribution made by this thesis. We demonstrate an account of the continuum in chapter seven where we illustrated the relational connections between findings from chapters five and six. These findings were the result of two separate, exploratory investigations into the creative process continuum.

Many researchers working on cognition are supporting a new paradigm which acknowledges

that the body permeates all spheres of cognition. In our research we build on their work to contribute a new perspective on artistic creativity from the standpoint of embodied cognition. In chapter two we visited research findings pertaining to studies on visual artists, and the role of the body in the process of creation. In this review we found that no links were made to embodied cognition principles in an attempt to contextualise findings as embodied cognitive acts.

As the second major research contribution, we undertook our research from the stance of embodied cognition. To do so we created scaffolding in two ways, we first established a theoretical lens via two major and distinct directions in this developing paradigm. This theoretical lens was adopted and applied to data collection and analysis in chapters five and six. Secondly, in chapter seven where we discussed findings side by side as belonging to the creative process continuum, we referenced empirical research conducted under the embodied cognition paradigm. Here we created links back to the theoretical lens and, where relevant, to creativity research.

The third major contribution is embedded in our case study research strategy with Sim-Suite, the digital, interactive installation artwork, as a foundation for our investigations. Created in a real-world environment and as an autotelic event, we focussed on providing an authentic portrayal of artistic creativity, which is able to give an embedded account of embodied cognition. We countered the common research approach where individuals' artistic creativity is tested in laboratory environments. In this thesis an interdisciplinary team built Sim-Suite, which was used as cultural platform for analytical investigations only after the installation had been completed and exhibited in genuine cultural settings. Thus Sim-Suite, as an authentically created and exhibited artwork, formed the basis for empirical investigations of the creative process continuum.

The fourth major contribution of this thesis' research to the field of creativity research is our methodological approach. We appropriated a mixed method approach from the social sciences to probe the creative process continuum with qualitative and quantitative methodologies. This was explained in detail in chapter four. Decisions on methodologies were guided by the research questions stated in chapter one. We proposed to investigate the physical cognitive aspects, as they would appear conditional to Sim-Suite's 'field of artistic communication'. Each probe into the creative process continuum was characterised and delineated by a set of parameters which necessitated a suitable methodology from creativity research, and needed to adhere to embodiment principles.

The fifth major contribution of this thesis is the translation of the conceptualisation of 'creative participation' into applied methodological terms. 'Creative participation' in Sim-Suite's 'field of artistic communication' was defined in chapter three. From there we had to interpret this definition into a functional procedure to obtain measured results. We achieved this by analysing Sim-Suite's logfile. From the numerical data in the logfile we were able to design a set of variables (corporeal, strategic, and timeline) that enabled us to measure how participants were playing Sim-Suite creatively.

The sixth major contribution of this thesis is the demonstration of a creative process continuum. The continuum was explained in detail in chapter seven. Each set of juxtaposed findings from chapters five and six formulated a multifocal account within a specific researched topic in

embodied cognition. We proceeded to explain the creative process continuum in this way, covering four major themes and a number of sub-themes. The first main theme we mentioned is embodied communication. Here we discussed signal cost in creative communication. The second major theme we addressed is agency. We discussed aspects of agency such as misattribution and discrepancies. The third theme pertained to forms of coordination, and the sub-themes discussed were joint action, affordances, linguistic entrainment, interactional synchrony, physical space and spatial orientation. The fourth theme looked at evaluation, we discussed three levels of evaluative processes and the role of empathy. Next, we list this thesis' five major empirical results.

8.2.0.1 Empirical results

The first empirical result stems from the early cycle, when the lead artist's focussed on the thematic selection of the artwork. We noted that a three-dimensional object, the wobble-board, was selected before the first collaboration began. From the perspective of the creative cognition agenda and the Geneplore model discussed in chapter two, a wobble-board is in its essence a preinventive form. It is comprised of two combined three-dimensional forms, a hemisphere covered with a flat cylinder shape. This thesis' contribution shows that embodied cognitive processes of real-world creativity references a three-dimensional object because it offers shared perception of affordances in creative collaboration. A two-dimensional representation of preinventive forms as used by the experimental studies of creative cognition concentrated on individual creativity is only an approximation. It does not consider the physical relationship between perception and the exploration of affordances when innovating creatively and collaboratively.

The second empirical result is located in the qualitative analysis. On the basis of enactive principles, we identified a relational systems view (the 2nd model in chapter five) of the collaborative idea implementation process of Sim-Suite's game. This revealed a detailed perspective of the components and their relations, covering conceptual context, idea generation, idea implementation, environmental coupling, observation, evaluative processes, and shared learning. Creativity research has a track record of pursuing stages in the artistic creative process. Efforts in this direction are historically linked to Wallas' classic four-stage model of the creative process. Stages are understood as linear conceptions that have served to generalise the creative process. The thesis contributes a view of the artistic creative process as nested networks of interactions. From the enactive perspective, the systems view of the creative process of Sim-Suite's game development, introduced in chapter five, identifies interrelational dependencies through structural coupling as emergent phenomena of embodied cognition.

The third empirical result centres on the same afore-mentioned model. The systems view in chapter five revealed that within the 'observation' complex, which further housed evaluative processes, a relational component called 'escrow' supported the collaborative creative process. In section 4.2.1.5, where we discussed principles within the embodied-embedded approach to cognition, we described epistemic actions that served to simplify problem-solving and improve cognition. In the systems view in chapter five we found a similar approach in 'escrow'. Team members executed and implemented traditional gaming-concepts and subsequently put these aside, or in 'escrow'. They returned to these at a later stage to re-conceptualise a particular conventional game

event by using it as point of departure when creating final game events for Sim-Suite. This made innovation much easier by off loading complicated interaction mechanisms and their dependencies, rendering these into an external version rather than working from mental computation.

The fourth empirical result originates from the quantitative analysis. We saw that each wobble-board position within the installation encouraged location-based 'playing styles' of Sim-Suite participants. It suggests that spatial orientation of Sim-Suite participants to each other affected action observation due to obstructing viewpoints which modulated mirror neuron activities and perception.

The final empirical contribution, also produced by quantitative analysis, was the resulting interactional synchrony between high-defensively playing Sim-Suite participants. This group of Sim-Suite participants demonstrated repeated 'full symmetry' correlations on corporeal variables, which captured data that provided information on bodily movements during game-play.

8.2.1 Limitations of this thesis

The approach taken by this thesis evolved over time. The investigation with Sim-Suite as case study research strategy was only formulated after the installation had been conceived, produced and exhibited. If the approach developed in this thesis were to be repeated with a new artwork, the lead artist would not be in the position to approach it from the same 'tabula rasa' state of mind. This does not mean that a subsequent study with a newly created media artwork could not be authentically executed. However, it would bring experiential lessons learned from investigating Sim-Suite's 'field of artistic communication' into the creative process. This might influence decision-making during the creative process, opting for decisions that take ensuing investigations into considerations. As with all new beginnings, the approach of this thesis had entered a virgin ground that will no longer be available in a follow up investigation with a new artwork.

There are a number of limitations that have been identified which will be discussed in this section. For the investigation of the collaborative creative process by Sim-Suite's team members, we collected data via retrospective dialogic reflection reports. These reflection reports do not capture aspects of the process that are contingent on real-time observation, such as video recording deployed by Yokochi and Okada's (2005) study of the Chinese ink painter. Real-time observation would have been impossible to master during the creative process of Sim-Suite because of its multiple locations and a broad range of actions including the presence at digital art festivals. It would have also no longer been an entirely authentic process since observation is an interference that affects those, who are being observed (Landsberger, 1958, c.f. Hawthorne effect). This of course has trade offs and limitations on what type of data can be collected in this kind of investigation. One example was given in chapter seven, were we discussed a possible instance of insight we were unable to verify because we had to rely on reflection data which did not yield enough information and detail to clarify the situation.

The thesis' mixed method approach emerged from research questions tailored to probe the macro and micro level of the creative process continuum via exploratory investigations. This meant that there was no hypothesis set forth as to what types and range of embodied cognitive

processes are expected to be obtained by the results. Results were gathered from both studies and were identified as relational in the creative process continuum. We then contextualised these with empirical and theoretical embodied cognition and creativity research. We focussed only on findings that were relational, where both analyses yielded a finding that was associated with a particular theme in embodied cognition. One finding in particular we were unable to integrate because we did not acquire a relational match. A type of epistemic action resulted from the study of the collaborative creative process that developed Sim-Suite's game but no similar result was obtained from the study into Sim-Suite's creative participation. We recognise that this limitation stems from our exploratory approach. We did not anticipate the level of detail needed to investigate Sim-Suite's game-board and fields traversed by Sim-Suite participants at certain stages in a game-round. The limitation lies within our more general approach as exploration, because technically this type of investigation would have been feasible.

Thirdly, the real-world and authentic approach of this thesis gave little information on the group of Sim-Suite participants that played the game during exhibitions. For example, we had a large range of ages among the participants, who contributed to our study. It would have been useful to see if 'playing styles' are influenced by age groups. Again, this would have meant a different kind of study, because it would entail a planned and premeditated approach to the investigation of real-world creativity.

8.2.2 Future work

In this thesis we proposed an exploratory approach to the study of embodied artistic creativity in computer-mediated interactive artworks. We have developed our concept around a case study research strategy by creating the interactive installation Sim-Suite. We were able to show the level of complexity of such an artwork and the inherent sociality of this kind of creativity.

Creativity in this context is a far cry from the traditional study of individual artistic creativity conducted in controlled environments. Computer-mediated artworks of this nature are not a rare occurrence, in fact the cultural landscape thrives with artworks of even greater complexity, which require even more interdisciplinarity and sophisticated technology in their production. The role of the artist is embedded in the social interaction with others, who are just as instrumental as the artist. In many cases the artist can but only take the conceptual lead in the communication of ideas. Therefore it is our understanding that with these contemporary developments we can no longer restrict the study to individual creativity but rather we need to take Donald's (2006) concept of art being created in the context of the larger distributed cognitive network as factual and apparent. We see the importance of creative developments from the perspective of how they shape as a network, the network from which they emerge.

This means that a static definition of creativity is no longer applicable because it cannot accommodate the evolving technological advances and the changing social paradigm of contemporary computer-mediated arts. It also questions where to draw the line between embodied cognition and embodied creative cognition, and whether there is a line to be drawn and why? These types of questions eventually have to be dealt with when creativity research fully accepts that the role of

the body in cognition is on par with mental operations.

By definition Sim-Suite did not contribute a socially-valued product, instead a 'field of artistic communication' had to be entered by each member of the public, who wanted to experience the artwork. In addition, the proliferation of artistic expression through recent symbolic technologies is increasingly democratising creativity. This demonstrates that creative expression is a universal human trait that exists as potential in every person only to be impoverished and confined within the limits of social and political forces. This would suggest that studies like the one conducted in this thesis should be adapted and pursued multitudinously, so that slowly a new outlook of contemporary artistic creativity can be forged, one that no longer focusses on quantifying individual creativity but tells a comprehensive story of how creative achievements are coupled to technological progress, forms of expressions and worldviews.

For researchers the challenge will be, as it is with our approach, to overcome shortcomings. These are inherent in the study of creative real-world performance. Researchers must strike a balance with investigative techniques and their potential interferences with the developmental stages of artistic creativity. Refining the application of mixed methodologies and data collection while maintaining the investigation of 'cognition in the wild' will be part of future work. In this it has to be taken into account that the study of collaborative and participatory creative processes involving computer-mediated artworks require flexible and adaptable methodologies and procedures. The reason is that neither materials, including technologies, are predisposed nor are actions predefined, but rather both depend on the artistic concept that is being conveyed.

Through iterative cycles of studies similar in approach to the one conducted for this thesis, but more refined and adapted, a repertoire of embodied cognitive processes in operation could be identified and a taxonomy of these established over time. This would enable future hypothesis-driven research in embodied artistic creativity. It could facilitate cross-referencing results from embodied cognition research conducted in controlled environments, and stimulate exchange between real-world findings, laboratory studies, and theoretical expositions.

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