Using naturalistic paradigms to study the influence of visual perspective during retrieval on subsequent accuracy for memory of events

Petra Marcotti

Thesis submitted for the degree of Doctor of Philosophy

School of Psychology

University of Sussex

September, 2019

Declaration

This thesis conforms to an article format in which the empirical chapters consists of articles in a style appropriate for publication in peer-reviewed journals in the field. The first and final chapters are an introduction of the research area and general discussion of the findings in the field of the current research. These experiments were designed together with Dr. Peggy St Jacques, who offered her expertise and advice. I was responsible for the design and creation of the additional mini-tasks of Chapter 3 and filming of all 360° videos of Chapter 4, whereas the mini-tasks of Chapter 2 were jointly created with my supervisor and postgraduate student Dan Cullen. I am the principle author of the manuscripts that form this thesis and take responsibility for analysis and write-up of the research.

A version of Chapter 2 was published in *Memory* as:

> Marcotti, P. & St Jacques, P.L. (2017). Shifting visual perspective during memory retrieval reduces the accuracy of subsequent memories. *Memory, 26(3),* 330-341.

Dr Peggy St Jacques provided feedback and corrections on the manuscript, and assisted in data analysis. I am responsible for the inclusion of additional analyses and ideas included in Chapter 2.

I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree. However, Chapter 2 of this thesis incorporates material already submitted for the degree of Master of Science in Cognitive Neuroscience, awarded by the University of Sussex in September 2015. This chapter contains additional analyses and ideas from the material previously submitted.

Petra Marcotti

September, 2019

Acknowledgments

Firstly, I'd like to offer my gratitude to my supervisor, Dr Peggy St Jacques, for all the mentoring, guidance and expertise she has offered me throughout this PhD. I also want to thank her for the constructive feedback on the chapters of this thesis (not to mention her patience and ability to interpret some of my not-so-easy discussion points and ideas). I am grateful to her for all the opportunities she has given me during these years and for knowing when to push me, which allowed me to develop as a researcher and to complete this PhD. I would also like to thank Dr Chris Bird, for taking over as my official supervisor at Sussex, and providing me support anytime I needed it. A thank you goes also to my assessor Prof Dora Duka, for her valuable feedback on earlier drafts of these chapters, but also for the support and encouragement she has provided me throughout this PhD.

Thank you also to all the members of the Memory for Events lab. To Heather, for guidance, support and for her patience in teaching me how to use VR. To the undergraduate students who have helped me design some of the mini-events and record of some of the 360° videos.

I would also like to express my gratitude to my family as well as my 'second family' Elio and Venerina, for the support given during challenging times and for always believing in me. My mum for always pushing me to never give up, for the amount of times she listened and supported me during stressful times (I am sure she is hoping to not hear me 'complain' for a while), and for her immense encouragement in every aspect of my life. My dad for teaching me how to be strong and how all problems can be overcome one way or the other; it is through his lessons that I have certainly learnt how to be resilient.

A special thank you goes also to my grandmother who, unfortunately, will not be able to see the end of this journey. She taught me how to be strong, independent, handle adversities and never 'hold a grudge', which helped me during this PhD and made me the person I am now. Together with my mum and dad, she always offered her support, allowed me to pursue my studies and accepted most decisions I'd take. She let me choose what I wanted to do and I am grateful to have had such a determined woman in my life.

Thank you to Anna, Jolyon, Joe, Jukka, Linda, Selin, Sofia, Sumeyra and all other people I have met in these years. With some of them I started my 9-year journey at Sussex University, while others I met during the PhD. Thank you for the support, encouragement, sometimes expert guidance (and all the wonderful times together that took my mind off things) during these years. I can say that I am very grateful to have you all by my side. Thank you to Vale, for our 20 and more years of friendship, for listening, supporting me and always being by my side, but also for her irony that made me feel 'lighter' during stressful times.

Finally, thank you to the School of Psychology at Sussex, to the 'actors' of my 360° videos who have been so kind, and patient (and brave) with the various attempts to record many different versions of the videos, but also to all the participants of my studies.

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Summary

Memories for events can be naturally experienced from different visual perspectives, but we can also deliberately shift from an own eyes perspective to a novel perspective when we see ourselves from an observer viewpoint in the remembered event. Previous research has shown that actively shifting to a novel perspective during retrieval influences the subjective experience associated with the original event but can also affect the content of memories and that these effects can even persist in subsequent memories. However, what still remains to be addressed is whether actively shifting visual perspective also contributes to more persistent changes in other properties of memories, such as their accuracy. To examine this, in this thesis I developed novel paradigms and methodologies to investigate the manipulation of visual perspective during retrieval of complex events encoded in the laboratory. In Chapter 1, I reviewed the current state of knowledge on how visual perspective contributes to changes in memories and proposed how naturalistic paradigms can provide the tools to manipulate visual perspective and study memory accuracy in the laboratory. In Chapter 2, I present two studies using a series of rich, engaging, and complex “mini-events” to examine the influence of shifting perspective during retrieval, when cued with photographs taken from different perspectives (study 1) and when the photo cues are removed (study 2), on subsequent memory accuracy for different memory details specific to the mini-events. Across both studies, I found that shifting visual perspective during retrieval reduced the accuracy of subsequent memories and demonstrated that these changes were predicted by reductions in subjective reports of vividness when actively shifting perspective. In Chapter 3, I used a similar paradigm and found that the presence of the physical self when cueing the observer perspective changed the visual perspective from which memories were later experienced. I

also examined whether shifting perspective during retrieval affected egocentric and allocentric aspects of memory and found that it contributes to changes in egocentric representation, such that it reduced egocentric accuracy of subsequent memories, but not allocentric accuracy. In Chapter 4, I developed a novel paradigm using immersive 360-degree videos of everyday life events to better control the point of view of encoding and retrieval; this allowed me to investigate for the first time how actively shifting to different viewpoints during retrieval might contribute to changes in subsequent perspective that extend beyond subjective reports of the visual perspective experienced, such as its accuracy. By directly comparing actively shifting to a novel viewpoint to shifting back towards the encoding viewpoint, I demonstrated that it is the novelty of the shift in perspective that contributes to changes in the phenomenological properties of memories, and that active shifts in perspective can alter the accuracy with which visual perspective is later remembered. In sum, this thesis demonstrates how shifting visual perspective during retrieval modifies subsequent memory accuracy for complex and immersive events encoded in a controlled laboratory setting. In Chapter 5, I will discuss the contributions of these findings to the wider literature, highlight the importance of using naturalistic paradigms to examine the role of perspective on memory, and propose how future research could extend and address some theoretical and methodological questions that this thesis raises.

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Chapter 1. Introduction

Memories can be retrieved from the visual perspective of one's own eyes, thus re-experiencing the event from the same vantage point as it was originally encoded, or from the perspective of an outside observer, watching yourself in the remembered event (Nigro & Neisser, 1983). Visual perspective influences the subjective experience associated with the original event and differentially affects what one can remember about the past (for a review see Rice, 2010). Adopting a perspective different from that experienced at the time of the event reflects the idea that memories are not an exact reproduction of our past, but they are the result of active reconstructive processes of a dynamic memory system (e.g., Bernstein & Loftus, 2009; Schacter, 1996). Constructive mechanisms are not only responsible for the presentation of our past, but they are also at the basis of abstract thinking and imagining the future (for reviews see Schacter, 2012; Schacter & Addis, 2007; Schacter, Guerin, & St. Jacques, 2011), for which representations are generated from the point of view of an outside observer (e.g., D'Argembeau & Van der Linden, 2004; Libby & Eibach, 2011; Macrae et al., 2015). The observer perspective can therefore be considered a 'novel' viewpoint typically constructed over time (but see below for memories encoded from this viewpoint) from which we experience past and future events. This chapter will consider how observer memories might be interpreted as a form of distorted memory as a consequence of constructive memory processes that distort and (re)-shape properties of memories and the way we think about the past in abstract terms to fit current goals and behaviours. Before evaluating the current state of knowledge on the role of visual perspective in memory, I will introduce the necessary role of the observer perspective in remembering the past as discussed within philosophy and discuss how adopting an observer perspective during retrieval reflects one of the ways in which memories are reconstructed over time. In the second I will outline how visual perspective is related to the concept of self in memory and how it can contribute to changes in memory. Thus, I will review evidence on the role of the observer perspective in abstract thinking whereby adopting an observer perspective is associated with abstract representations of events to direct current goals. I will then present research showing how adopting an observer perspective during retrieval leads to changes in both the phenomenology and the content of memories, and how these effects can contribute to more permanent modifications of the original memory trace. In the final part of the chapter, I will consider how recent technological advances using immersive virtual reality can contribute to creating controlled, ecologically valid experimental designs to study visual perspective and memory. This chapter will then conclude by describing how this thesis aims to investigate some of the questions in the visual perspective literature that have not yet been answered and/or addressed.

1. The role of the observer perspective in memory

1.1. Philosophical considerations

Adopting a perspective different from that of the original experience of the event has implications not only on the phenomenological properties of the memory (e.g., Berntsen & Rubin, 2006; Robinson & Swanson, 1993), but also on our sense of self at the time of the event (Libby & Eibach, 2002, 2011; Libby, Eibach, & Gilovich, 2005; Sutin & Robins, 2008) and what we remember about that experience (e.g., Bagri & Jones, 2009; McIsaac & Eich, 2002). If we interpret the influence of visual perspective from a philosophical point of view and draw on Kant (1724/1804)'s definition of *phenomenon* - intended as the object of the senses - it can be argued that the particular vantage point from which we remember the event is not merely the way the *phenomenon* of memory is presented to us, but also the consequence of active cognitive processes which lead to modifications, and 'reshape' the perception of the original event as it occurred. In other words, adopting an observer perspective at retrieval is not only understood as an intrinsic modification of the memory, but also as a process that alters or distorts what one can remember (or imagine) about their past (or future). Within philosophy, a debate has arisen on the distinction between own eyes and observer vantage point and whether observer memories are to be considered distorted memories. Two distinct lines of thought have emerged. On the one hand, McCarroll and Sutton (2017) do not consider observer memories as distorted memories, rather they interpret the distinction between own eyes and observer as two different modes of presentation of the same event (McCarroll, 2017; McCarroll & Sutton, 2017) and further claim that 'observer perspectives can be both true and authentic: they can both represent an event that occurred and the experiences occurring at the time of the event' (McCarroll & Sutton, 2017, p.13). Their claim seems to assume that to say that a memory is distorted is to say that that memory is false, or it represents an event that in fact did not occur. However, this may not be the only interpretation of the term 'distortion'. Fernández (2015) in fact claims that observer memories are beneficial distorted memories. He reviews both the traditional view of memory within philosophy which claims that the function of memory is to preserve the content of our past (storage conception) and introduces the conception of memory within psychology according to which its function is to reconstruct the past in order to help us build a narrative of our lives (narrative conception). He concludes his argument by claiming that a memory can provide a narrative of our past without preserving information acquired in the past, and in this sense the memory can be considered distorted. As an example, he takes the case of traumatic memories (typically remembered from the point of view of a detached spectator) (e.g., McIsaac & Eich, 2004) and argues that these are distorted memories in that they do not represent an event exactly as it was originally experienced. Yet, they are beneficial because they enable a narrative of our lives without preserving the 'perception' (in Fernandez's words) or emotions associated with the event.

It is important to note here that the focus of this chapter and the research projects of this thesis will be on adopting an observer perspective during memory *retrieval*, although there is a large body of evidence showing that memories can also be encoded from this vantage point (e.g., Clark & Wells, 1995; Nigro & Neisser, 1983; Spurr & Stopa, 2003). As Sartre (1905/1980) discussed within the philosophy of existentialism and phenomenology, we realise our being in the world, or that we exist, when we experience ourselves as seen from the point of view of the Other (i.e. when we know we are being observed) (Sartre, 1943). This idea has been scientifically examined within psychology by Nigro and Neisser (1983), who were amongst the first researchers to propose that immediate experience of an event can occur either from an own eyes or an observer vantage point and the latter is likely to occur when an individual is 'self-consciously aware of being observed or evaluated'. In some circumstances, this experience is however the consequence of situations that can be stressful to the individual. For example, people with social phobia tend to construct a negative image of how they will appear to others in social situations, and this image is predominately experienced from an observer perspective (e.g., Clark & Wells, 1995; Spurr & Stopa, 2003). It could be argued that these types of memories need not be considered a form of memory distortion in that they represent the original experience or the event as it occurred at the time of encoding. Although this claim is open to debate, a discussion on this idea is beyond the scope of this thesis. In the next sections, I will present some of the research in psychology that has investigated the role of active retrieval processes on memory updating and discuss how adopting an observer perspective during retrieval contributes to changes in memory.

1.2. Active retrieval processes that modify memories

By examining the act of retrieval, psychology embraces the idea of distortions as a result of the reconstructive nature of memory. In particular, the view advanced by cognitive psychology and neuroscience of 'adaptive constructive processes' supports the idea that memory distortions need not be considered the result of a malfunctioning memory system, rather as the consequence of a system that naturally reconstructs pieces of information from our past to provide a coherent story (Schacter & Addis, 2007; Schacter, Chiao, & Mitchell, 2003; Schacter, Guerin, & St Jacques, 2011; see also Bernstein & Loftus, 2009). Research has shown that memory is not a stable and fixed system rather it is the result of active and dynamic processes. Contrasting the standard model of consolidation according to which memories become more stable over time (Alvarez & Squire, 1994), each time a memory is retrieved (or reactivated) it becomes susceptible to the incorporation of novel information, which is maintained in later memories through reconsolidation processes (e.g., Chan & LaPaglia, 2013; Forcato, Rodriguez, Pedreira, & Maldonado, 2010; Hupbach, Gomez, Hardt, & Nadel, 2007; for a review see also Hardt, Einarsson, & Nader, 2010; Moscovitch et al., 2006).

A handful of studies have demonstrated that retrieval is an active process that can strengthen but also modify memories; retrieval of previously encoded material can lead to improved memory performance (e.g., Chan, McDermott, & Roediger, 2006; Koutstaal, Schacter, Johnson, & Galluccio, 1999; Karpicke & Roediger, 2008; Schacter Koutstaal, Johnson, Gross, & Angell, 1997; see also for a review Roediger & Butler, 2011), but when the memory is integrated with new information it can also increase erroneous recall of information, as it is the case for false memories (e.g., Koutstaal, et al., 1999; Schacter et al., 1997; Roediger, Jacoby, & McDermott, 1996; see also for a review Schacter, Guerin, & St Jacques, 2011) and for post-event misinformation (e.g., Chan & LaPaglia, 2011; Chan & Langley, 2011; for reviews see Loftus, 2005; Zaragoza, Belli, & Payment, 2007). Moreover, retrieval processes can also lead to (adaptive) forgetting of other related information that interferes with the information we seek, thereby reducing competition between memories to be retrieved (Anderson, 2003; Anderson, Bjork, & Bjork, 1994; Wimber, Alink, Charest, Kriegeskorte, & Anderson, 2015; see also for meta-analysis Murayama, Miyatsu, Buchli, & Storm, 2014). Crucially, more recent evidence has demonstrated that manipulating the quality of memory reactivation can also affect the accuracy with which later memories are remembered, leading to both enhancements and distortions (St Jacques & Schacter, 2013; St Jacques, Montgomery, & Schacter, 2015; St Jacques, Olm, & Schacter, 2013).

Constructing a novel perspective during remembering also reflects the idea that memories are the results of active reconstructive processes; this process requires updating one's egocentric reference frame and re-locating one's self in the spatial context of the remembered event, thereby updating and altering the way we remember the past. As I will present in the following sections, retrieval from an observer perspective can reshape the phenomenology and content of memories and these effects can persist over time. Critically, adopting this novel perspective may potentially influence other properties of memory, such as their accuracy. This is a question that still remains to be addressed in the visual perspective literature and it is the aim of the current thesis to address it to better understand the impact of visual perspective during retrieval on reshaping our past.

2. The observer perspective and changes in memory

The self-memory system model developed by Conway and Pleydell-Pierce (2005) highlights the importance of the self during remembering and posits that our memory system is necessary to maintain a coherent sense of self over time. One way in which autobiographical memory is related to the concept of self is that the memory is seen from an own eyes perspective, or 'through the eyes of the self' (Gillihan and Farah, 2005). Rubin & Umanath (2015) address visual perspective in autobiographical memory in terms of scene construction. They claim that an event memory can only be considered as such if it is experienced as the recall of a scene whereby we create a visual image of the spatial layout of the event context from a particular visual perspective. This construction involves the location of the self in time thereby allowing mental time travel (Rubin & Umanath, 2015), a key property of autobiographical recollection (Tulving, 1985). However, it is well documented in the visual perspective literature that memories can be both naturally (e.g., Nigro & Neisser, 1983) and deliberately (e.g., Rice & Rubin, 2011) experienced from different visual perspectives. Sutin and Robin (2008) suggest that memories are reconstructed to serve self-evaluative functions and that this novel or observer perspective allows us to take the point of view of another, such that of a judge, to evaluate our own behaviour.

Visual perspective is, in fact, one of the key properties that helps maintain consistent views of oneself in autobiographical memory (Sutin & Robin, 2008). In particular, they propose that imagining oneself from an outside perspective has two functions: 1) *dispassionate observer:* it promotes an objective view that distances the past self from the current self, needed to both evaluate one's own behaviour (i.e., 'to reduce the feeling of inauthenticity', when the self in the memory is inconsistent with the current self) and to reduce the negative emotions associated with the 'past' self that would limit current goals and behaviours (e.g., when remembering a negative first presentation in front of an audience, the individual can re-evaluate his/her past self and realise how much he/she has changed since); 2) *salient self:* it increases self-focus and promotes congruence between the past and current self, which can intensify feelings of authenticity. The authors put forward the idea that adopting an observer visual perspective is conceptually similar to seeing oneself in the mirror or in a photograph, in that all of these experiences activate self-evaluative processes. One interesting question that arises from this is whether the presence of the physical self in photographs may influence the visual perspective of subsequent memories. We often review personal photographs of past events (i.e., that include our face and/or body) that are typically taken from a perspective that was not experienced during encoding of the event, but it still remains to be empirically tested whether this influences the way we later remember the original event. This question will be addressed in Chapter 3.

2.1. Abstract thinking

Imagining oneself from an external (observer) visual perspective (i.e., constructing a scene from this new perspective) has implications on our sense of past and current self in memory (Sutin & Robin, 2008). Adopting an observer or novel visual perspective can also influence representations of events (i.e., concrete versus abstract) to direct current and future goals and behaviours, and can lead to (possibly adaptive) changes in the way memories are remembered. The observer perspective may in fact serve a specific function for our memory system. Similar to gist-based memories (see Schacter et al., 2011 for a review on gist-based processing), memories retrieved from an observer perspective could potentially serve to reduce storage demands by accessing or retaining only general details about the event rather than all its concrete and specific features that may not be required. This enables to extract the goal or gist of an event, thus allowing to extract the meaning of an event rather than the means by which the event has occurred.

Recent evidence in support of this idea comes from Libby and Eibach (2011) who have proposed that perspective functions as a ‘representational tool’ to understand the meaning of events depicted in the mental image. Each perspective facilitates different processing styles whereby the own eyes perspective allows understanding of a scene in terms of its concrete properties (e.g. spatiotemporal details) and the observer perspective allows a more abstract understanding of the event scene (e.g. the broader meaning). To take an example, actions of everyday activities can be imagined concretely or abstractly. The act of locking the door can be thought of in terms of its concrete features, i.e. putting a key in the hole, or in terms of its goal or abstract properties, i.e. securing the house. Libby (2003) tested the association between perspective and processing style and found that people who were more likely to picture actions in terms of their abstract properties also tended to construct the image from an observer perspective.

This effect is not only bidirectional, whereby picturing actions from an observer perspective leads to construct a more abstract description of those (Libby, Shaeffer, & Eibach, 2009), but it also works for tasks that are unrelated with the action being asked to imagine. For example, Shaeffer, Libby, and Eibach (2015) first primed participants with a series of own eyes and observer photographs of actions (e.g. wiping up a spill) and had them read a simple unrelated fable conveying an abstract moral. They were later given concrete (i.e. describing specific behaviours) and abstract (i.e. describing broader moral lessons) descriptions of the story for which they had to rate their preferences. Findings demonstrated that participants were more likely to define the fable in its abstract terms if they had been primed with observer as opposed to own eyes photographs.

Other studies have examined the adoption of an observer perspective in abstract representations by studying simulation of future goals. For example, Vasquez and Buehler (2007) demonstrated that the higher level of abstract construction involved by adopting an observer perspective increased academic motivation. In other words, participants integrated the goal (i.e., academic motivation) into its broader context (i.e., personal significance and importance of academic achievement). Another study (Kross, Ayduk, & Mischel, 2005) examining psychological strategies by manipulating visual imagery to process negative emotions revealed that adopting a detached perspective allowed participants to construe a more general or abstract representation of personal anger-related experiences. They further showed that remembering the distressing events from an observer vantage point enabled individuals to focus on the ‘why’ of the event as opposed to the ‘what’, which in turn decreased levels of negative affect.

The particular visual perspective one adopts at retrieval has therefore implications relative to the type of representation formed for both past events and simulation of future goals. It should be noted here that the role of visual perspective has also been investigated in episodic future thinking and it will be mentioned in the following part of this section to argue for the association between observer perspective and abstract representations (e.g., D'Argembeau & Van der Linden, 2004; Macrae et al., 2015; McDermott et al., 2015), although a review of this literature is beyond the scope of this chapter (but see Chapter 5). The different types of representation we form when remembering the past (or imagining the future) have been extensively explained by construal level theory (CLT; Trope & Liberman, 2003), which distinguishes between concrete and abstract representation in terms of level of construals and are dependent on the temporal distance of the event. In more detail, low-level construals are used to represent information of an event that will occur in the near past (or future). These representations tend to be more concrete and associated with richer and more detailed representation of the 'how' of the event or action. By contrast, to represent information of a more distant past (or future) event, we typically use higher-level construals, which are more general or abstract and allow to represent the meaning or 'why' of a specific event or action. Similarly, it may be proposed that the distinction between own eyes and observer perspective fits the distinction proposed by CLT. Specifically, the own eyes perspective can be considered as a form of low-level construal and it is generally adopted for more recent memories (Nigro & Neisser, 1983), as well as being richer in visual details (e.g., Butler et al., 2016), and typically adopted when imagining the near future (e.g., D'Argembeau & Van der Linden, 2004; Macrae et al., 2015). By contrast, adopting an observer vantage point reflects high-level construals in that it tends to be the preferred perspective when recollecting remote past events (Nigro & Neisser, 1983) (as well as imaging more distant future events; e.g., D'Argembeau & Van der Linden, 2004; Macrae et al., 2015), and it allows the representation of the meaning (i.e., abstractions) of a past event (e.g., Libby & Eibach, 2011). The temporal distance of events for remembering (and imaging the future), therefore influences the formation of a mental image such that it is represented more abstractly or gist-like as compared to the image for more recent events.

Taken together, these findings reflect the idea that the observer perspective can lead to changes in the representation of images that arise when imagining events; it creates an abstract representations rather than forming an image rich in information on the ‘how’ a specific event occurs or has occurred.

2.2. Phenomenological changes: immediate and long-lasting effects.

Other evidence in support of the idea that the observer perspective can change the way we remember the past comes from studies that have directly manipulated visual perspective during memory retrieval. In particular, it has been shown that deliberately shifting from an own eyes to an observer perspective leads to a decrease in the emotional intensity associated with the original event, whereas shifting back to the own eyes encoding vantage point does not result in an opposite effect (i.e. it does not increase ratings of emotional intensity) (Berntsen & Rubin, 2006; Robinson & Swanson, 1993; Vella & Moulds, 2014; see also St. Jacques, Szpunar, & Schacter, 2017). Thus, the observer perspective is associated with phenomenological changes of the memory in terms of the emotions and the sense of re-experiencing of the past which are both reduced compared to when recall occurs from the same perspective as at the time the event occurred.

Importantly, differences in emotional intensity as a function of changing perspective have also recently been found to persist over time. Sekiguchi and Nonaka (2014) examined changes in emotional intensity associated with past events over a period of four weeks after perspective manipulation. Results revealed a decrease in emotional intensity ratings when perspective was deliberately changed to an observer vantage point as opposed to events that had been retrieved from an own eyes perspective. Although these phenomenological changes are typically the result of online retrieval processes (e.g., Berntsen & Rubin, 2006; Robinson & Swanson, 1993), these findings provide the first piece of evidence in support of the idea that modifications also extend to subsequent memories.

More permanent changes in the phenomenology of memories have also been documented on other memory characteristics, such as the sense of reliving and level of vividness (see also Rice & Rubin, 2009). For example, Butler et al. (2016) manipulated perspective by having participants repeatedly retrieve lab-based and autobiographical memories from either the own eyes or observer perspective. One month later, phenomenological characteristics of both types of memory were examined and they found that observer memories were rated as less vivid and with decreased sense of recollection compared to own eyes memories. They additionally reported that visual information was not recovered even when eventually asked to shift back to an own eyes perspective. As the authors suggest, it is likely that retrieving from an alternative perspective is associated with a loss of visual details, thus again supporting the reconstructive view of observer memories.

More recently, St Jacques, Szpunar, and Schacter (2017) demonstrated that repeatedly retrieving autobiographical memories from a novel or observer perspective, initially experienced from an own eyes perspective, also contributes to long-lasting changes in the visual perspective from which memories are later experienced when perspective is not directly manipulated, such that it increased subsequent observer perspective ratings. These subsequent perspective changes were also linked to online neural changes and reductions in emotional intensity during memory retrieval.

Nonetheless, watching yourself as an outside spectator means updating one's location in the spatial context of the memory image and this process inevitably requires a high degree of engagement of constructive processes, which can in turn result in modifications in the way these memories are experienced online but also after a delay. Critically, these changes may also extend beyond subjective reports of visual perspective to more objective measures of visual perspective accuracy. To date, studies have not addressed this question. It will be one of the aims of Chapter 4 to directly investigate whether actively shifting to different viewpoints during retrieval influences the visual perspective accuracy of subsequent memories.

The next section will review how shifting to a novel perspective also influences the content of memories, and how the current thesis aims to expand this literature by addressing some other unanswered questions in the visual perspective literature.

2.3 Online and subsequent changes in the content of memory.

The particular vantage point adopted at retrieval not only alters the subjective experience of the memory, but it has also implications on the content of one's memory. Recent research has started to directly investigate how recall from different egocentric vantage points influences the content of one's memory (e.g., Bagri & Jones, 2009; Eich et al., 2009; McIsaac & Eich, 2002, 2004). McIsaac and Eich (2002), for example, tested immediate recall from different visual perspectives of memory for events encoded in the lab. Their results revealed that visual perspective differentially affected the type of details recalled; the own eyes perspective was associated with more statements reflecting the subjective perception of the event (such as emotions, sensations and thoughts), whereas retrieving from an observer vantage point led to a higher frequency of recall of the objective details of the memory (i.e., physical appearance, actions, spatial relations among objects). Moreover, Akhtar, Justice, Loveday, and Conway (2017) reported differences in the amount of episodic details recalled for own eyes and observer autobiographical memories. They found that memories, initially experienced from an own eyes perspective, contained fewer episodic details when retrieved from an observer perspective one week later. The opposite shift in perspective (i.e., from a dominant observer perspective to an own eyes vantage point) did not however lead to any differences in the number of details recalled.

These results contribute to the idea that memories retrieved from an observer perspective are potentially less rich in details compared to own eyes memories and suggest that adopting an alternative perspective not experienced during encoding might render certain memory details less accessible for recall. Critically, these studies have examined the frequency of details reported, but one question that still remains to be addressed is whether adopting different visual perspectives during retrieval also influences the accuracy with which these details are also reported.

Studies that have investigated how shifting perspective influences the accuracy with which details are remembered have focused on taking the perspective of another individual rather than changing one's egocentric point of view (i.e., seeing one's self from the outside). Anderson and Pichert (1978), for example, were amongst the first to demonstrate that recalling a story from the perspective of another person in the scene (i.e., of either the homebuyer or burglar – alternative to the one used during initial reading of the story) improves memory recall and that it aids the retrieval of certain details that would be otherwise unrecallable from the initial encoding perspective. Change in perspective and memory accuracy have also been examined in applied forensic settings, but have shown mixed results regarding its effectiveness in aiding memory (e.g., Boon & Noon, 1994; Geiselman et al., 1984). In particular, one of the recall techniques used in the Cognitive Interview during the interrogation process, where eyewitnesses are asked to adopt the perspective of another individual to remember details of a crime scene (Geiselman et al., 1984), has been largely criticized in that it does not appear to enhance memory recall (e.g., Boon & Noon, 1994; Mello & Fisher, 1996).

This line of research therefore provides some initial evidence in support of the idea that adopting a perspective different from one's own during retrieval affects the details one can successfully recall about an event. However, relatively little is still known about how shifting to a perspective where one can imagine themselves from the outside potentially alters the accuracy of memories. For example, Bagri and Jones (2009) replicated and extended McIsaac and Eich's (2002) findings by including a measure of memory accuracy for written passages (of the same types of events used by McIsaac & Eich) and found better memory performance for own eyes compared to observer memories.

Shifting visual perspective during retrieval may not only impact memory accuracy but also distort memories. Some authors have in fact suggested that changing perspective during memory recall may also lead to distortions and memory errors (e.g., Bekerian & Dennett, 1993; Memon & Higham, 1999; Schacter, 1996). Interestingly, St Jacques and Schacter (2013) demonstrated that manipulating the viewpoint from which memories are retrieved can also influence the accuracy of subsequent memories (i.e., after a delay). Specifically, they developed a naturalistic paradigm whereby participants took part in a museum tour and were later cued with their photos of the tour taken from either the same perspective as encoding or from an alternative perspective that was never experienced before. They found that cueing memories with photos taken from the original encoding perspective not only increased subsequent true memories for events of the museum tour relative to memories cued by photos taken from the alternative viewpoint, but that it also led memories to be more prone to distortions (i.e., it increased false memories). The authors discuss these findings in light of quality of memory reactivation, whereby photos depicting the same viewpoint as encoding should reflect higher level of reactivation compared to photos taken from a different or novel viewpoint. Critically, participants in this study were not explicitly instructed to adopt an own eyes or observer visual perspective, thus it remains unclear whether the subsequent memory effects were due to the effectiveness of the retrieval cues in reactivating memories or due to shifting to a novel viewpoint during retrieval.

Moreover, the higher frequency of spatial relations among objects revealed in McIsaac & Eich's (2002) study when recalling from an observer perspective does not clarify how accurately these details were reported. However, we know from research in the spatial memory literature (e.g., Burgess, Spiers, & Paleologou, 2004; Wang & Spelke, 2002) that spatial representation of objects can be computed with respect to one's self (i.e., egocentric), but also with respect to other objects (i.e., allocentric). The processes involved in constructing an observer perspective, thus updating one's egocentric frame of reference during retrieval, may influence egocentric and allocentric representations of the memory. This will be investigated in Chapter 3.

Given the few and mixed findings on influence of visual perspective on recall accuracy and distortions, it is the aim of the current thesis to directly investigate how actively shifting perspective influences the accuracy of subsequent memories. The literature reviewed above provides some interesting insights on the nature of adopting an alternative perspective, but it also demonstrates that the changes observed when retrieving memories from a viewpoint not experienced during encoding extend beyond the subjective experience associated with the original event. This emphasises the need for adopting more objective measures to investigate the role of visual perspective in memory (i.e., beyond participants' subjective reports). Studies looking at memories of one's life story have certainly provided interesting results, but the methodological constraints posed by studying autobiographical memories have left the questions reviewed in this chapter still unanswered. In the next section, I will discuss how recent technological advances can help in the assessment of objective properties of memory.

3. Methodological considerations to study visual perspective in memory for events

The literature reviewed above has mainly focused on examining personal memories of one's own past to examine the influence of visual perspective (with the exception of Bagri & Jones, 2009; Eich et al., 2009; McIsaac & Eich, 2002; see also Butler et al., 2016). However, as suggested by Butler et al. (2016), lab-created memories might be preferable when examining the influence of visual perspective on subsequent changes in the phenomenology of memories, because autobiographical memories might have already undergone natural transformations in visual perspective and other memory characteristics that might in turn be resistant to change when manipulating visual perspective. Moreover, experimental control over the encoding of events allows research to integrate outcome measures, such as subjective reports, with more objective measures that would not otherwise be possible to study on participants' autobiographical memories (e.g., memory accuracy or retrieval success).

Yet, strict experimental control can, in turn, compromise ecological validity; the methods and measures used might not always approximate to the real-world. For example, the subjective experience of memories created in the lab is inevitably different from that of autobiographical memories (e.g., sense of recollection, emotional content, self-relevance, age of memories). Thus, to be able to translate the findings to the real-world, one also needs to create conditions whereby the subjective qualities (e.g., sense of recollection, emotional content, self-relevance) of memories elicited in the lab are similar to those of autobiographical memories. In particular, eliciting memories that approximate to the real-world becomes critical when manipulating visual perspective. Naturalistic paradigms with rich, complex, real-life events to be encoded and manipulated in the laboratory can therefore be the means through which we can investigate visual perspective and verify memory accuracy.

In recent years, there has been an increase in the use of naturalistic paradigms to better understand the cognitive and neural mechanisms of memory for events. Memory researchers have developed paradigms re-creating events similar to the real-world whereby participants can explore varied and rich three-dimensional environments (e.g., Cabeza et al., 2004; St Jacques & Schacter, 2013). Although these are effective for verifying memory accuracy, they still present some limitations; for example, experimental power is typically reduced (i.e., fewer number of trials due to limited number of events typically encoded), they require longer testing sessions and even the strict experimental control might be compromised when testing participants in real-world environments. Standard 2D videos of everyday life events to create memories in the laboratory (e.g., Koustaal et al., 1999; Schacter et al., 1997; Bird et al., 2015) can overcome the shortcomings of real-world paradigms. Yet, the viewpoint from which 2D videos are encoded might not approximate to the standard own eyes perspective of real-world events such that the participant might feel like a passive observer of the video event. Moreover, there is typically no interaction with surroundings, objects and/or people. These aspects might in turn affect subsequent changes and/or manipulation in perspective during retrieval. As Cabeza et al. (2004) discuss, the sense of ‘immersion’ elicited by naturalistic paradigms is what allows the participant to feel like an active agent rather than a passive observer of the video event. Critically, this increases self-referential processing, which is a key property of episodic memory retrieval (Tulving, 2002) and, as reviewed in section 2 of this chapter, it is also a characterising aspect of the visual perspective experience of memories. The sense of immersion is therefore a crucial aspect when manipulating visual perspective: the participant needs to be an active agent in the experienced event for encoding to occur from a first-person so as to not compromise visual perspective at baseline (see also Butler et al., 2016 for a similar discussion on this).

One way in which we can bridge the gap between real-world paradigms and standard 2D videos to examine changes in memory accuracy due to shifting visual perspective is to use immersive reality technologies. Research has in fact shown that immersive relative to conventional videos can increase the sense of presence or of 'being there' in the environment and decrease the feeling of being a passive observer (Gorini et al., 2011; see for review Diemer, Alpers, Peperkorn, Shiban, & Mühlberger, 2015; see also Serino & Repetto, 2018 for a critical review on 360-degree videos). In immersive reality the individual is 'immersed' within diverse and perceptually rich environments with the opportunity to explore and interact with the surroundings of the event context without the 'barriers' imposed by a computer screen. Moreover, the encoding experience of immersive and standard 2D videos can also differentially influence recall success and its quality. For example, Schöne, Wessels, and Gruber (2019) showed two groups of participants an immersive video using a VR headset or the same video on a computer screen. 48-hours later, in a surprise recognition memory task, they were presented with screenshots of videos and they had to indicate whether the photo was taken from the video or not. Interestingly, the found that recognition performance was better for the immersive VR video experience compared to the non-immersive condition. In a similar experimental design, Kisker, Gruber, and Schöne (2019) further examined retrieval processes of recollection and familiarity for the recognition memory task. Despite failing to replicate Schöne et al.'s (2019) differences in recognition performance between the VR and 2D video conditions, using a remember/know paradigm they found that participants who watched the immersive video relied more on recollection mnemonic processes for the recognition task, whereas the non-immersive video was linked to higher sense of familiarity. Taken together, these results suggest that immersive videos show an advantage as opposed to conventional videos displayed on computer monitors and that we are potentially moving closer to creating events in the laboratory that resemble personal autobiographical memories.

The evidence reviewed in this section was therefore considered to develop naturalistic paradigms to manipulate visual perspective and study memory accuracy in the laboratory. In particular, in Chapter 4, I will present a new, naturalistic paradigm using 360-degree immersive videos of everyday life events (e.g., making breakfast) to examine visual perspective and memory distortion. This paradigm was designed with the objective to create a protocol that would approximate to the real-world whereby participants could explore diverse indoor and outdoor environments for each video event, thus aiming to ensure that visual perspective at baseline was from one's own eyes while controlling for the encoding angle and content of the events. This will extend the mini-events paradigm that I will present in Chapter 2 (and used in Chapter 3), which was also designed so that participants could be active agents of the encoded events by performing unique and complex hands-on mini-tasks in the laboratory.

Another novel aspect of the paradigms used in the current thesis to manipulate visual perspective was the use of photographic cues of the encoded events showing the particular visual perspective to adopt. Rice & Rubin (2009) demonstrated that the observer perspective can originate from multiple external viewpoints whereby the individual sees themselves and the event scene from different egocentric locations within the memory (e.g., from above or below individual's eye level; from the front or behind of the subject's body) (see also Iriye & St. Jacques, 2017; Rice & Rubin, 2011). Research has showed that the origin of the observer perspective can vary between types of events recalled (see McDermott et al., 2015; Rice & Rubin, 2011), but its origin might potentially affect the phenomenology and properties of memories – this awaits further research. Moreover, it has been shown that adopting an observer perspective during retrieval is typically more difficult than retrieval from an own eyes perspective (e.g., Eich et al., 2009; McIsaac & Eich, 2002; St Jacques et al., 2017). Photographic cues showing the particular visual perspective to adopt can be the experimental tractable way to ensure that the viewpoint from which memories are retrieved remains constant across memories and across participants, while potentially controlling for any differences in retrieval difficulty.

Photographs are effective retrieval cues that can allow research to verify memory accuracy while varying the retrieval context. For example, photographs have been included in naturalistic paradigms to examine the effects of rehearsal on subsequent memory accuracy (e.g., Koustaal et al., 1999). Others have used photographic cues to manipulate the content of memories by including erroneous information to investigate false memories (e.g., Schacter et al., 1997). Critically, St Jacques & Schacter (2013)'s naturalistic paradigm developed to examine the influence of adopting different viewpoints during retrieval on subsequent memory recall used photographs taken automatically by a camera (i.e., SenseCam) that participants during worn during encoding of events by developing a naturalistic paradigm. In the subsequent retrieval session, memories for the events were triggered with the same photographs took during the tour (i.e., showing the same perspective as encoding) or from a controlled set of photographs showing a novel viewpoint (i.e., from a controlled set of photographs). Photographic cues can be effective to elicit, control and manipulate visual perspective in a number of ways.

Thus, the paradigms used in the current thesis used photographs taken from different viewpoints to elicit visual perspective in different ways. In particular, in Chapter 2, I examined how the effectiveness of the retrieval cues in eliciting memories from different perspectives might influence subsequent memory accuracy; in Experiment 1 participants were shown photographs of the mini-events taken from an own eyes and observer visual perspective, whereas in Experiment 2 the photographic cues were removed during perspective manipulation. Moreover, given the role of the self in visual perspective and memory (as reviewed in section 2), the same paradigm of Chapter 2 was used in Chapter 3, with one difference; visual perspective was manipulated using also photographs that included participants' physical self. The immersive 360° video events paradigm developed for Chapter 4 extended these two chapters to better understand how active shifts in perspective and/or the nature of the photographic cues (i.e., encoding-retrieval match and mismatch of the perspective in the photos) during retrieval may contribute to subsequent memory distortions.

4. Objectives and overview of this thesis

Throughout this introduction, I have argued that adopting an observer perspective during retrieval alters the representation of our past. I have also referred to the observer perspective as an 'alternative' perspective, and/or as a 'novel' perspective in that it is not the vantage point from which memories are typically encoded. It is therefore the aim of this thesis to better understand how adopting a novel perspective during memory retrieval influences properties of subsequent memories by extending previous findings and addressing some of the questions that the literature has not yet examined. In particular, I will address how shifting visual perspective influences the accuracy for memory elements, egocentric and allocentric accuracy, but also whether it can lead to subsequent memory distortions and objective changes in visual perspective accuracy. To accomplish these aims, I developed naturalistic paradigms in the laboratory setting. In Chapter 2, I present two studies using a series of rich, engaging, and complex "mini-events" to examine the influence of adopting a novel perspective from encoding during retrieval and its influence on subsequent memory accuracy. In Chapter 3, I adopt the same paradigm of Chapter 2 to draw particular attention on the definition of observer perspective, whereby remembering from an observer vantage point is considered similar to seeing one's self in the mirror or in a photograph (see section).

In particular, the aim of this study is to investigate how seeing oneself in a photographs influences visual perspective . Thus, I compared observer memories cued by photos showing the bodily self versus not showing the self and the similarities and/or differences with own eyes memories. The influence of the different photo cues will be investigated in relation to subsequent memory accuracy. Based on the evidence reviewed in section 2.3, I also investigated whether shifting perspective differentially affected egocentric and allocentric aspects of memory, by developing more nuanced measures of spatial accuracy to assess both egocentric relations (i.e., with respect to the self) and allocentric relations (i.e., object-to-object relations) of the objects in the mini-events. In Chapter 4, I present a paradigm using immersive 360-degree videos to investigate how actively shifting to different viewpoints during retrieval might contribute to subsequent memory distortions (as reviewed in section 2.3). In particular, I directly compared actively shifting to a novel viewpoint to shifting back towards the original encoding viewpoint to examine modifications in the phenomenological properties of immersive memories, as well as subsequent true and false recognition memory and potential changes in subsequent visual perspective accuracy. In Chapter 5, I will discuss the contributions of the findings to the wider literature and propose some mechanisms by which visual perspective operates. I will then highlight the importance of using naturalistic paradigms over personal autobiographical memories and advantages of 360° videos to examine the role of perspective on memory. I will also discuss 1) the real-world implications of reviewing personal photographs and how this influences visual perspective 2) the forensic implications for eyewitness testimony of the current findings and it will be proposed how future research could extend and address some theoretical and methodological questions that this thesis raises.

Chapter 2. Shifting Visual Perspective During Memory Retrieval Reduces the Accuracy of Subsequent Memories

Introduction

Memories are reconstructed through active retrieval processes that can reshape our experience of the past in multiple ways. One of the ways we reconstruct memories is by recalling the past from multiple visual perspectives. Although we typically experience the world from a first person in-body perspective (i.e., from our own eyes), we sometimes retrieve memories from a first person out-of-body perspective (i.e., observing our physical body from the outside (Nigro & Neisser, 1983). By definition, observer perspectives reflect vantage points that are not typically experienced during memory encoding. The ability to retrieve memories from visual perspectives that were never experienced can thereby provide insight regarding the dynamic nature of memories (Schacter, 1996). Supporting this idea, a large body of evidence has shown that remote memories are typically remembered from an observer perspective, whereas recent memories are more likely to be naturally retrieved from an own eyes perspective (e.g. Frank & Gilovich, 1989; Nigro & Neisser, 1983; Piolino et al., 2006; Rice & Rubin, 2009; Robinson & Swanson, 1993; Talarico et al., 2004). One reason is that remote memories are more likely to have undergone modifications over the course of time when compared to recent memories, in line with theories of memories that emphasize the critical role of reactivation in shaping long-term memory representations (McClelland, McNaughton, & Oreilly, 1995; Winocur & Moscovitch, 2011). Although memories are typically retrieved from a natural or preferred visual perspective, people can flexibly adopt multiple visual perspectives and shift back and forth between them (Rice & Rubin, 2011). Thus, remembering from an observer perspective is likely the result of these reconstructive processes resulting in memory modifications over time. Here we investigate how shifting visual perspective during retrieval of memories for complex events encoded in the laboratory influences subsequent memory accuracy.

A number of studies have shown that the particular visual perspective adopted during memory retrieval influences the characteristics of memory recall (for review see Rice, 2010). A seminal study conducted by Nigro and Neisser (1983) demonstrated that the visual perspective people adopt depends on the type of phenomenal elements they recall. More specifically, when participants were asked to focus on the emotions elicited by their autobiographical memories, they tended to adopt an own eyes perspective, whereas the observer vantage point was associated with a focus on the objective circumstances or physical context of the event. Visual perspective also influences the types of information recalled in memories (Anderson & Pichert, 1978; Bagri & Jones, 2009; Eich, Nelson, Leghari, & Handy, 2009; McIsaac & Eich, 2002, 2004). For example, McIsaac and Eich (2002) examined how visual perspective during retrieval of complex events encoded in the lab affects the content of verbal recall. They found that memories retrieved from an own eyes perspective contained more details related to internal aspects of the memory (i.e., sensations experienced, emotions and thoughts). In contrast, memories retrieved from an observer perspective included a greater number of details related to external aspects of the events (i.e., statements about the subject's personal appearance, the actions performed and the spatial relations among the objects). These findings are consistent with research demonstrating that adopting an own eyes compared to an observer perspective leads to a more detailed account of emotions associated with memory retrieval (Berntsen & Rubin, 2006; D'Argembeau, Comblain, & Van der Linden, 2003; Holmes, Coughtrey, & Connor, 2008; Nigro & Neisser, 1983; Sutin & Robins, 2010; Talarico, LaBar, & Rubin, 2004; Vella & Moulds, 2014). Other research has suggested that adopting an own eyes perspective leads to greater focus during memory retrieval on the concrete aspects of events, whereas the observer perspective involves greater attention to more abstract features (Libby & Eibach, 2011).

Shifting visual perspective during retrieval, by changing from a preferred or dominant perspective to an alternative perspective typically not experienced during encoding, also affects the phenomenological characteristics of memory retrieval. For example, Robinson and Swanson (1993) asked participants to classify a series of autobiographical events as either own eyes or observer memories, to rate their original as well as their current emotional intensity, and then to recall them again two weeks later from either the original perspective or from the alternative vantage point. Their findings revealed that shifting perspective from an own eyes to an observer perspective yielded a significant decrease in reported affect, whereas shifting in the opposite direction, from an observer to an own eyes vantage point, did not increase emotional intensity ratings (also see Berntsen & Rubin, 2006; Vella & Moulds, 2014). Additionally, shifting from an own eyes to an observer perspective can sometimes reduce the vividness of memory recall (Butler, Rice, Wooldridge, & Rubin, 2016; Rice & Rubin, 2009; Vella & Moulds, 2014).

These changes are not limited to immediate recall; a handful of studies have also demonstrated that the effects of actively shifting visual perspective during retrieval can also persist in the phenomenological experience of subsequent memories. For example, Sekiguchi and Nonaka (2014) asked participants to shift from an own eyes to an observer perspective and found a reduction in subjective reports of emotional intensity during memory retrieval that persisted in memories retrieved one month later. Butler and colleagues (2016) examined how repeatedly shifting visual perspective during retrieval of mini-events and recent autobiographical memories over several weeks influenced subjective ratings of memories when compared to initial ratings. They found that repeatedly retrieving memories from an observer vantage point reduced the subjective sense of vividness and recollection associated with memories. Moreover, changes in memories due to repeatedly shifting to an observer perspective persisted even when participants were later asked to shift back to an own eyes perspective. Butler and colleagues (2016) suggested that there was a loss of visual information in memories when repeatedly shifting to an observer perspective during memory retrieval. Similarly, St. Jacques, Szpunar, and Schacter (2017) asked participants to repeatedly shift from a dominant own eyes to an observer perspective during retrieval of autobiographical memories. After actively shifting visual perspective during retrieval, they found that memories initially experienced from a dominant own eyes perspective were more likely to be more spontaneously retrieved later from an observer perspective, when compared to dominant own eyes memories in which the same visual perspective was maintained during retrieval or to baseline memories that had not been previously retrieved. Critically, St. Jacques et al. (2017) also linked these subsequent memory changes in visual perspective to online behavioural and neural changes when participants were instructed to actively shift perspective during memory retrieval.

Taken together the evidence presented here suggests that shifting visual perspective during retrieval can modify the phenomenology of subsequent memories. What has yet to be determined is whether actively shifting visual perspective during retrieval also influences the accuracy of subsequent memories. If shifting perspective during retrieval reduces the amount of visual information in memories, then adopting an alternative vantage point could also decrease the number of accurate details one remembers about the original event (also see Sutin & Robins, 2008). Previous research, however, has found mixed findings regarding the influence of actively shifting visual perspective on memory accuracy. On the one hand, some research has suggested that adopting an alternative visual perspective benefits accurate memory recall. For example, the classic burglar and homebuyer perspective study by Anderson and Pichert (1978) demonstrated that adopting another individual’s perspective (i.e., a homebuyer if you originally adopted a burglar perspective) contributed to the recall of additional memory details, which boosted overall memory accuracy. The potential beneficial effect of adopting an alternative perspective on accurate memory recall is also evident in the *change in perspective* mnemonic included in the cognitive interview, a technique developed to help law enforcement officials increase the total amount of correct information in eyewitness statements in which people are typically instructed to adopt the alternative perspective of another individual in the memory (Geiselman et al., 1984). On the other hand, other research suggests that shifting visual perspective can have a detrimental effect on accurate memory recall. The change in perspective mnemonic in the cognitive interview has not consistently been shown to improve memory accuracy (Boon & Noon, 1994), and some researchers have suggested it could even increase errors and other distortions in memories (Bekerian & Dennett, 1993; Memon, 1999). This research, however, has mainly focused on how taking another individual's perspective (i.e., theory of mind), rather than how shifting one's egocentric (i.e., self-centred) perspective, influences memory accuracy. Bagri and Jones (2009), instead, directly investigated the effect of visual perspective on memory recall for written passages, and found that retrieval from an own eyes compared to an observer perspective led to greater memory accuracy. However, this and other studies have not examined the long-term effects of shifting visual perspective on subsequent memory accuracy.

Only one study, to our knowledge, has examined how visual perspective during retrieval influences subsequent memory accuracy. St. Jacques and Schacter (2013; Experiment 2) asked participants to recall memories for a guided museum tour that were cued using photos in which the visual perspective was the same as encoding (i.e., photo taken from the participant's perspective during the tour) or showed an alternative perspective (i.e., photo taken from a different angle than the participant's perspective during the tour). On a subsequent recognition memory test, a couple of days later, they found that memories for tour events that were cued using photos from the same visual perspective as encoding were more accurately recognized. However, participants were not explicitly instructed to shift visual perspective in this study. Thus, it is unclear whether the reported difference in subsequent memory accuracy was due to differences in the visual perspective of memories during retrieval or due to differences in the effectiveness of the altered photo cue to reactivate memories (i.e., encoding specificity; Tulving & Thomson, 1973).

The aim of the current study was to directly examine how actively shifting visual perspective during memory retrieval influences the accuracy of subsequent memory recall for complex and realistic events, and whether potential differences in subsequent memory accuracy due to perspective shifting are related to the effectiveness of retrieval cues to elicit memories. We developed a mini-events paradigm in which participants were asked to perform a series of tasks created in the laboratory, which consisted of hands-on and actively engaging tasks replete of physical actions, sensorial elements and visual details. About a week later, they were exposed to a perspective manipulation during memory retrieval, whereby participants were asked to mentally reinstate some of the mini-events from an own eyes perspective and others from an observer perspective, thus maintaining or shifting their visual perspective, respectively. Two days later in session 3, memory accuracy was tested using a series of short-answer questions about different elements of memory specific to the mini-tasks. On the basis of the research reviewed above, we hypothesised that visual perspective during memory retrieval would influence the accuracy of subsequent memories. Specifically, we predicted that shifting perspective, by retrieving memories originally encoded from an own eyes perspective, would reduce the accuracy of subsequent memories. Further, given previous findings demonstrating how adopting different visual perspectives differentially affects recall of memory details (Bagri & Jones, 2009; Eich et al., 2009;

McIsaac & Eich, 2002), we also predicted to find differences in accurate recall of internal and external memory details specific to the mini-tasks. Maintaining the same encoding own eyes perspective should be related with a higher proportion of the internal aspects of the memory (i.e., sensorial details), whereas adopting an alternative vantage point should facilitate recall of the more concrete aspects of the memory such as physical actions performed and spatial relations among objects (as well visual details and temporal order of actions). Two experiments were included to test these predictions.

Experiment 1

In this experiment, we used photos of the events taken from own eyes and observer perspectives as cues to retrieve memories for events from a non-shifted (i.e., own eyes) and shifted (i.e., observer) perspective, respectively. Previous studies have suggested that shifting to an observer perspective is more difficult than maintaining an own eyes perspective (e.g., Eich et al., 2009). One reason for this may be that any one of a number of observer perspectives can be adopted (e.g., Rice & Rubin, 2011). We reasoned that including photos taken from the particular perspective being manipulated would potentially decrease differences in difficulty between the conditions by providing the exact viewpoint participants were instructed to adopt.

Method

Participants

Twenty fluent English speakers were included in the experiment [16 women; mean age in years (*M*) = 21.65, *SD* = 2.70; mean years of education (*M*) = 16.55, *SD* = 1.79]. They reported no history of psychiatric and/or mental health impairments, were not taking any medication that could affect cognitive function, and had normal or corrected to normal vision/hearing. They provided written informed consent for a protocol approved by the School of Psychology at the University of Sussex.

Procedure

The study involved three separate study sessions. In session 1, participants performed 24 mini-events lasting two minutes each. The mini-events consisted of a series of hands-on, unique and actively engaging tasks with small objects (e.g. shaping play dough to create a beach scene; for list of events see Appendix A). Critically, the mini-events were created to be replete of physical actions (e.g., using pliers to operate a shredder, using tweezers to remove miniature shoes from boxes, using a whisk to mix paint ingredients, etc.), visual details (i.e. objects' colour, shape, pattern), and sensorial details (e.g., smell of honey of shoe polish, clanking noise of watering can, feeling of rubbery gel frogs, etc.). To ensure that the sensorial detail was sufficiently prominent, smells and fragrances were added immediately prior to the start of session 1 to those objects that did not already possess a natural smell (e.g., bubble gum soap to sponges). The order of the mini-events performed was randomly assigned across participants.

During session 1, objects comprising each mini-event were presented on separate trays along with the unique title of each task (e.g., Polish the Shoes; see Figure 2.1). Participants were instructed to look carefully at the titles for each mini-event, and attend to the physical actions and physical sensations they experienced. Participants were guided through the actions of each mini task by the experimenter, who read the titles and instructions of each mini-task once to familiarize the participant with the mini-event and then a second time while the participant followed along by completing the steps as instructed (see Appendix A for example of descriptions). An example mini-event was presented first in order to familiarize participants with the procedures. The experimenter timed each mini-event and prompted participants to keep the right pace so that each lasted approximately two minutes.

In session 2, approximately one week later [mean delay (*M*) = 6.6, *SD* = .99], participants were presented with titles and photos of the mini-event and asked to retrieve memories while adopting either the own eyes or observer perspective depicted in the photos. Specifically, participants were instructed: "If the perspective is own eyes, mentally reinstate your memory for the event as if seeing it again through your own eyes. If the perspective is observer, mentally reinstate your memory for the event as if viewing it from the perspective of a spectator or observer, watching yourself in the remembered event." Thus, in the non-shifted perspective condition, memories were retrieved from the same own eyes perspective that memories were encoded from, whereas in the shifted perspective condition memories were retrieved from an alternative visual perspective from encoding. A digital camera was used to photograph each mini-event from both an own eyes perspective (taken from the viewpoint of the participant) and an observer perspective (photo taken from the perspective of someone sitting across from the participant; see Figure 2.1). Each photo depicted the mini-event as it would have appeared to participants at the start of testing in session 1, and participants were instructed to recall the task they had conducted in as much detail as possible.

Eight mini-events were retrieved in each of the shifted and non-shifted conditions. Participants were given 7.5 s to retrieve each memory and each mini-event was repeated four times in an interleaved fashion. Immediately following each retrieval trial, participants were given 2.5 s each to rate on 5-point scales (1=low to 5=high) how consistently they could maintain the indicated perspective and how vivid their memory was. The timing of the task was based on previous studies that examined retrieval and manipulation of memories for complex events (Szpunar, St Jacques, Robbins, Wig, & Schacter, 2014; St. Jacques, Szpunar,

& Schacter, 2017), and we conducted further pilot testing to ensure that participants had sufficient time for memory retrieval. Sixteen mini-events were retrieved during session 2, and the remaining 8 mini-events were used in a baseline condition to assess potential changes in memory due to delay.

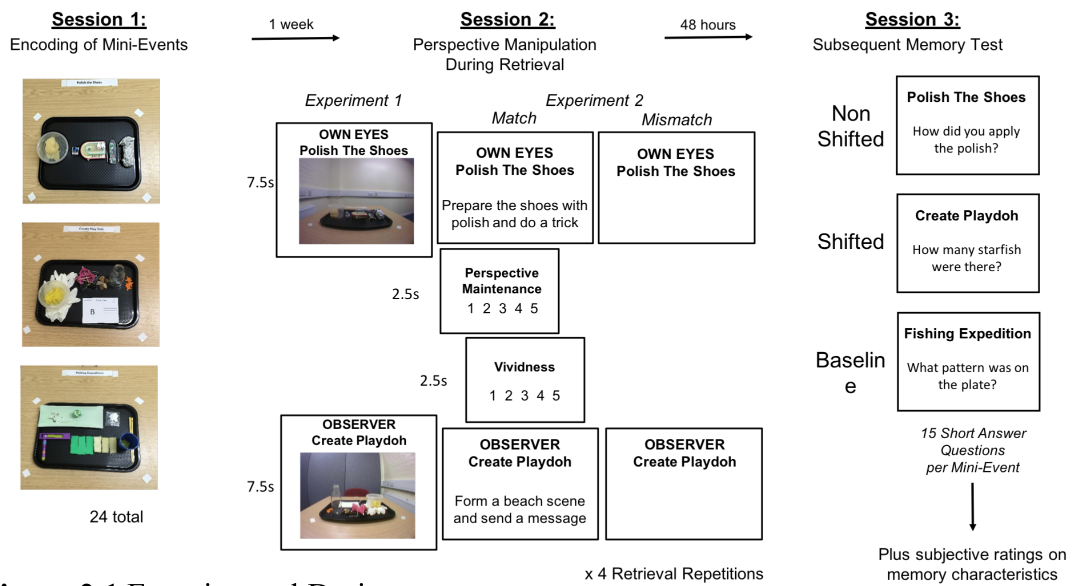

Figure 2.1 Experimental Design

The study took place in three separate sessions. In Session 1, participant completed a series of hands on mini-tasks. In Session 2, they were asked to retrieve some of the mini-events from an own eyes (non-shifted condition) and some from an observer perspective (shifted condition). In Experiment 1, they were given photographs of the mini-events taken from the two different perspectives; in Experiment 2 they were either presented with a description of the mini-event (match group) or with no retrieval cue (mismatch group). In both experiments, participants were then asked to rate their ability to maintain the given perspective and the degree of vividness of each retrieved mini-event. In Session 3, memory accuracy was tested using a series of short-answer questions about each of the mini-events followed by subjective ratings on characteristics of memory retrieval.

In session 3, two days later, memory accuracy for the mini-events was assessed using a cued-recall memory test. Participants were presented with the titles of all 24 mini-events and asked a series of 15 short-answer comprehensive questions about the mini-event related to the physical actions they conducted (e.g., *How did you add the powder to the bottle?* Answer: *with a funnel*), physical sensations (e.g., *What did the container smell like?* Answer: coffee), visual details (e.g., *What colour was the present?* Answer: Red), temporal order of the actions to complete the task (e.g., *When did you seal the box?* Answer: last action), and spatial relations of objects with respect to one another and to one's self (e.g., *Where was the box with respect to where you were sitting?* Answer: centre). Participants were instructed to provide a correct response by typing short answers and to try as best as possible to answer all questions (or to leave it blank if the answer could not be recalled). The average proportion of correct responses on the short-answer questions for each mini-event was then calculated and averaged across trials in each perspective condition. The order of presentation of the mini-events was randomized across participants, and the order of questions asked within each mini-event was also randomized. Following the short-answer questions for each mini-event, participants were asked to provide subjective ratings on a 7-point scale (1=low to 7=high) on the following characteristics: sense of reliving, emotional intensity, the visual perspective from which they remembered the event (separately for own eyes and observer), the degree of visual details, the degree to which their memories involved recall of physical sensations (sound, touch, smell), and physical actions, the clarity of temporal order of actions and spatial arrangements of objects, and how accurate they felt their memory was (i.e., recalling all the details of the event exactly as they occurred). Both the cued-recall and subjective rating tasks were self-paced.

Correct responses to the short-answer questions were coded by the experimenter. We used a conservative approach,[1] whereby a response was coded as correct only if precisely matched the mini-event in question (e.g., *How did you mix the ingredients?* Correct Answer: *With a whisk*, Incorrect Answer: *By stirring*). The total number of correct responses within each detail category for each perspective conditions was summed, and the proportion of correct responses was calculated separately for each participant.

Results

Subjective Ratings

Session 2. To determine potential differences in the subjective ratings made during retrieval in session 2, we conducted paired t-tests between the perspective conditions separately on perspective maintenance and vividness ratings (for means and SD see Table 2.1). There was a significant difference in perspective maintenance between the non-shifted and shifted perspective conditions, t (19) = 4.43, p < .001, d = .99. There was also a significant difference in vividness between the non-shifted, and shifted perspective conditions, t (19) = 2.73, p = .01, d = .61. Thus, despite using photo cues depicting the perspective to be adopted, participants still found it more difficult to maintain the shifted perspective than the non-shifted perspective during memory retrieval, which was also less vivid.

Table 2.1. Means (with standard deviations) for subjective ratings in session 2 perspective manipulation of experiment 1 and 2

	Experiment 1		**Experiment 2**			
			Match		*Mismatch*	
Subjective Rating	*NS*	*S*	*NS*	*S*	*NS*	*S*
Perspective Maintenance	4.01	3.32	3.62	2.89	3.81	2.78
	(0.49)	(0.71)	(0.66)	(0.53)	(0.72)	(0.54)
Vividness	3.91	3.54	3.4	2.97	3.54	3.03
	(0.47)	(0.70)	(0.56)	(0.45)	(0.64)	(0.54)

Note: (NS) = non-shifted condition; (S) = shifted condition

Session 3. Separate repeated measures ANOVAs on the non-shifted, shifted and baseline conditions were conducted on subjective ratings (for means and SD see Table 2.2). There was a main effect of condition on own eyes ratings, F (2, 38) = 3.41, p = .043, partial η^2 = .15. Follow-up analysis indicated that own eyes ratings were higher in the non-shifted compared to the baseline condition, p = .038, which may reflect maintenance of the own eyes perspective as the result of repeated memory retrieval (Butler et al., 2016). There was also a main effect of condition on spatial ratings, F (2, 38) = 6.18, p = .005, partial η^2 = .25, which was reflected by higher ratings compared to baseline in both the non-shifted, $p = .031$, and shifted conditions, $p = .003$. Thus, repeated retrieval of memories while adopting a particular perspective influenced some of the phenomenology of subsequent memories, but there were no differences between the shifted and non-shifted perspective conditions.

Table 2.2. Means (with standard deviations) for subjective ratings in session 3 of experiment 1 and 2.

	Experiment 1			**Experiment 2**					
				Match			*Mismatch*		
Subjective Rating	*NS*	*S*	*BA*	*NS*	*S*	*BA*	*NS*	*S*	*BA*
Reliving	4.18	4.17	4.05	3.92	3.87	3.66	3.85	3.83	3.67
	(1.29)	(1.51)	(1.37)	(0.98)	(0.86)	(0.96)	(1.02)	(1.06)	(1.15)
Emotional intensity	3.05	2.99	2.72	2.78	2.79	2.57	2.58	2.51	2.59
	(1.19)	(1.46)	(1.18)	(1.35)	(1.19)	(1.11)	(1.33)	(1.18)	(1.38)
Own Eyes ratings	5.13	5.08	4.83	5.08	5.13	4.95	4.75	4.83	4.89
	(1.31)	(1.53)	(1.44)	(1.28)	(1.21)	(1.28)	(1.01)	(1.15)	(1.07)
Observer ratings	2.14	2.21	1.98	2.04	2.09	2.08	2.22	2.39	2.35
	(0.93)	(0.96)	(0.82)	(0.91)	(0.86)	(0.91)	(0.94)	(1.02)	(1.03)
Visual	4.31	4.26	3.98	4.09	4.01	4.04	3.85	3.92	3.99
	(1.43)	(1.37)	(1.21)	(0.87)	(0.97)	(0.92)	(0.73)	(0.72)	(0.88)
Sensation	3.78	3.89	3.7	3.69	3.63	3.49	3.4	3.49	3.39
	(1.15)	(1.16)	(1.21)	(1.02)	(0.82)	(0.87)	(1.07)	(1.22)	(1.21)
Actions	4.69	4.65	4.43	4.47	4.44	4.41	4.46	4.47	4.47
	(1.33)	(1.31)	(1.34)	(1.04)	(0.94)	(0.91)	(1.06)	(1.16)	(1.17)
Temporal order	3.56	3.63	3.29	3.31	3.29	3.32	3.56	3.6	3.53
	(1.23)	(1.22)	(1.01)	(0.82)	(0.74)	(0.68)	(0.75)	(0.92)	(1.00)
Spatial arrangements	3.91	3.94	3.56	3.52	3.49	3.38	3.63	3.6	3.77
	(1.20)	(1.27)	(1.02)	(1.22)	(1.16)	(1.11)	(1.13)	(1.18)	(1.26)
Accuracy	3.55	3.61	3.27	3.28	3.18	3.16	3.24	3.28	3.4
	(1.25)	(1.26)	(1.12)	(0.92)	(0.97)	(0.83)	(1.06)	(1.16)	(1.18)

Note: (NS) = non-shifted condition; (S) = shifted condition; (BA) = baseline

Subsequent Memory Accuracy

To examine differences in subsequent memory accuracy due to shifting perspective during memory retrieval we conducted a 5 (category detail: physical actions, sensorial details, visual details, temporal order of actions, spatial arrangements of objects) X 3 (study condition: shifted, non-shifted, baseline) repeated measures ANOVA on the proportion of correct items recalled in the short-answer question. We found a main effect of condition, *F*

(2, 38) = 16.04, $p < .0001$, partial $\eta^2 = .46$. Follow-up analyses indicated that subsequent memory accuracy was greater in the non-shifted compared to both the shifted perspective, and baseline conditions (see Figure 2.2A; for means and SD see Table 2.3). Thus, there was a large effect of perspective shifting during retrieval on subsequent accuracy of memories.

Table 2.3. Means proportion correct (with standard deviations) of memory accuracy of experiment 1 and 2 (collapsed across category details).

Experiment 1			Experiment 2					
			Match			*Mismatch*		
NS	*S*	*BA*	*NS*	*S*	*BA*	*NS*	*S*	*BA*
0.45	0.40	0.37	0.39	0.35	0.37	0.41	0.39	0.39
(0.13)	(0.12)	(0.12)	(0.13)	(0.13)	(0.16)	(0.14)	(0.13)	(0.11)

Note: (NS) = non-shifted condition; (S) = shifted condition; (BA) = baseline

There was also a main effect of category detail, F (4, 76) = 42.24, $p < .0001$, partial $\eta^2 = .69$. Follow-up tests revealed that memory accuracy was greater for physical actions and spatial arrangement of objects than for sensorial details, visual details, and temporal order of actions (for means and SD see Table 2.4). However, the interaction between study condition and category details was not significant. This suggests that, regardless of retrieval condition, the more objective memory details were better remembered compared to the more internal aspects of memory (i.e., sensorial details).

Table 2.4. Means proportion correct (with standard deviations) of category details memory accuracy of experiment 1 and 2.

	Experiment 1			**Experiment 2**					
				Match			*Mismatch*		
Category Detail	*NS*	*S*	*BA*	*NS*	*S*	*BA*	*NS*	*S*	*BA*
Physical actions	0.54	0.48	0.48	0.44	0.45	0.46	0.50	0.45	0.52
	(0.19)	(0.17)	(0.15)	(0.17)	(0.21)	(0.24)	(0.20)	(0.20)	(0.16)
Physical sensations	0.35	0.32	0.28	0.31	0.31	0.30	0.34	0.30	0.31
	(0.16)	(0.15)	(0.12)	(0.15)	(0.14)	(0.16)	(0.15)	(0.12)	(0.13)
Visual details	0.41	0.34	0.30	0.31	0.25	0.31	0.35	0.36	0.38
	(0.12)	(0.14)	(0.12)	(0.13)	(0.13)	(0.17)	(0.14)	(0.12)	(0.10)
Temporal order of actions	0.36	0.33	0.32	0.35	0.26	0.30	0.31	0.30	0.27
	(0.13)	(0.14)	(0.14)	(0.11)	(0.13)	(0.13)	(0.11)	(0.14)	(0.12)
Spatial relations of objects	0.57	0.51	0.46	0.52	0.48	0.47	0.53	0.53	0.47
	(0.18)	(0.18)	(0.19)	(0.20)	(0.18)	(0.19)	(0.22)	(0.19)	(0.20)

Note: (NS) = non-shifted condition; (S) = shifted condition; (BA) = baseline

Experiment 2

One reason why shifting visual perspective during memory retrieval may reduce subsequent memory accuracy is because retrieving memories from an observer perspective reflects less encoding specificity (i.e., the match between the retrieval cues and encoding; St. Jacques & Schacter, 2013; Tulving & Thomson, 1973). To account for the influence of encoding specificity effects, in Experiment 2 we varied the effectiveness of the retrieval cue to elicit memories. One group was presented with the title and description of the mini-event (match group), and the other group was presented with the title only (mismatch group). We reasoned that if potential differences between the non-shifted and shifted perspective conditions were due to encoding specificity then increasing the match of the retrieval cue between encoding and retrieval should also increase the difference between the perspective conditions when compared to the mismatch group (i.e., an interaction).

Method

Participants

Thirty-eight fluent English speakers were included in the experiment [33 women; mean age in years (*M*) = 21.89, *SD* = 3.02; mean years of education (*M*) = 16.45, *SD* = 1.35]. They reported no history of psychiatric and/or mental health impairments, were not taking any medication that could affect cognitive function, had normal or corrected to normal vision/hearing, and had not previously participated in Experiment 1. They provided written informed consent for a protocol approved by the School of Psychology at the University of Sussex.

Procedure

The study procedure was identical to Experiment 1, except that photos were not used as retrieval cues in session 2. To manipulate encoding specificity, we included two retrieval groups that varied in the match or mismatch of the retrieval cue used to elicit memories. The match group was provided with both the mini-event title and a brief description of the event that was identical to the one heard during memory encoding. In contrast, the mismatch group was provided with the title only.

Results

Subjective Ratings

Session 2. To determine potential differences in the subjective ratings made during retrieval in session 2 we conducted two separate repeated measures ANOVAs on perspective maintenance and vividness ratings, with perspective condition (non-shifted, shifted) as the within-subjects measure and retrieval group (match, mismatch) as the between-subjects factor, and Bonferroni's correction was used in the post-hoc analyses (for means and SD see Table 2.1).

The ANOVA on perspective maintenance rating revealed a significant main effect of perspective condition, F (1, 36) = 62.52, p <.001, partial η^2 = .64, reflecting greater ease in maintaining the indicated perspective in the non-shifted perspective (M = 3.72, SD = .69) compared to the shifted perspective condition (M = 2.84, SD = .53). Similarly, the ANOVA on vividness also showed a main effect perspective condition, F (1, 36) = 37.81, p <.001, partial η^2 = .51, reflecting greater ease in maintaining the indicated perspective in the non-shifted perspective (M = 3.47, SD = .59) compared to the shifted perspective condition (M = 3.00, SD = .49). There were no main effects of retrieval group or perspective condition by retrieval group interactions in either ANOVA. Consistent with the findings of Experiment 1, it was more difficult to maintain a shifted than non-shifted perspective during memory retrieval and these memories were also retrieved less vividly.

Session 3. A series of repeated measures ANOVAs were conducted on subjective ratings made in session 3 with condition (non-shifted, shifted, baseline) as a within-subjects factor and retrieval group as a between subjects factor (for means and SD see Table 2.2). There were no significant main effects or interactions. Thus, shifting perspective during retrieval did not influence the phenomenology of subsequent memories.

Subsequent Memory Accuracy

To examine differences in subsequent memory accuracy due to shifting perspective during memory retrieval, we conducted a 5 (category detail: physical actions, sensorial details, visual details, temporal order of actions, spatial arrangements of objects) x 3 (perspective condition: non-shifted, shifted, baseline) x 2 (retrieval group: match, mismatch) ANOVA on the average proportion of accurate responses. Perspective condition and category details were the within-subjects factors and retrieval group was a between-participants factor.

Bonferroni's correction was used to test post-hoc analyses. The ANOVA on memory accuracy revealed that there was no main effect of retrieval group, and no interaction between retrieval group and perspective condition nor with category details. As in Experiment 1, there was a main effect of category detail, F (4, 144) = 64.94, p < .0001, partial η^2 = .64. Follow-up tests revealed that memory accuracy was greater for physical actions and spatial arrangement of objects than for sensorial details, visual details, and temporal order of actions (for means and SD see Table 2.4). However, the main effect of perspective condition did not reach significance, F (2, 72) = 2.59, p = .082, partial η^2 = .07. Further inspection of the data revealed that the non-significant effect of condition was primarily due to the lack of difference from baseline in the two perspective conditions.

Given that our main interest in Experiment 2 was how visual perspective during retrieval influenced the two experimental conditions, we conducted an additional repeated measures ANOVA that excluded the baseline condition. These results showed a significant main effect of perspective condition, F (1, 36) = 7.16, p = .011, partial η^2 = .17. Inspection of the means revealed a greater proportion of correct responses in the non-shifted (M = .40, SD = .13) compared to the shifted perspective conditions (M = .37, SD = .13, see Figure 2.1B; for means and SD see Table 2.3). Thus, as in Experiment 1, we found that shifting perspective during retrieval reduced subsequent memory accuracy compared to maintaining the same visual perspective as memory encoding. Further, the main effect of category detail was also significant, F (4, 144) = 54.05, p < .0001, partial η^2 = .60, with greater accuracy for physical actions and spatial relations of objects compared to all other category details. As before, we found no main effect of retrieval group, nor an interaction between retrieval group and perspective condition. However, there was a three-way interaction between retrieval group, category details and perspective condition, F (4, 144) = 2.82, p = .027, partial η^2 = .07. This was explained by less accurate recall of temporal order (p = .001) and visual details (p = .01) in the match group in the shifted compared to the non-shifted retrieval condition. Additionally, in the shifted condition, participants in the match group also had less accurate recall of visual details when compared to the mismatch group, $p = .01$.

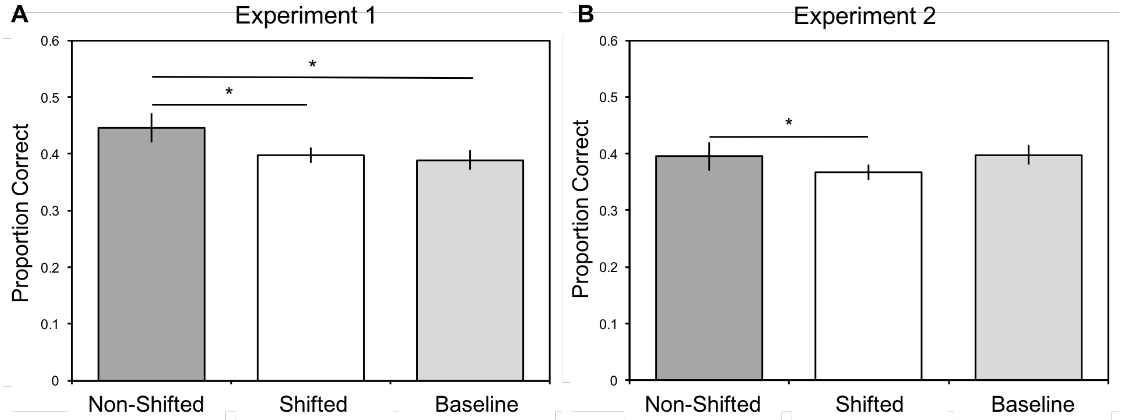

Figure 2.2 Subsequent memory accuracy.

(A) In Experiment 1, shifting perspective during retrieval reduced accuracy for subsequent memories when compared to the non-shifted perspective and baseline conditions. (B) In Experiment 2, both the match and mismatch groups showed a decrease in memory accuracy following a shift in perspective. Error bars reflect within-subject standard error.

Experiment 1 and 2

The findings from Experiment 2 replicated those from Experiment 1. One limitation of Experiment 2, however, was that there was no difference in vividness ratings in session 2 between the two retrieval groups suggesting that our manipulation of encoding-retrieval match of the retrieval cues may have been less effective than expected. Looking across the two experiments, use of the photo retrieval cues in Experiment 1, however, did result in overall higher vividness ratings during retrieval in session 2 when compared to Experiment 2, t (56) = 3.60, $p = .001$, $d = .99$. Thus, to better understand the potential influence of encoding specificity due to visual perspective, we conducted an additional repeated measures ANOVA on subsequent memory accuracy on the shifted, non-shifted and baseline conditions, with experiment as a between-subjects factor and perspective condition as within-subjects factor (category details were not included as a factor given that the differences between perspective conditions only emerged when baseline was removed from the analysis – see above). There was no main effect of experiment, F (1, 56) = .44, p = .51, partial η^2 = .01. As expected, however, these results revealed a main effect of perspective condition, F (2, 112) = 13.44, $p <$ .0001, partial η^2 = .19, reflecting greater memory accuracy in the non-shifted than shifted perspective conditions, and the non-shifted and baseline conditions, both p's < .0001. However, the main effect of condition was qualified by a significant interaction with experiment, F (2, 112) = 5.43, p = .006, partial η^2 = .09. Post-hoc analyses revealed that subsequent memory accuracy was greater in the non-shifted than shifted perspective conditions in both Experiment 1, p = .002, and Experiment 2, p = .021.[2] In Experiment 1 memory accuracy was also greater in the non-shifted condition compared to baseline, $p <$ .0001. In contrast, in Experiment 2 there was no difference in the non-shifted condition compared to baseline. Thus, the greater encoding-retrieval match of cues used in Experiment 1 versus 2, did not influence the overall size of the difference in memory accuracy between the non-shifted and shifted perspective condition; however, it did impact whether the non-shifted retrieval condition differed from baseline.

When examining the effects across the two experiments, we also found that differences in subsequent memory accuracy in the retrieval conditions (i.e., difference in the non-shifted minus shifted conditions) due to perspective shifting were predicted by differences in subjective ratings made in session 2. A partial correlation controlling for the two experiments, revealed a significant relationship between differences in subsequent memory accuracy and differences in subjective ratings of vividness in the non-shifted versus shifted perspective conditions, r = .43, p = .001 (see Figure 2.3A). In contrast, subsequent memory accuracy was not related to differences in perspective maintenance ratings in session 2, r = .05, p = .72 (see Figure 2.3B). We conducted a multiple linear regression analysis to determine whether the difference in vividness ratings between the perspective conditions uniquely predicted differences in subsequent memory accuracy when including differences in perspective maintenance as an additional predictor. Although the ratings were correlated, r = .47, p < .001, collinearity assumptions were not violated, *VIF* = 1.29, *tolerance* = .78. A significant regression equation was found, F (2, 57) = 6.83, p = .002, R^2 = .20. The analysis showed that differences in perspective maintenance did not predict differences in subsequent memory accuracy, *Beta* = -.21, t (54) = -1.55, p = .13, however, differences in vividness did uniquely predict differences in subsequent memory accuracy, *Beta* = .51, t (54) = 3.69, p = .001. Thus, differences in the vividness of memory retrieval during perspective shifting in session 2, but not perspective maintenance, predicted subsequent changes in memory accuracy.

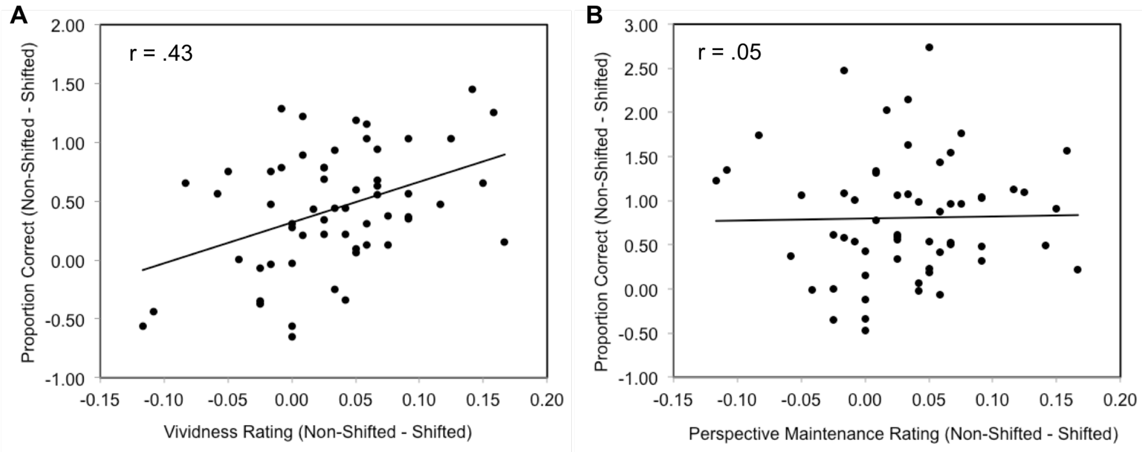

Figure 2.3 Correlation between subsequent memory accuracy and subjective ratings. (A) There was a positive relationship between differences in subsequent memory accuracy and differences in vividness ratings made in session 2 in the non-shifted and shifted perspective conditions. (B) There was no relationship between differences in subsequent memory accuracy and differences in perspective maintenance ratings made in session 2 in the non-shifted and shifted perspective conditions.

General Discussion

The influence of visual perspective during memory retrieval is not just limited to the subjective experience associated with the original event, but can reconstruct memories during their retrieval and lead to long-term changes in how memories are later remembered. The current study shows that actively shifting visual perspective not only affects the phenomenological characteristics, but also influences the accuracy with which we remember the past. Across two experiments, we found that shifting from a dominant own eyes to an alternative observer perspective during retrieval impaired subsequent memory accuracy for events encoded in the lab when compared to maintaining an own eyes perspective during retrieval or baseline changes in memories due to time alone. Moreover, our results suggest that the differences in the difficulty of maintaining a shifted perspective or encoding specificity does not explain the differences in subsequent memory accuracy. Instead, we show that differences in the vividness of memory retrieval predicted subsequent reductions in memory accuracy due to perspective shifting.

Our findings contribute to the growing literature on the role of visual perspective in modifying long-term memories for events. Visual perspective alters how memories are retrieved online (for a review see Rice, 2010), and these changes can persist in the phenomenology of later memories (Butler et al., 2016; Sekiguchi & Nonaka, 2014; St. Jacques et al., 2017). In the current study we show that shifting visual perspective during retrieval also influences the accurate recall of subsequent memories for complex events that were performed in the lab. We further showed that differences in accuracy were linked to reductions in the level of vividness during memory retrieval. We did not find that shifting versus maintaining the same visual perspective as encoding modified the phenomenology of subsequent memories (e.g., participants subjective report of visual perspective during session 3 ratings showed that memories were still experienced from an own eyes vantage point, regardless of whether they shifted visual perspective or not during retrieval), as has sometimes been shown (Butler et al., 2016; Sekiguchi & Nonaka, 2014; St. Jacques et al., 2017). One reason may be due to retrieving memories encoded in the lab versus autobiographical memories. Controlled encoding of complex events, either in the lab or the real-world, is generally preferable over eliciting personal memories when memory accuracy must be verified (for a review see Cabeza & St Jacques, 2007). However, direct comparisons between the two types of memories can involve differences in the characteristics of memories, such as the recency of events, their emotional intensity, and baseline perspective, which could affect how visual perspective influences memory (Butler et al., 2016). The memories used here were not particularly emotional and were less than two weeks old, which could make them less prone to persistent changes in the phenomenology of memories (also see Grol, Vingerhoets, & De Raedt, 2017). Another possibility is the way the mini-events were encoded in the lab versus in more naturalistic environments. All of the mini-tasks were 'static,' because they were performed while sitting in the same location and involved minimal body movement throughout the session. By contrast, real-world memories are typically never encoded from one single viewpoint, rather within perceptually-rich and diverse environments. This suggests that shifting perspective may have a stronger impact when visual perspective plays a larger role in memory. Despite the lack of subsequent differences in the visual perspective experienced, this study shows that shifting visual perspective during retrieval still influenced the amount of details one later remembered of memories encoded in the lab.

Several studies have shown that shifting perspective from an own eyes to an observer perspective reduces online ratings of subjective vividness during memory retrieval (Butler et al., 2016; Rice & Rubin, 2009; Vella & Moulds, 2014). Here we also found that shifting visual perspective reduced subjective ratings of vividness during memory retrieval. Moreover, our results revealed that differences in the vividness of memory retrieval between the shifted and non-shifted perspective conditions also predicted later reductions in the accuracy of memories. In the current study, retrieval of memories from an observer perspective may have been less vivid because they were not encoded from this perspective in the lab, and thus there was less visual information available from this novel perspective during memory retrieval (e.g., Butler et al., 2016). These findings are in line with evidence that the availability of visual information supports memory retrieval from an own eyes perspective (Rubin, Burt, & Fifield, 2003), and that verbatim rehearsal of memories in the same way they were originally experienced can also protect memories from changes in vividness over time (Butler et al., 2016; also see Campbell, Nadel, Duke, & Ryan, 2011; Svoboda & Levine, 2009). Recently, Butler et al. (2016) found that the preservation of the amount of visual information, measured with subjective ratings, due to repeated retrieval also prevented memories from naturally transforming from an own eyes to an observer perspective over time - particularly when memories were repeatedly retrieved from an own eyes versus an observer perspective. They additionally reported that visual information was not recovered even when eventually asked to shift back to an own eyes perspective, in a final retrieval attempt. A similar effect may have occurred in the current study. In other words, rehearsing memories from an observer perspective may not only have reduced vividness ratings during retrieval, but could have also decreased the availability of visual information during subsequent retrieval. Our findings show for the first time that changes in vividness due to shifting perspective during retrieval also contributes to reductions in the accuracy of subsequent memory recall. These and other findings suggest that shifting from an own eyes to an observer perspective during retrieval potentially contributes to more permanent changes in memories (see also Berntsen & Rubin, 2006).

A number of lines of evidence have shown that retrieval is an active process that can update memories (Anderson, Bjork, & Bjork, 2000; Bjork, 1975; Hupbach, Gomez, Hardt, & Nadel, 2007; Marsh, 2007; Roediger & Butler, 2011). Theories of memory reconsolidation propose that reactivating a stable memory can render it susceptible to modification (Hardt, Einarsson, & Nader, 2010; Nadel, Hupbach, Gomez, & Newman-Smith, 2012; Winocur &

Moscovitch, 2011). Our findings contribute to theoretical understanding of retrieval-related changes in memories by showing that visual perspective is a key property that can reshape long-term memories for events by altering the vividness of memory retrieval.

Recalling memories from a shifted perspective likely requires re-organising the mental images that arise during memory retrieval from a new perspective, thereby involving greater reconstruction of memories. Previous research has shown that the intensity or quality with which long-term memories are reactivated modulates the accurate recall of later memories (St. Jacques, Montgomery, & Schacter, 2015; St Jacques, Olm, & Schacter, 2013; St. Jacques & Schacter, 2013). For example, St Jacques and Schacter (2013; Experiment 2) found that differences in reliving during retrieval of memories cued in shifted or non-shifted perspective conditions contributed to differences in subsequent memory effects. In the current study we also found that the influence of retrieval on subsequent memory is attenuated when retrieval cues were less effective in reactivating memories in the non-shifted perspective condition (i.e., no difference between baseline and the non-shifted perspective condition in Experiment 2). However, the effectiveness of the retrieval cue did not influence subsequent memory effects between the shifted and non-shifted perspective conditions, suggesting that shifting visual perspective is not identical to “weaker” reactivation of memories due to differences in encoding specificity. Instead shifting visual perspective during memory retrieval may reshape memories, perhaps by altering the vividness of mental images as they are elaborated upon during retrieval. According to the mental context shift hypothesis (Sahakyn & Kelley, 2002), changes in context between encoding and retrieval can lead to forgetting (also see Mensink & Raajimakers, 1988; 1989). A similar mechanism could occur when shifting visual perspective during memory retrieval, because adopting an alternative visual perspective requires greater remapping of the spatial context of memories compared to maintaining the same visual perspective as encoding.

An alternative explanation of our findings is that difficulty in maintaining the observer vantage point could have contributed to differences in subsequent memory accuracy between the perspective conditions. Indeed, shifting perspective likely requires additional and potentially effortful cognitive process whereby the individual has to update the spatial context of the memory so that they are now a spectator watching the scene. In the current study, the short amount of time (i.e., 7.5s) allowed to retrieve memories from the shifted perspective may have not been sufficient to both update one's egocentric representation in the memory and to retrieve a sufficient level of memory. For example, we found that maintaining an alternative observer perspective during memory retrieval was harder than maintaining the same own eyes perspective as memories were originally encoded (also see Eich et al., 2009; St. Jacques et al., 2017), and that perspective maintenance ratings were correlated with vividness ratings. However, differences in perspective maintenance between the perspective conditions were unrelated to differences in subsequent memory accuracy. Moreover, other research has demonstrated shifting visual perspective reduces memory vividness even when retrieval is unlimited in time (e.g., Berntsen & Rubin, 2006; Butler et al., 2016). Thus, the reduction in subsequent memory accuracy shown here cannot be readily explained by differences in difficulty. Future research should aim to directly investigate these issues by modulating the duration of memory retrieval and/or by equating the difficulty of retrieving memories from own eyes and observer perspectives.

We also examined differences in the type of details recalled following a shift in visual perspective. Previous research found that adopting an own eyes perspective is associated with better recall of internal aspects of a memory (e.g., sensorial details; Bagri & Jones, 2009; Eich et al., 2009; McIsaac & Eich, 2002), whereas memories that are retrieved from an observer perspective typically include more objective details about a past event (e.g., physical actions, spatial relations among objects; Eich et al., 2009; McIsaac & Eich, 2002). Overall, participants recalled more physical actions and spatial relations among objects relative to sensorial detail, temporal order of actions, and visual details. In Experiment 2, we found less accurate recall of temporal order and visual details in the shifted compared to the non-shifted perspective condition when we increased the match between encoding and retrieval cues (only when the baseline condition was removed from the analysis). Shifting perspective reduced the accuracy with which temporal order of actions and visual details were later remembered, but there was no impact of shifting perspective on these details when the retrieval cues were less effective in eliciting memories (i.e., the mismatch group). This shows that increasing the effectiveness of the retrieval cues in eliciting memories contributed to greater effects of shifting perspective on these types of details relative to retrieval cues that reflected a lower match between encoding and retrieval. Varying the effectiveness of the retrieval cues or shifting perspective did not, however, contribute to differences in in accuracy of physical actions, sensorial details or spatial relations of objects. One possibility for this lack of difference might be due to the delayed recall following perspective manipulation introduced in this study. In fact, in the studies cited above participants free-recalled their memories *while* adopting a particular visual perspective, whereas in the final memory test of our study participants were not instructed to adopt a particular vantage point. It is possible that the influence of visual perspective on the type of details recall is evident during immediate recall, because adopting a particular vantage point leads to an increased focus on certain memory details over others, but might not persist over time when visual perspective is not cued. Interestingly, similar to our findings, Bagri and Jones (2009) did not find any differences between own eyes and observer perspective conditions in the amount of external details recalled. However, they did find an advantage of the own eyes perspective on the internal aspects of the memory (e.g., physical sensations, associated ideas, affective reactions, psychological states). They suggested that the adoption of an own eyes perspective might have facilitated recall of information that was encoded with respect to the self (i.e., self-reference effect, Conway & Dewhurst, 1995) and was later only accessible to introspection. In the current study, only one out of five category details involved introspection, however we did not find enhanced recall of physical sensations in the non-shifted perspective condition. One reason may be that recall of these was overall lower compared to other category details. For example, although the smells used here were designed to be unique to each mini-task, this might have had the opposite effect (i.e., there were too unique to be recognised and/or later remembered). Future research could aim to examine additional internal aspects of memory such as psychological states, affective reactions and associated ideas to better understand whether the accessibility of these details from an own eyes perspective is limited to immediate recall or extends to subsequent memories.

Our findings have important implications in forensic settings, particularly with protocols used for eyewitness testimony. For example, the cognitive interview partly relies on the mnemonic effect of changing perspective to facilitate retrieval of accurate information (Geiselman et al., 1984). Adopting an alternative perspective may sometimes benefit the recall of details that would have been otherwise missed (e.g., Anderson & Pichert, 1978). Our findings argue against the generalizability of using visual perspective shifting as an effective interview technique. One important difference between the current findings and changes in perspective reported in these settings, is that here we manipulate egocentric perspective (i.e., self-centred frame of reference) rather than asking people to directly adopt another person's perspective (e.g., the cashier being held up in a convenience store). Better understanding these differing aspects of perspective taking on memory and its potential impact on memory accuracy and other types of changes in memories will be important directions for future research.

Conclusion. One of the main assumptions about visual perspective is that adopting an observer perspective reflects the transformation of memories (e.g., Schacter, 1996; Sutin & Robins, 2008). In the current study we show for the first time that deliberately shifting perspective from an own eyes to an observer perspective at retrieval can have detrimental effects on the subsequent accuracy of memories. Effortful reconstructive processes involved in updating egocentric perspective during memory retrieval, by adopting the viewpoint of an observer, decreased the subjective vividness of memories online, which in turn predicted the decreased accuracy of these memories in later retrieval. Better understanding the nature of observer perspectives in transforming long-term representation of memories will expand our theoretical understanding of visual perspective in memories, as well as the impact of the use of this technique in applied forensic and clinical settings.

Chapter 3. The Effects of Seeing One's Self In A Photo During Retrieval On Visual Perspective And Memory Accuracy

Introduction

Reviewing photographs of our past often entails seeing ourselves from an external viewpoint (e.g., photos taken by someone else, or 'selfies'). During remembering, we can also see ourselves in the memory from this external vantage point. Memories can in fact be remembered from an own eyes perspective, re-experiencing the event from the same viewpoint from which the event was initially encoded, or from a novel or observer perspective, typically not experienced during memory encoding, where we see our physical body from an external vantage point (Nigro & Neisser, 1983). Previous studies have shown that explicitly instructing participants to adopt different visual perspectives during retrieval differentially affects the phenomenological properties of memories (for a review see Rice, 2010) and it can change the visual perspective from which memories are later experienced (St Jacques et al., 2017). Photographs of events taken from an own eyes or from a novel viewpoint can be experimentally tractable tools to elicit visual perspective in the laboratory. Critically, retrieving memories while cued with photographs taken from different viewpoints (St Jacques and Schacter, 2013), but also active instructions to shift visual perspective (Chapter 2) can contribute to later changes in the properties of memories, including their accuracy. However, to date, little is known about how physically seeing oneself in photographs taken from a novel viewpoint potentially influences the visual perspective of memories, as well as their accuracy. It is therefore the aim of the current study to extend previous and Chapter 2's findings to investigate the role of the physical self in photographs on the phenomenological properties and subsequent accuracy for memories of complex mini-events encoded in the lab.

Photographs can sometimes benefit memory recall. For example, research has shown that personal and family snapshots are useful in therapeutic settings to recollect particular feelings and memories (Weiser, 2004); photographs can be useful to elicit and examine the neural mechanisms of autobiographical memories (e.g., St Jacques, Conway, & Cabeza, 2011), and reviewing of photographed events can enhance memories in both healthy individuals and patients with memory impairments (for reviews see Chow & Rissman, 2017; Silva, Pinho, Macedo, & Moulin 2016). Moreover, showing participants photographs of previously encoded events during retrieval can enhance later memory recall relative to conditions where no photographic review occurs (e.g., Koutstaal, Schacter, Johnson, and Galluccio, 1999). Critically, in most of these studies participants were presented with photos that were either previously taken by someone else (e.g., experimenter) or automatically taken during encoding (i.e., using wearable cameras), suggesting that their benefits are due to reviewing photographs during memory retrieval and cannot be attributed to encoding effects. These findings thus show that photos depicting the event as it originally occurred can act as effective retrieval cues helping retain our memories for the past by creating a better match with the encoded event.

Reviewing photographs can, however, also have the reverse effect by reducing memory accuracy and even leading to false memories (e.g., Lindsay, Hagen, Don Read, Wade, & Garry, 2004; Schacter, Koutstaal, Johnson, Gross, and Angell, 1997; Wade, Garry, Don Read, & Lindsay, 2002). For example, Schacter et al. (1997) presented old and young adults with altered photographs of a previously watched video of everyday activities (e.g., spring cleaning and tidying) whereby some of the objects were changed from the original encoding video. On a subsequent recognition memory task for the items, they found that older adults were more likely than young adults to falsely report remembering the changed items as part of the original video event. These ‘detrimental’ effects on memory can also extend to doctored personal photographs of one's life events that include the participant's self. Wade and colleagues (2002) presented participants with a series of family photographs of their childhood. One of the photos was edited to show a hot-air balloon ride that participants never actually experienced. After a series of interviews that guided participants to remember the erroneous event in as much detail as possible, they found that half of their participants reported having a false belief or a partial false belief of the hot-balloon ride depicted in the doctored photograph. True photographs of one's life, where the erroneous event is not depicted in the photograph itself, can also lead to false memories. Using a procedure similar to Wade et al. (2002) to implant false beliefs, Lindsay et al. (2004) showed half of their participants true photographs of different time periods of their childhood (e.g., class photos) and asked them to repeatedly retrieve, over the course of a week, two narratives of events that did occur and one that never occurred. They found that, relative to the no-photograph condition, participants reported falsely remembering the erroneous event as having occurred (it was also associated with high subjective ratings of reliving and remembering compared to the no-photograph condition). As the authors suggest, it is possible that the photograph aided recollection of perceptual details of the memory (e.g., physical appearance of teachers and classmates), which might have been combined with imagination to produce a vivid image of the false event. Thus, photographs can act as a 'cognitive springboard' whereby aspects of a photo can be embedded in the mental representation of an event (e.g., Bays et al., 2018; Henkel & Carbuto, 2008; Wade et al., 2002) and can lead to the formation of memories for events that never occurred.

In sum, the previous literature suggests that photographs can be an effective retrieval cue to recollect the personal past but can also reshape and modify memories in a number of ways, in particular when these do not reflect the event as it originally occurred. The particular viewpoint from which photos are taken is also another way in which the original event can be 'distorted'. Photographs of past events are in fact typically taken from one of two viewpoints: 1) from our own eyes, capturing the moment from the same visual perspective as we were experiencing the event at the time, or 2) from a novel (or observer) perspective not experienced during encoding of the event, such that the photograph is taken by someone else at the time of the event or by ourselves in the case of 'selfies', where in both cases we see ourselves from an external viewpoint. Critically, the different viewpoints from which photographs are shown during retrieval can influence memory accuracy. St Jacques and Schacter (2013) found that presenting participants photo cues taken from a novel perspective from encoding reduced the effectiveness of the retrieval cue to reactivate memories, leading to a reduction in subsequent memory accuracy when compared to photo cues taken from the original viewpoint. Similarly, in Chapter 2, I showed that actively shifting visual perspective for memories cued by a novel viewpoint compared to encoding was also detrimental for memory accuracy. However, the photographs used in these studies did not include the participant's physical self. Moreover, participants in St Jacques & Schacter's study were not explicitly instructed to shift visual perspective, whereas in the study of Chapter 2 participants were given active instructions to adopt an own eyes or observer visual perspective during retrieval. Critically, in Chapter 2 (Experiment 2) I also showed that removing the photographic cues still led to similar reductions in memory accuracy. This highlights the importance of better examining whether it is the novelty of the viewpoint in the photograph or the active instructions to adopt a novel perspective to influence subsequent memories. Thus, here I also directly explored the effects of active (i.e., explicitly instruct to adopt an own eyes or observer perspective) versus passive (i.e., cueing visual perspective with photographs without explicit instructions) visual perspective instructions on subsequent accuracy of memories.

By definition, adopting an observer perspective during remembering involves seeing yourself from the outside, which is conceptually similar to seeing yourself in a mirror or in a photograph (Sutin & Robins, 2008). A few lines of research investigating the effects of seeing oneself in a photograph (e.g., Brédart, Delchambre, & Laureys, 2006; Liu, Liu, Zhu, et al., 2015) or in a video (e.g., Robinson and John, 1997) have showed that the presence of the physical self can increase attention directed to the self. This may, in turn, influence the effectiveness of such cues on memory. In particular, research on attention has showed that self-related stimuli (e.g., participant's own name, photos of participant's face) are typically more difficult to ignore compared to non-self or control stimuli (e.g., common names, photos of celebrities) (e.g., Brédart, Delchambre, & Laureys, 2006; Gronau, Cohen, & Ben-Shakar, 2003; Liu, Liu, Zhu, et al., 2015). Brédart et al. (2006) presented participants with a photo of themselves or of someone familiar (i.e., college professor) while having to classify a target name as being their own or their classmate's name. They found increased reaction times when participants were showed a photo of themselves compared to a photo of a familiar person, suggesting that self-related stimuli may be 'attention-grabbing'. During memory retrieval, this increase in self-focus when seeing oneself in a photo may potentially influence the visual perspective of subsequent memories. Some recent studies in the visual perspective literature has showed that imagining oneself from an observer perspective during retrieval of dominant own eyes memories can bias the visual perspective from which memories are later experienced (e.g., Butler et al., 2016; St Jacques et al., 2017). The increase in self-focus when physically seeing oneself in a photograph during retrieval may heighten the effects of adopting an observer perspective thereby affecting the visual perspective from which memories are later remembered.

Another way in which the presence of the physical self in photographic cues could modify subsequent memories is by influencing the accuracy of subsequent recall. On the one hand, seeing yourself in a photo during retrieval may be 'attention-grabbing' (i.e., increase in self-focus), which could reduce the effectiveness of the retrieval cues in eliciting memories thereby reducing their accuracy. On the other hand, seeing yourself in a photograph could increase self-relevance (thus the effectiveness of the retrieval cues) and potentially improving later memory retrieval. For example, research on the self-reference effect has reported better memory performance for information that is processed with relation to the self (compared to conditions where information is related to another person or is semantic in nature) due to the increase in the match between encoding and retrieval conditions (e.g., Conway & Dewhurst, 1995; Kesebir & Oishi, 2010; Symons & Johnson, 1997). These effects are attributed to encoding processing (but see Bergström, Vogelsang, Benoit, & Simons, 2015), thus it still remains to be explored whether the presence of the self during retrieval may elicit similar self-referential processes. However, findings from the studies using doctored photographs of one's childhood (Wade et al., 2002; Lindsay et al., 2004) may partly be explained by self-reference effects. In other words, the inclusion of the self in photographs during retrieval of childhood's events increased the relevance with respect to oneself thereby heightening the belief that the event did occur in participants' childhood.

The presence of the physical self might also affect the types of details one remembers about a memory. For example, the increase in self-focus when seeing oneself in photographs might direct attention to details that are more relevant to the self (e.g., physical appearance), as opposed to the more objective details of the event (e.g., objects in a scene). McIsaac & Eich (2002) showed that retrieval from an own eyes perspective is associated with higher frequency of internal aspects of a memory (e.g., sensorial and perceptual details) whereas retrieval from an observer perspective increases recall of more objective details of the event (e.g., physical appearance, spatial relations of objects). Here, I will explore whether including a condition that potentially heightens self-referential processes when adopting an observer perspective may increase the differences between internal and objective aspects of the memory.

Moreover, McIsaac & Eich (2002) reported a higher frequency recall of spatial relations of objects in the observer perspective condition, however the accuracy with which these details are subsequently remembered still remains to be assessed. Spatial representations of the environment rely on both an egocentric (i.e., objects described with respect to the self) and allocentric (i.e., objects described with respect to other objects) reference system (e.g., Wang & Spelke, 2002), and studies on spatial memory have investigated how these are stored and integrated in memory (e.g., Burgess, Spiers, & Paleologou, 2004). A number of studies within this literature have directly examined the influence of changes in viewpoint on allocentric reference frames (e.g., Chan, Baumann, Bellgrove, & Mattingley, 2013; Mou & McNamara, 2002; Mou, McNamara, Valiquette, & Rump, 2004). In particular, they have shown that spatial judgments are equally accurate between conditions where the learning and testing direction of participants remains the same and conditions where they are asked to imagine the array of objects from novel perspective that are however aligned (parallel or orthogonal) to initial study location. These author suggest that spatial memories can be formed on the basis of intrinsic frames of reference such that mental representations (i.e., recall) of a spatial layout depends on the layout itself (i.e., the orientation and position of objects during learning and testing) and not on the perspective from which the participant is viewing the spatial layout. Critically, adopting a novel perspective requires updating the egocentric frame of reference in memories (i.e., the spatial context of the memory is updated relative to oneself) rather than the allocentric frame of reference (i.e., relative to the external environment), but little is known about how actively seeing the physical self in a photograph might influence this egocentric frame of reference. Previous evidence has shown that the presence of other people or avatars in photographs

(Tversky & Hard, 2009; Furlanetto, Cavallo, Manera, Tversky, & Becchio, 2013; David, Bewernick, Cohen, et al., 2006; Samson, Apperly, Braithwaite, & Andrews, Bodley Scott, 2010) influences the ability to make spatial relations judgments (of objects) from a viewpoint different from one's own (i.e., spatial perspective-taking). For example, Tversky & Hard (2009) asked participants to report the spatial relations of objects presented in a photograph either depicting another person (gazing or reaching for objects) or not. When a person was included in the photograph participants were more likely to describe the spatial relations of objects from the other person's point of view relative to their own, but adopted their own perspective instead when the other person was not present. These results suggest that participants spontaneously took a perspective different from their own and reversed left and right of objects when making spatial relations judgements. Thus, the mere presence of another person in a photograph determined whether participants adopted their own or another person's perspective. Similarly, seeing one's own physical self in a photo might increase the effects of adopting an observer perspective and affect the spatial representations of later memories. Further, Cavallo, Ansuini, Capozzi, Tversky, and Becchio (2017) showed that participants spontaneously adopted a perspective different from their own even when the person in the scene is replaced with an empty chair (Exp. 2). They suggested that adopting someone else's perspective can occur with the mere 'possibility of a human perspective', such as the case of a chair placed at the opposite side of the table. The spatial perspective literature, however, has primarily focused on seeing someone else in a photograph rather than seeing oneself in a photo. Here, I examined how the presence versus the absence of the bodily self in photographs taken from a novel viewpoint (i.e., observer perspective photographs similar to those used in study 1 of Chapter 2) potentially contribute to changes in subsequent spatial accuracy.

The aim of the current study was to examine how the presence of the self in photographic retrieval cues and active versus passive instructions to shift visual perspective influences subsequent accuracy for memory elements as well as spatial accuracy, and visual perspective ratings. A paradigm similar to that of Chapter 2 was used. A novel aspect of the current study was that photographs were automatically taken during encoding of the mini-events. Two SenseCams, wearable cameras, were used: one was worn by participants throughout the encoding session, whereas the other was placed opposite where the participant was sitting (see Figure 3.1 for example of photographs from the different viewpoints). One week later, they were asked to retrieve memories for the mini-events cued with photos taken from their own eyes or from an observer perspective; half of the observer perspective photos included the participant's bodily self, half did not (i.e., taken from a controlled set of photos). Perspective instructions during retrieval were manipulated between groups: the 'no-instructions' group was not given explicit instructions of visual perspective and asked to recall the mini-events while looking at the photos, whereas the 'instructions' group received instructions to adopt an own eyes or observer perspective while remembering the mini-events in the photo cues. Two days later, memory was tested similar to Chapter 2. Additionally, I included a novel test of spatial accuracy to examine egocentric (i.e., with respect to the self) and allocentric (object-to-object) spatial relations of objects; participants were asked to re-arrange photos of the objects used for the mini-events as they were initially presented to them in session 1. There were three predictions. First, the presence of the bodily self should influence subsequent memory accuracy: if it increases self-focus, adopting a novel perspective should impair subsequent memory accuracy relative to an own eyes perspective (i.e., similar reductions for memories retrieved from the two novel perspective conditions). The increase in self-focus might, however, lead to a higher proportion of self-relevant details (i.e., physical actions and sensorial details) compared to memories retrieved from an alternative perspective where the bodily self is not available in the photo cue. Alternatively, if it increases self-relevance, the presence of the bodily self might affect differences in accuracy between the two novel perspective conditions, facilitating subsequent recall compared to memories retrieved from a novel perspective that do not include the bodily self. Additionally, based on the spatial perspective taking literature, it is expected that retrieval from novel perspectives will decrease subsequent egocentric accuracy compared to the own perspective (i.e., inverting left and right of objects with respect to oneself). Second, active instructions of shifting perspective should lead to stronger effects on subsequent memories compared to passive instructions (i.e., no explicit instructions of visual perspective). Third, if the presence of the self increases the effects of adopting an observer perspective, then it is predicted that retrieving memories cued with the physical self should change the subsequent visual perspective of memories.

Method

Participants

Forty fluent English speakers were included in the experiment [29 women; mean age in years (*M*) = 21.67, *SD* = 3.27; mean years of education (*M*) = 16.10, *SD* = 1.86]. They reported no history of psychiatric and/or mental health impairments, were not taking any medication that could affect cognitive function, and had normal or corrected to normal vision/hearing. They provided written informed consent for a protocol approved by the School of Psychology at the University of Sussex.

Procedure

The study procedure was similar to that of Chapter 2, with some exceptions. In session 1, participants performed 32 mini-events (for a list of events including the additional 8 created for this study see Appendix A). They also wore a ViconRevue (Vicon, Oxford, United Kingdom) camera at chest level, which automatically takes photos every 15s using a timer. An additional ViconRevue camera was placed on the desk in front of where the participant was sitting. Thus, photos from two camera views were taken for each participant: 1) from an own eyes perspective, and 2) from an observer perspective that showed the participant's face and upper half of their body as they were conducting the mini-event (see Figure 3.1 for an example).

In session 2, approximately one week later [mean delay (*M*) = 6.59, *SD* = 1.05], participants were presented with titles and photos of the mini-event and asked to retrieve memories while looking at the photos. Participants were presented with the same photos that were taken from the camera they wore during session 1 (i.e., own eyes perspective), from a camera placed opposite to where they were sitting (i.e., observer-self perspective), or from a set of photos taken by the experimenter from the identical observer perspective but showing an empty chair only instead of the participant (i.e., observer-noself perspective) (see Figure 3.1). To examine the role of active versus passive instructions to adopt an alternative visual perspective during retrieval, a between subjective design was used to vary the type of instructions given to participants. One group was instructed to retrieve the memories for the mini-events while looking at the photos, but no explicit instructions about visual perspective were provided (i.e., no-instruction group). Another group was explicitly instructed to adopt either an own eyes or an observer perspective while looking at the photographs (i.e., instruction group), using instructions identical to those used in Experiment 1 of Chapter 2. Thus, the two groups only differed in the type of instructions they received, but the photographs taken from the different viewpoints were identical. Each photo depicted the mini-event as it would have appeared to participants at the start of each mini-event during testing in session 1, and participants were instructed to recall the task they had conducted in as much detail as possible.

Twenty-four mini-events were retrieved during session 2, 8 in each of the own eyes, observer-self and observer-noself conditions, and the remaining 8 mini-events were used in a baseline condition to assess potential changes in memory due to delay. Participants were given 12 s to retrieve each memory and each mini-event was repeated four times in an interleaved fashion. The timing of the task was increased slightly from the study of Chapter 2 to maximise the impact of seeing the photos from different viewpoints. Immediately following each retrieval trial, participants were asked to provide a number of subjective ratings on 5-point scales (1 = low to 5 = high). In the no-instructions group, participants were asked to indicate the difficulty in retrieving the mini-event while looking at the given photo. In the instructions group, participants were asked about difficulty in retrieving the memory from the indicated perspective and to rate how consistently they could maintain the indicated perspective. Both groups were then asked to rate emotional intensity, reliving, and vividness.

In session 3, two days later, memory accuracy for the mini-events was assessed using a similar cued-recall test as Chapter 2. However, questions concerning the spatial arrangements of objects were excluded, because they were asked instead in a new spatial task (described below). Participants were presented with the titles of all 32 mini-events and asked a series of 12 short-answer questions related to the physical actions, physical sensations, visual details, temporal order of the actions to complete the task (see Chapter 2 for example of questions and answers). The coding of responses was identical to those of Chapter 2. Following the short-answer questions for each mini-event, participants were asked to provide subjective ratings on a 7-point scale (1=low to 7=high) on the following characteristics: reliving, emotional intensity, the visual perspective from which they remembered the event (separately for own eyes and observer), vividness, and how accurate they felt their memory was (i.e., recalling all the details of the event exactly as they occurred). I additionally included a more nuanced scale of visual perspective based on Rice & Rubin (2011) and used by McDermott et al. (2015). Here, participants were asked to categorise the origin of their perspective along the dimensions of height (e.g., own eye level, from ceiling height, from the level of floor), location (e.g., directly behind yourself, directly to your left, directly to your right) and distance (e.g., 3 feet away from your location, 3-6 feet away). Both the cued-recall and subjective rating tasks were self-paced.

To assess the impact of visual perspective during retrieval on subsequent spatial memory, a novel test was created in which participants were asked to arrange the objects from the mini-events as they were originally displayed during session 1. Compared to Chapter 2, this allowed more strict ‘left’ and ‘right’ spatial judgments of objects and removed the possibility of neutral response as found before (e.g., ‘on the tray’, ‘next to me’). Thus, participants were presented with Microsoft PowerPoint slide showing the title of the mini-event, a photo of an empty tray along with photos of each of the individual objects used in that mini-event. They were asked to arrange the objects on the tray as they were initially presented at the start of each mini-event during session 1 (see Figure 3.1 for example of the task).[3] I calculated the proportion of objects correctly positioned on the tray separately for each mini-event (i.e., total number of objects used in each mini-event varied) according to several different measures: i) tray location, correct position on the tray, ii) egocentric location, correct placement on the left or on the right on the tray (from the midline of the tray) according to the original perspective of the participant; iii) allocentric location, correct placement according to the left or to the right of the nearest objects on the tray. Correct responses for each of the measures were coded by the experimenter; these were also coded by another trained assistant blind to recall conditions (interrater reliability: overall > .93; tray location > .77; egocentric > .88; allocentric > .90).

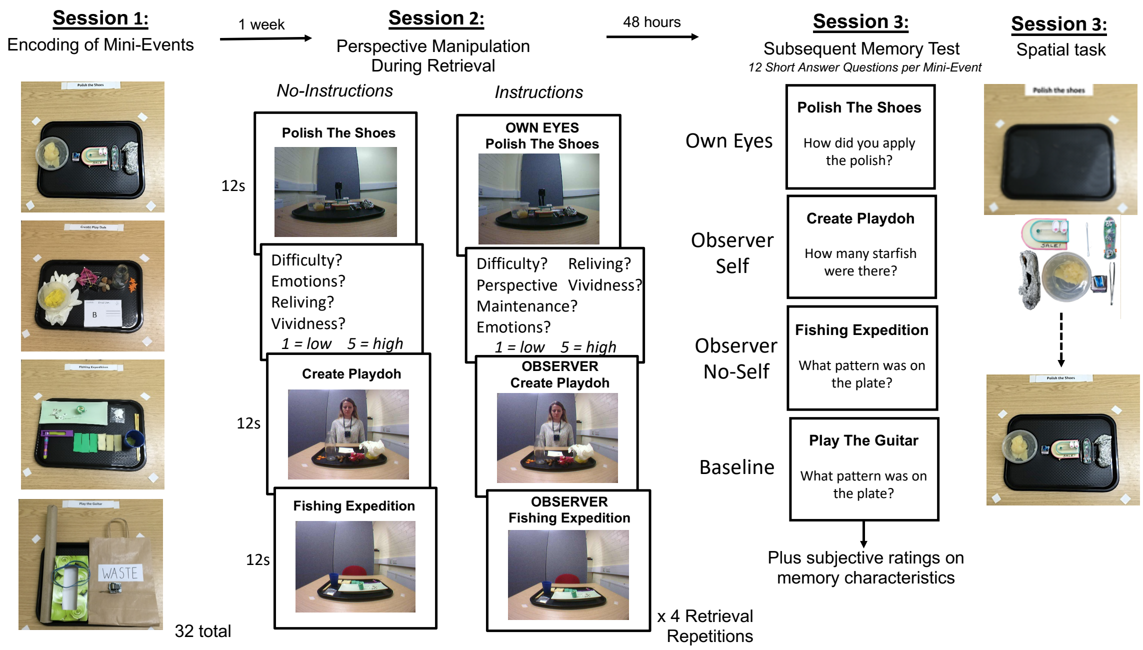

Figure 3.1 Experimental design.

The experiment took place in 3 separate study sessions. In Session 1, participants performed a series of hands-on mini-events while wearing a camera that automatically takes photos. In Session 2, they were cued with photos taken from an own eyes perspective, from an observer perspective showing their body, or from an observer perspective not showing the participant's body. The 'no-instructions' group did not receive any instructions of visual perspective, whereas the 'instructions' group was instructed to retrieve the mini-events while adopting an own eyes (own eyes condition) or an observer perspective (observer-self and observer-noself condition). In Session 3, memory accuracy was tested using a series of short-answer questions about the mini-events followed by subjective ratings on some memory characteristics. The final test was a spatial task to test spatial relations of objects, where participants had to re-position the objects on the tray as they were initially presented to them in session 1.

Results

Unless otherwise stated, all main analyses were conducted using mixed ANOVAs, with perspective condition (own eyes, observer-self, observer-noself) as the within-subjects factor and the visual perspective instructions group (no-instructions, instructions) as the between-subjects factor. To control for multiple comparisons, Bonferroni's correction was used in the *post hoc* analyses.

Subjective Ratings

Session 2. To examine online differences during retrieval in the memory characteristics reported during session 2 a series of mixed ANOVAs were conducted on each subjective rating separately (for means and SDs see Table 3.1). The ANOVA on difficulty ratings revealed a main effect of perspective condition, F (2, 76) = 5.00, p = .01, η2 = .12, reflected by greater difficulty in retrieving from an observer-self condition (M = 2.23, SD = .72) compared to the own eyes condition (M = 2.01, SD = .61), p = .02. There were no differences between the own eyes condition and the observer-noself condition (M = 2.10, SD = .65), p = .72. However, the difference between the two observer conditions approached significance, p = .06. There was no perspective condition by instructions group interaction.

The analysis on emotional intensity and reliving ratings showed similar findings. For emotional intensity, there was a main effect of perspective condition, F (2, 76) = 4.27, p = .02, η2 = .10, reflected by higher ratings for memories retrieved from an own eyes perspective (M = 2.92, SD = .71) relative to memories retrieved from the observer-noself condition (M = 2.75, SD = .69), p = .02, but not relative to the observer-self condition (M = 2.79, SD = .68), p = .19. The difference in emotional intensity between the observer perspective conditions was also not significant, p = 1.00. However, there was a perspective condition X instruction group interaction, F (2, 76) = 4.29, p = .02, η2 = .10. Follow-up analysis revealed that for the instructions group only emotional intensity ratings were higher for the own eyes perspective condition compared to the observer-noself condition, p = .001. Instead, for reliving ratings, there was only a main effect of perspective condition, F (2, 76) = 3.27, p = .04, η2 = .08. After controlling for multiple comparison correction, however, follow-up pairwise comparisons did not reveal significant differences between the perspective conditions. There were no other differences.

Examining vividness ratings, the analysis did not reveal a main effect of perspective condition nor an interaction between perspective and instructions group. However, given the results of Chapter 2 where explicitly instructing participants to adopt an own eyes or observer perspective led to differences in vividness ratings, I examined the groups separately.[4] There was no difference between the conditions in the no-instructions group. However, there was a main effect of condition in the instruction group, F (2, 38) = 5.31, p = .009, η2 = .22, reflecting a reduction in vividness ratings in both observer conditions (observer-self: M = 3.33, SD = .68; observer-noself: M = 3.25, SD = .67) compared to the own eyes condition (M = 3.57, SD = .49), both $p_s < .05$. Thus, these findings show that the presence of the physical self increased the difficulty in retrieving memories cued with photos taken from a novel perspective relative to memories cued with photos taken from the same perspective as encoding. By contrast, differences in emotional intensity and vividness emerged only when participants were explicitly instructed to adopt a particular perspective, but were not sensitive to differences in the presence of the physical self in the photo.

Table 3.1. Means (with standard deviations) for subjective ratings in Session 2 perspective manipulation.

	No Instructions			**Instructions**		
Subjective Rating	*OE*	*OB Self*	*OB No Self*	*OE*	*OB Self*	*OB No Self*
Difficulty	1.85	2.19	1.91	2.16	2.28	2.29
	(0.59)	(0.72)	(0.65)	(0.61)	(0.61)	(0.70)
Emotional Intensity	2.83	2.77	2.84	3.01	2.80	2.65
	(0.71)	(0.68)	(0.69)	(0.70)	(0.76)	(0.73)
Reliving	3.38	3.32	3.39	3.48	3.23	3.13
	(0.60)	(0.59)	(0.62)	(0.55)	(0.61)	(0.60)
Vividness	3.38	3.35	3.39	3.57	3.33	3.25
	(0.60)	(0.67)	(0.67)	(0.49)	(0.68)	(0.67)

Note: (OE) = own eyes condition; (OB Self) = observer-self condition; (OB No Self) = observer-noself condition; (BA) = baseline

Session 3. To investigate the influence of perspective during retrieval on subsequent memory characteristics, a series of mixed ANOVAs were conducted on subjective ratings made in session 3 (for means and SDs see Table 3.2).

Table 3.2. Means (with standard deviations) for subjective ratings in session 3 of the two visual perspective instruction groups.

	No Instructions				**Instructions**			
Subjective Rating	*OE*	*OB Self*	*OB No Self*	*BA*	*OE*	*OB Self*	*OB No Self*	*BA*
Emotional Intensity	3.34	3.37	3.45	2.88	3.46	3.40	3.30	2.86
	(1.43)	(1.24)	(1.25)	(1.15)	(1.21)	(1.09)	(1.34)	(1.08)
Reliving	4.24	3.93	4.11	3.54	4.04	3.94	3.78	3.41
	(0.99)	(0.85)	(0.97)	(1.07)	(1.14)	(1.18)	(1.30)	(1.15)
Own eyes ratings	4.78	4.76	4.71	4.46	5.08	4.68	4.54	4.78
	(1.09)	(0.94)	(1.12)	(1.23)	(1.29)	(1.33)	(1.43)	(1.36)
Observer ratings	2.16	2.19	2.40	1.85	1.82	2.34	2.26	1.78
	(1.03)	(1.00)	(1.08)	(0.76)	(0.72)	(1.04)	(1.16)	(0.72)
Vividness	4.08	3.98	4.03	3.27	4.13	4.03	4.04	3.43
	(0.89)	(0.77)	(0.89)	(0.78)	(1.06)	(1.12)	(1.09)	(1.00)
Accuracy	3.72	3.66	3.68	2.93	3.79	3.65	3.68	3.18
	(0.71)	(0.83)	(0.78)	(0.76)	(1.06)	(0.96)	(1.03)	(0.86)

Note: (OE) = own eyes condition; (OB Self) = observer-self condition; (OB No Self) = observer-noself condition; (BA) = baseline

For emotional intensity ratings, there was a main effect of perspective condition, F (3, 114) = 9.18, $p < .001$, η2 = .20, with higher ratings in all perspective conditions compared to baseline (all $p_s < .001$). The interaction between perspective condition and instruction group was not significant. Similarly, there was a main effect of perspective condition on reliving, F (2, 76) = 12.35, $p < .001$, η2 = .25, vividness, F (3, 114) = 22.16, $p < .001$, η2 = .37, and accuracy ratings, F (2, 76) = 21.83, $p < .001$, η2 = .37. All main effects were explained by higher ratings in all retrieval perspective conditions compared to baseline (all $p_s < .001$). The perspective condition by instruction group interactions on reliving, vividness and accuracy ratings were not significant. Thus, these results show that memories retrieved during session 2 were overall associated with higher emotional intensity, vividness, reliving and perceived accuracy compared to memories that were not rehearsed in session 2.

Turning to visual perspective ratings, the analysis on own eyes ratings did not reveal any differences. However, when looking at observer ratings, the analysis revealed a main effect of perspective condition, F (3, 114) = 7.07, $p < .001$, η2 = .16 (see Figure 3.2).

Observer perspective ratings were higher for memories in the observer-self (*M* = 2.27, SD = 1.01) and observer-noself (*M* = 2.33, SD = 1.11) conditions compared to baseline memories (*M* = 1.81, SD = .73), $p_s < .05$. There was no difference in observer ratings between own eyes (*M* = 1.99, SD = .90) memories and baseline, $p = .47$. The interaction between perspective condition and instruction group was not significant. Thus, these findings show that although memories were equally rated on own eyes ratings across the retrieval perspective conditions, adopting a novel perspective during retrieval increased whether participants adopted an observer perspective during later memory retrieval when compared to memories that were not rehearsed in session 2.

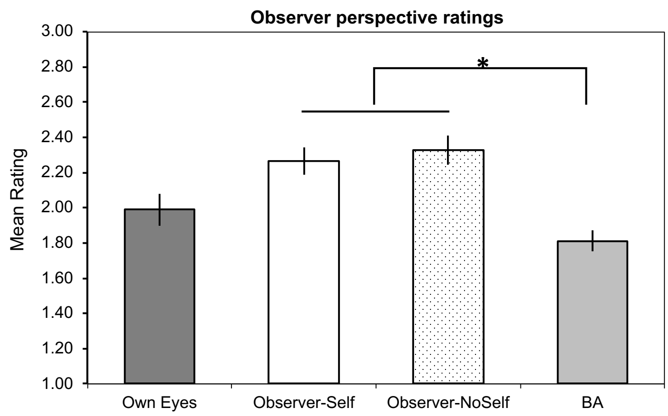

Figure 3.2 Subsequent observer perspective ratings.

Adopting novel perspectives increased subsequent observer perspective ratings in session 3 compared to memories that were not rehearsed in session 2. Error bars reflect within-subject standard errors.

Session 2 subjective ratings and subsequent changes in perspective. Additional analyses were conducted to better understand how the visual perspective manipulation during retrieval in session 2 contributed to the changes in subjective reports of subsequent visual perspective. In Chapter 2 I showed that differences in vividness, but not in retrieval difficulty, during perspective manipulation were related to subsequent changes in memories for the mini-events (i.e., their accuracy), whereas St Jacques et al. (2017) showed that differences in emotional intensity as well as difficulty during retrieval between the own eyes and observer perspective conditions contributed to the changes in the visual perspective of autobiographical memories. Thus, here, I examined 1) whether the increase in observer perspective ratings in session 3 for memories retrieved in the two observer perspective conditions (relative to the own eyes perspective condition) was also related to differences in the subjective qualities of memories (i.e., emotional intensity, reliving, and vividness) and differences in retrieval difficulty, and 2) whether the presence (or absence) of the physical self may have influenced the relationship between retrieval experience and subsequent changes in visual perspective of memories. All the analyses presented below used mean difference scores calculated between own eyes and observer-self condition and between own eyes and observer-noself condition for each of the following variables: session 2 subjective ratings of difficulty, emotional intensity, reliving, vividness and on subsequent observer perspective ratings (i.e., of session 3).

Difference scores on session 2 ratings and subsequent observer ratings for the observer-self and for the observer-noself conditions, respectively, were entered in two partial correlations controlling for the two visual perspective instructions groups (i.e., to control for group effects - see Table 3.3 for correlations). For differences with observer-self condition, reductions in emotional intensity (see Figure 3.3A) and reliving ratings were associated with greater changes in subsequent observer perspective ratings. In contrast, differences in difficulty and vividness ratings were not related to subsequent changes in observer perspective ratings. For the differences with the observer-noself condition, reductions in emotional intensity, reliving as well as vividness were associated with greater changes in subsequent observer perspective ratings. Increases in difficulty during session 2 were also related to subsequent changes in observer perspective ratings (see Figure 3.3B).

Table 3.3. Partial correlations between subsequent observer perspective ratings and subjective ratings of session 2.

Observer-Self (OE minus OB-self)	1	2	3	4	5
1. Observer perspective ratings (Session 3)	-				
2. Difficulty	0.30	-			
3. Emotional Intensity	-0.42**	-0.33*	-		
4. Reliving	-0.36*	-0.57***	0.83***	-	
5. Vividness	-0.26	-0.51**	0.77***	0.93***	-
Observer-NoSelf (OE minus OB-noself)					
1. Observer perspective ratings (Session 3)	-				
2. Difficulty	0.43*	-			
3. Emotional Intensity	-0.47**	-0.64***	-		
4. Reliving	-0.46**	-0.87***	0.77***	-	
5. Vividness	-0.40*	-0.80***	0.70***	0.91***	-

Notes: (OE) = own eyes condition; (OB-self) = observer-self condition; (OB-noself) = observer-noself condition. *$p < .05$. **$p < .01$. ***$p < .001$

These results confirm that changes in at least some of the subjective qualities of memories were related to subsequent differences in visual perspective. Specifically, reductions in emotional intensity and reliving, in both observer perspective conditions, were associated with subsequent changes in observer perspective ratings. However, the relationship between online differences in vividness and difficulty and the subsequent increase in observer perspective ratings was influenced by the presence versus absence of the self in the photos during perspective manipulation. Online changes in vividness and retrieval difficulty were related to the increase in subsequent observer ratings for memories not cued with the physical self, but not for memories in the observer-self condition.

Further exploratory analyses were then conducted to investigate whether the increase in subsequent observer perspective ratings in the observer perspective conditions were due to the changes in the subjective qualities of memories and/or retrieval difficulty between the own eyes and the two observer perspective conditions. Two separate multiple linear regressions were performed to examine whether the differences in session 2 ratings of emotional intensity, reliving and vividness (note that vividness was also included as a predictor given the findings of Chapter 2) uniquely predicted subsequent differences in observer ratings (i.e., between the own eyes condition and the observer-self and observer-noself conditions) when also including differences in difficulty as an additional predictor. Differences in reliving ratings violated collinearity assumptions when entered in the regression model for the differences in observer ratings in the observer-self condition, VIF = 11.26, tolerance = .09, and in the observer-noself condition, VIF = 11.97, tolerance = .08. For the purpose of this analysis, reliving was thus removed as an additional predictor. The linear regression on the observer-self condition was significant, F (3,36) = 3.26, p = .03, R^2 = .21. The analysis showed that only the differences in emotional intensity predicted subsequent differences in observer perspective ratings, β = - 1.13, t (36) = -2.26, p = .03. Differences in difficulty nor vividness were significant predictors in the model. The regression on the observer-noself condition (note that one participant was removed from this analysis because detected as an outlier with standardized residual greater than 2 for the difference in observer ratings) was also significant, F (3,35) = 7.86, p < .001, R^2 = .40, where differences in emotional intensity predicted subsequent differences in observer ratings, β = - .75, t (35) = -2.19, p = .04. The difference in difficulty in session 2 was also a significant predictor of subsequent differences in observer ratings between own eyes and observer-noself, β = .69, t (35) = 2.11, p = .04. Thus, changes in emotional intensity between memories retrieved from the original encoding perspective and the two types of observer memories, but not the changes in vividness, predicted the subsequent increase in observer ratings. Further, differences in retrieval difficulty predicted the increase in observer ratings, but only for memories retrieved from an observer perspective not cued with the physical self.

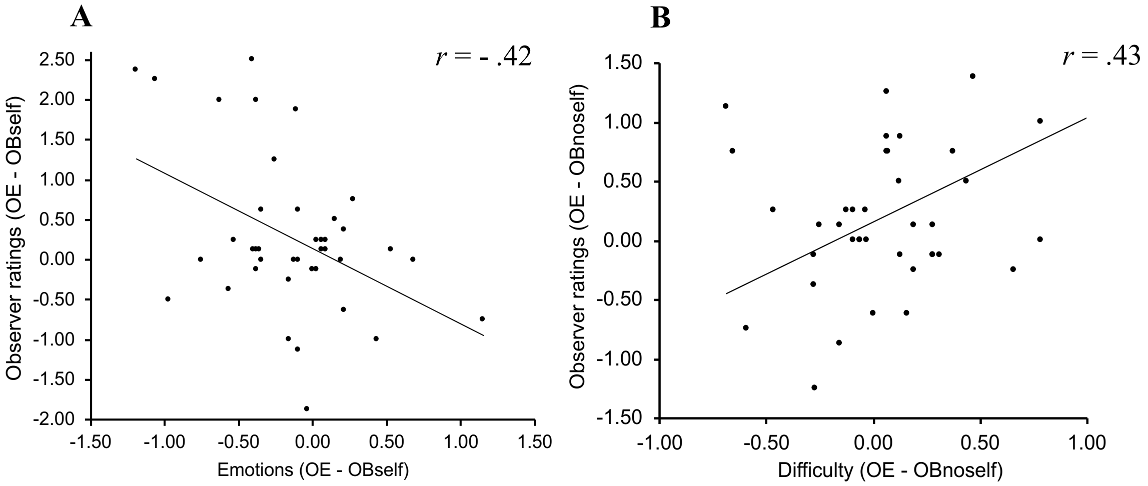

Figure 3.3 Correlation between subsequent observer ratings and subjective ratings during retrieval.

(A) For observer memories cued with the physical self, there was a negative relationship between differences in subsequent observer perspective ratings and emotional intensity ratings made in Session 2. (B) For observer memories not cued with the physical self, there was a positive relationship between differences in subsequent observer ratings and differences in retrieval difficulty online.

Nuanced visual perspective rating scale. To investigate subsequent differences in the spatial locations of the two observer perspective conditions, participants' responses to the perspective locations were categorised into 4 dimensions based on McDermott et al. (2015): height (eye level, above eye level, below eye level); distance, (near – less than six feet, far – greater than six feet); location- front/back (in front, alongside, behind); location – side/body (centre, right, left). Proportion of responses on each of the four dimensions was calculated for memories in the observer-self and observer-noself conditions. Bonferroni's correction was used in all post-hoc analyses. A series of mixed ANOVAs were conducted on the proportion of responses on each dimension separately with observer perspective (observer-self, observer-noself) and perspective location dimension (height, distance, location front/back, location side/body) as the within-subjects factors, and instruction groups (instructions, no-instructions) as the between-subjects factor. For height, the analysis revealed a main effect of location, F (2, 76) = 48.11, $p < .001$, $\eta2 = .56$, with participants reporting a higher proportion of memories from eye level (*M* = .73, SD = .32) compared to above eye level (*M* = .16, SD = .23) and below eye level (*M* = .10 , SD = .24) (all p_s < .001). There were no differences in proportion of memories experienced from above and below eye level, *p* = .79. There was also a height dimension by observer perspective condition interaction, *F* (2, 76) = 3.32, *p* = .04, η2 = .08. Follow-up analysis revealed that memories in the observer-noself condition (*M* = .19, SD = .25) were more often experienced from above eye level compared to memories in observer-self condition (*M* = .14, SD = .20), *p* = .04. No further main effects or interactions were found. These results suggest that, although the observer perspective was more often experienced from eye level, the presence of the bodily self in the photo cue protected memories from changes in the height from which they were later experienced.

When examining the location front/back dimension, there was a main effect of location, *F* (2, 76) = 85.00, *p* < .001, η2 = .69, with a higher proportion of observer perspectives from in front (*M* = .74, SD = .26) of the individual than alongside (*M* = .03, SD = .08) or behind (*M* = .21, SD = .26), and perspectives experienced more often from behind than alongside the individual (all p_s < .001). There was no location by observer perspective interaction, nor any other main effects or interactions.

For the location side/body dimension, there was a main effect of location, *F* (2, 76) = 345.95, *p* < .001, η2 = .90. This was also qualified by an interaction between location and observer perspective, *F* (2, 76) = 3.22, *p* = .046, η2 = .08, reflected by a higher proportion of observer perspectives experienced from the centre (*M* = .88, SD = .19) than from the left (*M* = .09, SD = .16) or the right (*M* = .02, SD = .08) of the individual (all p_s < .001), reflecting the nature of the photo cues used for perspective manipulation. For the observer-noself condition, participants also experienced their perspective more often from the left than from the right of themselves (*p* = .002). This was, however, explained by a 3-way interaction between location, observer perspective and instructions group, *F* (2, 76) = 5.34, *p* = .01, η2 =

.12, whereby this effect emerged only for the group that did not receive visual perspective instructions ($p < .001$), but not in the group that receive explicit instructions ($p = 1.00$). This latter interaction also revealed that the instruction group experienced memories in the observer-noself condition more often from the centre (*M* = .94, SD = .12) compared to the no-instructions group (*M* = .81, SD = .24), $p = .03$, whereas memories in the observer- self condition were more often experienced from the left of the individual in the no-instruction group (*M* = .09, SD = .12) compared to the instruction group (*M* = .07, SD = .15), $p = .02$. Further differences between observer perspectives emerged only in the no-instruction group: the proportion of perspective experienced from the centre was higher in the observer-self (*M* = .86, SD = .18) compared to observer-noself condition (*M* = .81, SD = .24) ($p = .03$), whereas memories in the observer-noself condition (*M* = .16, SD = .20) were more often experienced from the left compared to memories in the observer-self condition (*M* = .09, SD = .12), $p = .02$. These results thus suggest that explicit instructions of visual perspective overall preserved memories from subsequent changes in the side from which they were experienced. When no explicit instructions were given, the presence of the bodily self in the photo cues might have instead protected subsequent perspective from naturally shifting towards the side of the individual.

For the distance dimension, although there was a main effect of location, F (2, 76) = 2627.43, $p < .001$, η2 = .99, there were ceiling effects (i.e., proportion experienced from near the individual was .98), probably due to the nature of controlling the viewpoint with the photo cues, which may have affected analysis on this variable. Hence, further analyses are not reported.

Subsequent memory accuracy

To examine differences in subsequent memory accuracy between the perspective conditions, a 4 (perspective condition: own eyes, observer-self, observer-noself, baseline) X 4 (category detail: physical actions, sensations, temporal order of actions, visual details) X 2 (instructions group: no-instructions, instructions) ANOVA was conducted on the proportion of items correctly recalled in the short-answer questions. Perspective condition and category detail were the within-subjects factors and instructions group was the between-subjects factor. Bonferroni's correction was used to control for multiple comparisons (for means and SDs see Table 3.4 & 3.5). There was a main effect of perspective condition, F (3, 114) = 14.82, $p < .001$, $\eta 2 = .28$, with higher proportion of items correctly recalled in all perspective conditions compared to baseline, all $p_s < .001$. The main effect of category detail was also significant, F (3, 114) = 26.89, $p < .001$, $\eta 2 = .41$. Participants correctly recalled significantly more physical actions (M = .42, SD = .18) compared to sensations (M = .27, SD = .13), temporal order of actions (M = .30, SD = .14) and visual details (M = .34, SD = .14), all $p_s < .001$, and visual details compared to sensations, $p < .001$, and temporal order of actions, p =.03. There was no perspective condition by category detail interaction, F (9, 342) = 1.62, p = .11, $\eta 2 = .04$, nor any interaction with instructions group. Thus, subsequent memory accuracy was overall better for mini-events that were retrieved in session 2, but there were no differences between adopting different perspectives during retrieval.

Table 3.4. Means proportion correct (with standard deviations) of memory accuracy across experimental conditions of the two visual perspective instruction groups.

No Instructions				Instructions			
OE	*OB Self*	*OB No Self*	*BA*	*OE*	*OB Self*	*OB No Self*	*BA*
0.34	0.37	0.35	0.27	0.35	0.36	0.36	0.30
(0.10)	(0.11)	(0.10)	(0.09)	(0.12)	(0.13)	(0.12)	(0.11)

Table 3.5. Means proportion correct (with standard deviations) memory accuracy across category details of the two visual perspective instruction groups.

	No Instructions				Instructions			
Category Detail	*OE*	*OB Self*	*OB No Self*	*BA*	*OE*	*OB Self*	*OB No Self*	*BA*
Physical actions	0.44	0.46	0.45	0.33	0.43	0.46	0.41	0.35
	(0.19)	(0.18)	(0.17)	(0.15)	(0.19)	(0.21)	(0.18)	(0.16)
Sensations	0.30	0.31	0.31	0.20	0.25	0.28	0.29	0.24
	(0.10)	(0.11)	(0.11)	(0.12)	(0.16)	(0.17)	(0.15)	(0.12)
Temporal order	0.29	0.30	0.32	0.27	0.31	0.30	0.34	0.29
	(0.12)	(0.14)	(0.10)	(0.12)	(0.15)	(0.17)	(0.16)	(0.12)
Visual details	0.34	0.39	0.32	0.26	0.36	0.36	0.38	0.28
	(0.11)	(0.11)	(0.15)	(0.12)	(0.14)	(0.15)	(0.18)	(0.14)

Note: (OE) = own eyes condition; (OB Self) = observer-self condition; (OB No Self) = observer-no self condition; (BA) = baseline

Spatial Accuracy

To examine differences in spatial accuracy as a result of adopting an own eyes or an observer perspective during memory retrieval, a 4 (perspective condition: own eyes, observer-self, observer-no self, baseline) X 2 (instructions group: no-instructions, instructions) on the proportion of objects correctly arranged on the tray according to their absolute position on the tray, as well as the allocentric and egocentric spatial accuracy measures (for means and SDs see Table 3.6).

Table 3.6. Means proportion correct (with standard deviations) of spatial accuracy of the two visual perspective instruction groups

	No Instructions				Instructions			
Spatial Measure	*OE*	*OB Self*	*OB No Self*	*BA*	*OE*	*OB Self*	*OB No Self*	*BA*
Allocentric	0.57	0.53	0.54	0.47	0.56	0.56	0.53	0.53
	(0.09)	(0.10)	(0.10)	(0.14)	(0.18)	(0.13)	(0.13)	(0.13)
Egocentric	0.75	0.71	0.68	0.66	0.73	0.69	0.71	0.70
	(0.12)	(0.09)	(0.10)	(0.07)	(0.17)	(0.15)	(0.14)	(0.10)
Tray	0.47	0.43	0.44	0.37	0.49	0.47	0.43	0.42
	(0.13)	(0.11)	(0.11)	(0.10)	(0.20)	(0.15)	(0.15)	(0.12)

Note: (OE) = own eyes condition; (OB Self) = observer-self condition; (OB No Self) = observer-no self condition; (BA) = baseline

Examining the absolute spatial measure of objects on the tray, there was a main effect of perspective condition, *F* (3, 114) = 6.44, $p < .001$, η2 = .15. Participants were more accurate at arranging the objects on the correct position on the tray for memories retrieved in the own eyes (*M* = .48, SD = .16), *p* = .02, and observer-self perspective (*M* = .45, SD = .13) conditions, *p* = .02, compared to baseline (*M* = .40, SD = .11).

Turning to the allocentric and egocentric measures (see Figure 3.4A & 3.4B), for allocentric (object-to-object) accuracy, there was a main effect of perspective condition, *F* (3, 114) = 3.76, *p* = .013, η2 = .09, which was reflected by greater accuracy for the own eyes (*M* = .56, SD = .14) compared to baseline (*M* = .50, SD = .13) condition, *p* = .02. Examining the egocentric measure, the main effect of perspective condition was significant, *F* (3, 114) = 4.80, *p* = .003, η2 = .11, such that accuracy was greater in the own eyes perspective condition (*M* = .74, SD = .14) compared to baseline (*M* = .68, SD = .12), p = .04. Given the a priori prediction that retrieving from a novel perspective would decrease egocentric accuracy compared to memories retrieved from an own eyes perspective (and baseline), one-tailed tests were used in the follow-up analysis. Relative to the own eyes perspective, retrieval from a novel perspective significantly reduced egocentric spatial accuracy both in the observer-self (*M* = .70, SD = .12) and observer-noself condition (*M* = .69, SD = .12), p's = .03. There were no differences between memories retrieved from a novel perspective and baseline memories, $p_s = .50$. There were no interactions or other main effects. In sum, memories retrieved from a novel perspective changed subsequent egocentric memory representations such that participants were more likely to invert the left and right position of objects with respect to themselves compared to memories that were retrieved from the same perspective as encoding (see Figure 3.5 for an example response)

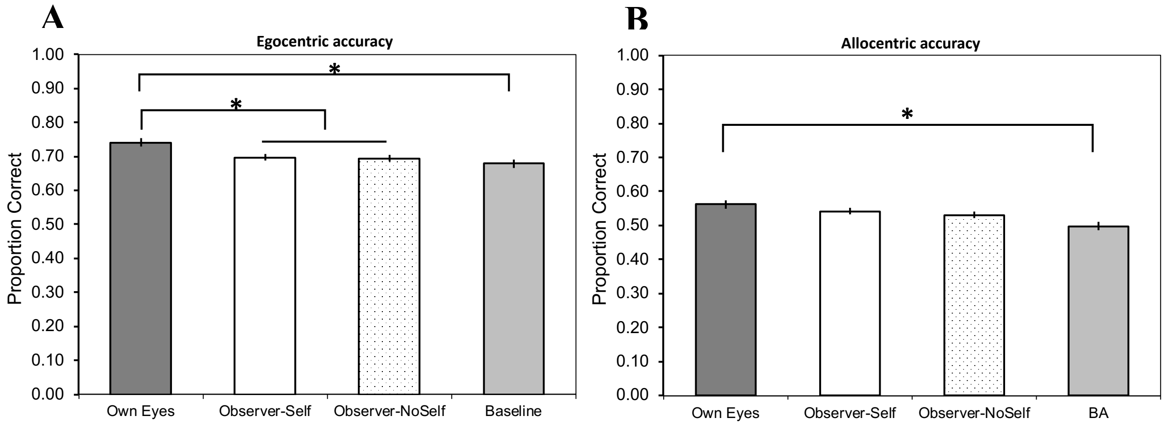

Figure 3.4 Subsequent egocentric and allocentric accuracy of memories.

Graphs are collapsed across instruction groups. (A) There were differences in subsequent allocentric accuracy between the retrieval conditions and baseline. (B) Adopting novel perspectives during retrieval reduced egocentric accuracy compared to memories retrieved from an own eyes perspective. Error bars reflect within-subject standard error.

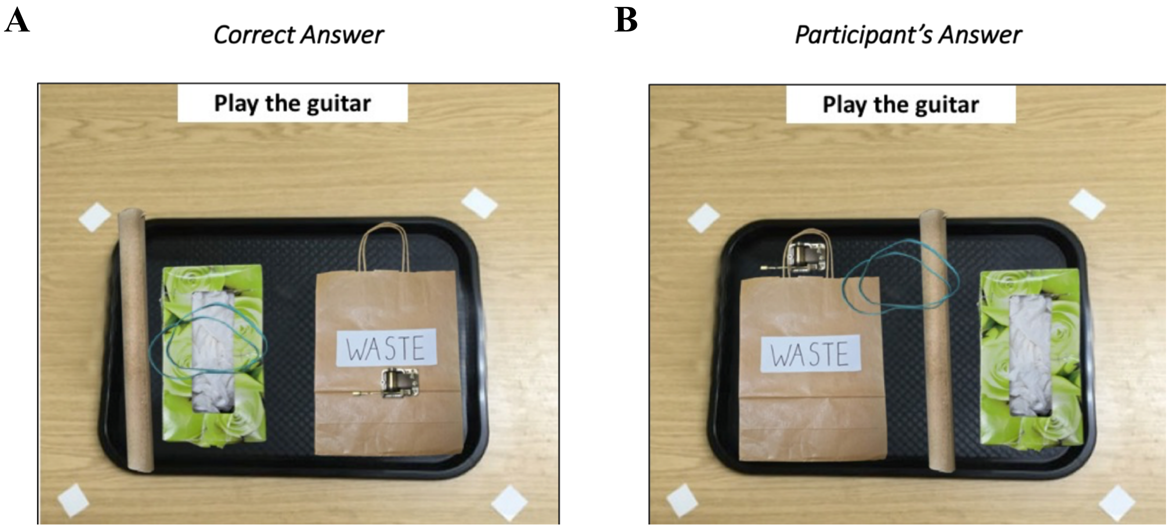

Figure 3.5 Example response on the spatial accuracy task in session 3.

(A) correct arrangements of objects on the tray; (B) participant's arrangement of objects that have been inverted left to right.

Discussion

The findings of this study revealed that seeing oneself in a photograph influences the visual perspective from which memories are later remembered and the egocentric representation of subsequent memories for complex events encoded in the lab. Similar effects were also found for memories that were not cued with the physical self during retrieval. Moreover, active relative to passive instructions to shift visual perspective contributed to changes in the subjective experience of memories during retrieval. These novel findings and their implications are discussed in light of previous literature below.

The current study contributes to the growing visual perspective literature by showing that active instructions to adopt a novel perspective during retrieval influences the online subjective experience of memories. In line with previous research (Butler et al., 2016; Berntsen & Rubin, 2006; Robinson & Swanson, 1993), these findings demonstrate that retrieval from an observer perspective not cued with the bodily self reduced online ratings of emotional intensity of memories compared to memories that were retrieved from the same perspective as encoding. Further, although no interaction effect emerged (probably due to the smaller mean differences between the perspective conditions across the two instruction groups), when examining vividness ratings in the two instructions group separately, adopting a novel perspective also reduced the vividness of memories compared to memories retrieved from an own eyes perspective. This replicates findings of Chapter 2 and support previous evidence that memories retrieved from an observer perspective are typically less vivid relative to own eyes memories (e.g., Butler et al., 2016; Rice & Rubin, 2009). Interestingly, these differences emerged only in the group that received active instructions of visual perspective. St Jacques and Schacter (2013) showed that even without explicit instructions to adopt a particular visual perspective, cueing memories with photos taken from a novel perspective still reduced the sense of reliving associated with memories compared to memories cued with the same perspective as encoding. The potential differences in the nature of the photo cues between the two studies may explain these findings. In St Jacques & Schacter, the viewpoint change also led to changes in the content of photographs such that there was a greater mismatch between the content of photographs taken from a novel viewpoint and those taken from the same angle as encoding, which might have driven the increase in reliving ratings for memories cued from the original encoding perspective. In the current study, the content of each mini-event showed in the photos was held fairly constant in both the own eyes and novel viewpoint. Although participants could see slightly different information about the objects (i.e., back side), both types of photographs showed the same encoding lab setting (and related mini-events objects) but from different viewpoints. This shows that it is the explicit instructions to adopt an observer visual perspective, rather than the nature of the retrieval cue, that drives the differences in the phenomenology of memories.

These changes in the subjective qualities of memories were not reported for memories that were cued with the physical self (but see vividness findings when analysing the two visual perspective instructions groups separately). When actively instructing participants to shift visual perspective, the presence of the self may have instead protected some of the phenomenology of memories, potentially due to the increase in self-focus (and possibly self-relevance) of these memories. The physical self in the photo cue also protected memory from changes in the spatial location from which the observer perspective originated. The observer perspective can originate from various spatial locations during memory retrieval and the location from which observer perspectives are constructed depends on the type of event to be recalled (e.g., McDermott et al., 2015; Rice & Rubin, 2011). However, in these studies, participants are typically asked to categorise the spatial location of naturally occurring observer memories. Here, I examined for the first time the spatial location of a ‘forced’ observer perspective, where the viewpoint of the novel perspectives was controlled using photographs showing the particular visual perspective to adopt. Memories cued with the physical self were more often experienced from the centre and less often from the left of the individual compared to memories that did not include the self. Critically, this effect only emerged for the group that did not receive specific instructions to adopt a particular visual perspective. These results may therefore suggest that instructing participants to adopt a particular visual perspective may have protected memories from subsequent changes in the spatial location from which they were later experienced, but that in the absence of direct instructions the presence of the self contributed to the maintenance of a more 'centred' perspective, that more closely matched the viewpoint from which photographs were taken.

Shifting perspective did not lead to differences in sense of reliving, vividness and emotional intensity of subsequent memories. Although previous studies using personal autobiographical memories reported changes in the phenomenology of subsequent memories (Butler et al., 2016; Sekiguchi & Nonaka, 2014), these effects were likely due to the nature and recency of mini-events encoded in the lab (see Chapter 2 for similar discussion on this). Critically, while the presence of the physical self did not influence these characteristics, it did contribute to changes in the visual perspective of subsequent memories.

Retrieving memories from both types of observer perspectives (i.e., cued with and without the physical self) in fact increased subsequent observer perspective ratings compared to memories that were not rehearsed during retrieval. Previous studies (Butler et al., 2016; St Jacques et al., 2017) showed that relative to retrieval from an own perspective or to baseline memories, shifting the perspective of memories initially experienced from a dominant own eyes perspective increased observer perspective ratings of later memories. Here, I show that the presence of the physical self in photos can also bias the visual perspective of subsequent memories. Critically, in Chapter 2, there were no differences in subsequent visual perspective due to shifting perspective; using similar memories for events encoded in the lab, the findings on own eyes ratings of the previous chapter even suggested that participants' perspective naturally shifted back to the same encoding perspective for the final recall. In the current study, despite the lack of differences in subsequent own eyes ratings, manipulating visual perspective by including a condition where participants could actively see themselves in the photograph may have increased the impact of adopting a novel perspective during retrieval (i.e., increasing the propensity to adopt the observer perspective). These results argue for a potential interference with retrieval of the physical self for memories not cued with the bodily self. In other words, the presence of the physical self contributed to the subsequent changes in visual perspective and potentially also influenced the visual perspective of memories retrieved from a novel perspective that were not cued with the bodily self.

The subsequent differences in visual perspective due to adopting an observer perspective during retrieval were also explained by some of the changes in the online subjective experience of memories. In particular, online differences in emotional intensity between the own eyes and observer perspectives (i.e., observer-self and observer-noself), but not the differences in vividness, predicted the increase in observer perspective ratings between the perspective conditions. Similarly, St Jacques et al. (2017) found that for memories retrieved from an observer perspective higher ratings of perspective maintenance and reductions in emotional intensity ratings during retrieval predicted subsequent changes in visual perspective. Here, differences in difficulty between the own eyes and the two observer perspective conditions did not uniquely contribute to subsequent differences in observer perspective ratings. Difficulty in retrieval due to the absence of the self modulated the changes in subsequent perspective (i.e., perhaps by reducing the quality of memory reactivation), but difficulty in retrieval due to the presence of the self did not contribute to the increase in observer perspective ratings. Thus, as discussed above, seeing oneself in a photo might have protected some of the phenomenological properties of memories to a greater extent relative to memories that were not cued with the physical self, and only changes in emotional intensity affected the perspective of subsequent memories when perspective was not directly manipulated. All in all, these results also demonstrate that the reductions in emotional intensity when adopting an observer perspective typically reported in the literature (e.g., Berntsen & Rubin, 2006; McIsaac & Eich, 2004; Robinson & Swanson, 1993) can also contribute to more persistent changes in the visual perspective from which memories are later experienced. Although further research is needed to better understand whether the physical self might affect online and subsequent changes in the phenomenology of memories, the current findings still show that adopting novel perspectives during retrieval can change the perspective of subsequent memories for events encoded in the lab and the presence of the self might modulate the long-term impact of adopting the perspective of an outside observer.

A novel finding of the current study is that the presence of the bodily self, and more generally adopting a novel perspective, reduced spatial accuracy of subsequent memories. In particular, it was found that egocentric spatial judgments of objects (i.e., the position of objects with respect to oneself) were overall less accurate for memories retrieved from a novel perspective compared to memories retrieved from the same perspective as encoding, regardless of whether this was cued with the physical self or not. Previous evidence on spatial perspective-taking showed that participants spontaneously adopt the perspective of a person in a photograph, such that they tend to reverse left/right of objects when making spatial relations judgments (i.e., judgment described as ‘to the person’s left/right’) (e.g., Samson et al., 2010; Tversky & Hard, 2009). Here I show that retrieval from a perspective cued with photographs taken from a viewpoint different from the original own eyes vantage point also led participants to compute spatial relations by reversing the left/right position of objects with respect to where they were sitting in the encoding session. As discussed in Chapter 2, imagining oneself from an outside perspective requires updating the spatial context of memories so that the person is an observer watching themselves from an external perspective. Findings of the current study show that these updating mechanisms of one’s egocentric reference frame also contribute to changes in egocentric representation of the memory. Critically, the left/right inversion of objects was not only due to the presence of the self, but also when the self was removed from the photo cue. Tversky and Hard (2009) showed that the absence of a person in the scene reversed the perspective-taking effect such that participants adopted their ‘own’ perspective when describing spatial judgments. However, as Cavallo et al. (2017) demonstrated, even the possibility of a human perspective such as an empty chair opposite the participants can engage cognitive effortful processes to reverse left/right of objects. The photographs used in this study to cue the observer-noself condition displayed an empty chair instead of the participant’s body, which might have potentially aided updating of one’s egocentric reference frame, thus resulting in mechanisms similar to perspective-taking by reversing left/right of objects.

Difficulty in retrieving from a novel perspective could have also potentially contributed to the reductions in egocentric accuracy. Adopting novel viewpoints during retrieval did not reduce egocentric accuracy compared to memories not retrieved during session 2, which might suggest a ‘weaker’ reactivation of the memory. However, online ratings of difficulty suggest that participants found it easier to retrieve from an own eyes perspective compared to memories cued with the physical self, but not compared to memories that did not include the physical self. Critically, although the mean difference was marginally significant, the data suggest that retrieval in the observer-self condition was more difficult than retrieval in the observer-noself condition. Thus, if retrieval difficulty was driving the differences in egocentric accuracy, one would expect to find reduced spatial accuracy only for memories cued with the physical self, which was not the case in the current study. In support of this, in Chapter 2, although examining overall accuracy for memory details, I found that online differences in perspective maintenance between own eyes and observer perspective conditions did not predict subsequent differences in memory accuracy. Moreover, if the difficulty in retrieving from a novel perspective decreased the accuracy for the spatial relations of objects, then one would expect to find differences even when objects are arranged with respect to one another. However, findings on the accuracy of allocentric spatial judgments (i.e., percentage of objects correctly arranged with respect to other objects on the tray) revealed only an advantage for memories retrieved from the same perspective as encoding compared to memories that were not rehearsed during session 2, but that allocentric judgments were equally accurate in the own eyes and observer perspective conditions. The spatial memory literature has shown that spatial judgments of objects are typically equally well remembered in testing conditions where participants have to imagine an array of objects from novel perspectives that are aligned parallelly (i.e., 180°) or orthogonally (i.e., 90° or 270°) to the initial study location (at 0°) (e.g., Mou & McNamara, 2002; Mou, McNamara, Valiquette, & Rump, 2004). Similarly, in the current study, the viewpoint of the observer perspective was parallelly aligned with the initial encoding viewpoint (i.e., 180° from the encoding viewpoint). Future research could investigate how retrieval from a novel viewpoint that is not directly aligned with the original encoding viewpoint affects subsequent allocentric (and egocentric) memory representations, as well as potentially contributing to changes in the visual perspective and spatial location of subsequent memories. Taken together, these findings show adopting a perspective different from encoding where one can physically see or imagine oneself from an outside vantage point recruits mechanisms similar to taking the perspective of another person. It would also be of interest to directly compare taking a different egocentric reference frame versus taking someone else’s perspective and understand whether the mechanisms involved in these processes lead to similar changes in memory accuracy and other properties of memories.

Another aim of the current study was to replicate findings of Chapter 2 and to extend these and previous findings (i.e., St Jacques & Schacter, 2013) by examining the role of the physical self in photographs taken from novel perspective in subsequent memory accuracy. In the current study, subsequent memory accuracy was overall better for memories that were retrieved in session 2 compared to baseline memories, consistent with evidence on the benefits of memory reactivation during retrieval and improved memory performance after photographic reviewing (e.g., Koutsaal et al., 1999; St. Jacques, Olm, & Schacter, 2013; St. Jacques, Montgomery, & Schacter, 2015). These findings also support previous studies that have used photographs of childhood memories to implant false memories (e.g., Wade et al., 2002; Lindsay et a;., 2004) showing that seeing oneself in a photograph can also lead to distortions in the way subsequent memories are remembered, influencing their visual perspective and accuracy for the spatial context. However, adopting novel perspectives during retrieval did not reduce subsequent memory accuracy when compared to maintaining an own eyes perspective and the presence of the physical self in photographs did not contribute to differences in the type of category details recalled (this latter finding was probably due to the delay introduced between perspective manipulation and subsequent memory test - see Chapter 2 for similar discussion on this). Some key differences between this study and Chapter 2 might explain the lack of the effects of shifting perspective on subsequent memory accuracy in the cued-recall test. In Chapter 2, the inclusion of the spatial relations of objects category in the short-answer questions may have contributed to the overall increase in accuracy found in the study, thus influencing the differences between perspective conditions, despite the lack of an interaction effect. Nonetheless, physical actions and spatial relations of objects were overall better remembered compared to all other category details. Moreover, the number of memories to be remembered was increased in the current study due to the inclusion of the additional observer perspective condition (i.e., cued with the physical self). Inspection of the means across the previous and the current study also showed that proportion correct within each perspective condition was lower in the current study, demonstrating that participants recalled the mini-events less accurately overall compared to the previous study (Experiment 1). Taken together, these methodological limitations may have contributed to the lack of differences in subsequent memory accuracy between the perspective conditions.

In sum, this study provides for the first time a direct investigation on the influence of seeing one's self from an external perspective, such as in photographs, on changes in subsequent memory. With the increase in the number of photographs we take and upload everyday on social networks and, in particular, the increase in the number of 'selfies', the current study provides some insights into the importance of better examining the role of the self in photographs on memory. The nature of photographs can distort how and what we remember about the past. Moreover, other research looking at the act of taking photographs and its effects on memories has shown that it can decrease what we subsequently remember about the photographed event (photo-taking impairment effect, e.g., Henkel, 2014; Soares & Storm, 2018). Given the findings of the current study showing that automatic photographs of oneself can change the visual perspective from which memories are remembered but also decrease their spatial accuracy, future studies should aim to investigate the effects of manually taking photographs of oneself (i.e., selfies) and how review of these can influence other properties of memory. Better understanding how the presence of the physical self in observer memories influences subsequent properties of memory can provide interesting insights in the mechanisms of visual perspective. It can further inform clinical settings, which often integrate personal photographs as a therapeutic tool to evoke inaccessible memories (see Halkola, 2009 for a review).

Conclusion. Seeing oneself from an outside perspective is similar to seeing oneself in a mirror or in a photograph (Sutin & Robin, 2008). The current study shows that the presence of the self in observer memories can influence the phenomenology of subsequent memories, in particular the visual perspective from which they are remembered, but also contributes to changes in egocentric memory representation by reducing spatial accuracy. Better understanding the role of the physical self in photographs will expand the theoretical understanding of how adopting a novel perspective during retrieval influences the properties of memory. It will also provide insights into similarities (and differences) between taking the perspective of an outside observer and the perspective of someone else contributing to the growing literature in theory of mind, as well as providing avenues for research in clinical settings

Chapter 4. How Shifting Visual Perspective During Memory Retrieval Distorts Subsequent Memories

Introduction

Memories are not an exact reproduction of our past, but are the result of active reconstructive processes (e.g., Bernstein & Loftus, 2009; Schacter, 1999) that can modify the way we remember past events. The ability to adopt different visual perspectives during memory retrieval reflects one of the ways in which memories can be reshaped as a consequence of reconstructive processes. Memories can in fact be retrieved from the visual perspective of one's own eyes, thus re-experiencing the event from the same vantage point as it was originally encoded, or from an observer perspective seeing yourself in the remembered event (Nigro & Neisser, 1983), reflecting a novel vantage point that is typically not experienced during memory encoding. Critically, shifting to a novel viewpoint during retrieval can contribute to changes in memories; it can lead to more persistent changes in the subjective qualities and visual perspective of memories (e.g., Butler et al., 2016; St Jacques et al., 2017) but also influence the accuracy with which subsequent memories are remembered St Jacques & Schacter, 2013; see also Chapter 2). Retrieval from this novel perspective may therefore reflect a type of memory distortion in that it can update and modify the original memory for the event. Moreover, research has showed that reactivation of memories with the integration of new information can lead to updating and distortions of the original memory (e.g., Hupbach, Gomex, Hardt, and Nadel, 2007) as it is the case for post-event misinformation or false memories (Chan & Langley, 2011; Loftus, 2005; Koutstaal et al., 1999). However, to date, only a few studies have directly investigated how adopting this novel perspective during retrieval can lead to distortions (e.g., St Jacques & Schacter, 2013; Memon & Higham, 1999; Memon, Cronin, Eaves, & Bull, 1993; Wells, Memon, & Penrod, 2006). The current study will examine how adopting different viewpoints during retrieval distorts subsequent memories, in particular how it influences subsequent true and false memories as well as the accuracy of subsequent visual perspective.

Studies have shown that changing visual perspective during retrieval influences the subjective experience (e.g., Berntsen & Rubin, 2006; Robinson & Swanson, 1993) and the content associated with the original event (e.g., Bagri & Jones, 2009; Eich et al., 2009; McIsaac & Eich, 2002). These effects have not only been demonstrated during immediate memory recall, but studies have shown that shifting visual perspective during retrieval can produce changes that can persist over time (e.g., Butler et al., 2016; Sekiguchi & Nonaka, 2014; St. Jacques & Schacter, 2017). For example, Butler et al. (2016) showed that shifting perspective can reduce the vividness of memories and that this reduction persisted even when participants were later asked to shift back to an own eyes perspective. Retrieving memories from a perspective different from the original encoding perspective can also alter the viewpoint from which memories are later remembered. For example, St. Jacques, Szpunar, and Schacter (2017) instructed participants to repeatedly shift from a dominant own eyes to an observer perspective and found that memories initially experienced from an own eyes perspective were later remembered from an observer perspective. Butler et al. (2016) found similar effects on subsequent visual perspective due to repeatedly shifting perspective. These results demonstrate that explicitly instructing participants to shift their perspective produces changes in the qualities of memories, but can also bias the visual perspective from which memories are later experienced. Critically, in these studies visual perspective was assessed using subjective ratings provided by participants; however, these changes may extend to more objective measure of visual perspective such as the accuracy which the original visual perspective is later remembered.

Shifting visual perspective also influences memory accuracy. For example, research on the recall techniques used in the Cognitive Interview during interrogation of eyewitness testimony has shown that asking witnesses to recall the event from alternative perspectives (i.e., change perspective technique), such as from the perspective of someone else in the scene, improves the accurate recall of information (Boon & Noon, 2004). However, other studies have suggested that the change in perspective does not increase the amount of details recalled and that it could even increase memory errors (e.g., Memon & Higham, 1999; Memon, Cronin, Eaves, & Bull, 1993; Wells, Memon, & Penrod, 2006). More recently, Bagri & Jones (2009) showed that adopting an observer perspective during retrieval of written passages reduced the amount of details recalled compared to memories retrieved from an own eyes perspective. Similar findings were also reported in Chapter 2 of this thesis, where across two studies I showed that shifting to an observer visual perspective during retrieval reduced subsequent accuracy for memories of complex events encoded in the lab. More specifically, in Experiment 1, participants were presented with photo cues of memories showing the particular visual perspective to adopt; in Experiment 2, I replicated the findings on memory accuracy by removing the photos to vary the effectiveness of the retrieval cue in reactivating memories. I showed that these effects were due to shifting to an alternative perspective rather than the nature of the retrieval cue in eliciting memories from different perspectives. Moreover, in Chapter 3, I demonstrated that shifting perspective can also affect egocentric representations in later memories. Specifically, participants were less accurate at computing spatial relations of objects with respect to the self for memories retrieved from novel perspectives compared to memories retrieved from the same perspective as encoding. Taken together, the previous literature suggests that memory retrieval from novel perspectives alters subsequent memory accuracy.

Retrieval is an active process that can facilitate memory recall (see for review Roediger & Butler, 2011), but also lead to memory updating processes with detrimental effects on subsequent recall (Anderson, 2003; Anderson, Bjork, & Bjork, 1994; Koutstaal et al., 1999; Roediger, Jacoby, & McDermott, 1996; St Jacques & Schacter, 2013; Schacter et al., 2011). Previous research has demonstrated that reactivating a stable memory can also render it prone to further modifications (e.g., Hardt, Einarsson, & Nader, 2010; Hupbach et al., 2007), and that the quality or intensity of reactivation of the memory modulates the degree of changes in subsequent memories (St Jacques & Schacter, 2013; St Jacques, Montgomery, & Schacter, 2015; St Jacques, Olm, & Schacter, 2013). For example, in misinformation paradigm asking questions containing misinformation during reactivation of complex events can result in the integration of the new information in later memory recall (e.g., Karpel, Hoyer, and Toglia, 2001; Rindal et al., 2016). It has also been demonstrated that false recollection can be induced during memory retrieval by reviewing photographs depicting objects different from those seen in the original event. Schacter et al. (1997) had participants watch videos of a series of everyday events and they were later asked to recall the events while looking at photographs that either depicted the same events as in the original videos or events that were not seen during the encoding session. In a later recognition task on original and misinformation objects, they found increased false recollection for objects that were presented in the photographs during retrieval. These results suggest that reactivating memories during retrieval with photos that include false information can lead to distortions of what is remembered about the original event. Crucially, the photos used in Schacter et al. (1997) were taken from the same viewpoint as encoding. However, a more recent study by St Jacques & Schacter (2013) showed for the first time that similar distortions are reported when memories are reactivated with photos taken from alternative viewpoints. More specifically, they varied the quality of memory reactivation by manipulating visual perspective during retrieval (i.e., Study 2) to examine how visual perspective affects subsequent true and false memories. After encoding memories for a guided museum tour, participants were cued with photos taken from the same visual perspective as encoding (i.e., reflecting greater memory reactivation) or with photos that showed a perspective different from the original encoding perspective (i.e., reflecting less memory reactivation). Using a recognition memory task, they found that accuracy was better for highly reactivated memories, retrieved from the original encoding perspective, relative to memories retrieved from an alternative perspective, thus less reactivated. Interestingly, they found that a higher degree of reactivation also increased false recognition of events that were not experienced during encoding. However, what still remains to be addressed is whether these effects were driven by the effectiveness of the retrieval cues to reactivate memories or were due to actively shifting perspective. Shifting perspective requires re-organising the spatial context of one's egocentric viewpoint, likely affecting the quality with which memories are reactivated. This might in turn render the memory labile and open for further modifications, such as allowing the integration of new information.

These questions can be addressed using memories created in the laboratory whereby we can exert control over the content and viewpoint of memories during retrieval. One of the advantages of lab-based over personal autobiographical memories is that memory accuracy can be verified. Critically, when visual perspective is manipulated, it is important to elicit memories that approximate the real-world. For example, some studies in memory have used standard 2D videos of everyday life events, enabling researchers to vary the contextual setting and environments of events to be encoded in the lab to create more realistic conditions (e.g., Bird et al., 2015; Koutstaal et al., 1998; see also Hasson et al. 2008). Schacter et al.'s (1997) study used standard 2D videos of everyday life events to examine the influence of photographs in creating false memories. Bird et al (2015) also used video clips as encoding stimuli to examine the behavioural and neural mechanisms of active rehearsal on accurate recall of memories for complex events. However, when studying visual perspective, it is critical to control for visual perspective of memories at baseline (see also Butler et al., 2016), such that events are experienced from an own eyes perspective. With conventional videos, the participant may not perceive themselves as an active agent within the event context, but rather as a passive observer in the audience. This may in turn affect the visual perspective of later memories, particularly during perspective manipulation. One way to overcome this is to design encoding tasks that can elicit a sense of immersion and agency (Cabeza et al., 2004). For example, in the mini-events paradigm used in Chapter 2 and 3, the sense of agency was ensured by having participants as active agents of each event context (i.e., actively engaged while performing the mini-tasks). Yet, these types of lab-based memories may still not approximate the real-world. The viewpoint from which these are encoded does not substantially vary across events, with little changes in the surrounding environment and context (i.e., participant sitting at the same location in the laboratory throughout the encoding session); by contrast, real-world memories are typically never experienced from one single viewpoint, rather they may be encoded within diverse and perceptually-rich environments. One way in which we can bridge the gap between these types of lab-based memories and the problems raised in eliciting visual perspective is to use immersive technologies, such as 360° videos. Immersive videos are a viable substitute to real-world memories where we can exert control over the content (i.e., to measure accuracy) and viewpoint of memories, whilst presenting participants with diverse environmental contexts at encoding. Moreover, the sense of presence (i.e. immersion) elicited by exploring an immersive environment versus watching the same environment on a computer monitor is increased and the experience can be perceived as more real and engaging compared to the 2D video experience (e.g., Gorini et al., 2011).

Thus, to examine how actively shifting perspective influences subsequent true and false memories as well as objective changes in subsequent visual perspective, I developed a novel paradigm using immersive 360° videos. Participants watched a series of immersive videos of complex everyday life events (e.g., making breakfast) through a virtual reality headset while exploring different indoor and outdoor environments. Critically, to ensure a sense of immersion and that participants would feel like active agents of the events, verbal interaction between the participants and the actors of each video event was also included. In each video, actors performed one unique action with a unique object (e.g., *pouring cereal* in a bowl), while interacting with the participant by asking questions (e.g., 'Is this enough for breakfast?'). In a subsequent session, participants were shown photos of some of the video events. To manipulate visual perspective, the angle in the photo cues either matched or mismatched the original encoding angle and participants were instructed to either maintain the angle in the photo cue or to rotate from the angle shown. Thus, they actively shifted back to encoding or actively shifted to a novel viewpoint. To examine subsequent true and false recognition memory, some of the photos showed the critical item seen during encoding (e.g., *cereal*), while others contained misinformation (in this example *biscuits* - a changed item not seen during encoding). Two days later, memory for both target and misinformation items was tested using a recognition memory task. Additionally, to investigate how visual perspective influences the perspective of subsequent memories, an objective measure of perspective accuracy was developed. Specifically, participants were presented a bird's eye view of the video events and were asked to adjust the angle of view to match the encoding vantage point (see Figure 4.1 for example). Thus, angle changes between encoding and final retrieval were measured to test for any differences in one's perspective as a consequence of shifting perspective. On the basis of the literature reviewed above, it is predicted that if the effectiveness of the retrieval cues in eliciting memories drives the subsequent changes in memories, then there should be reductions in subsequent true memories (and the accuracy with which subsequent perspective is remembered) for memories cued with photos that mismatch the encoding viewpoint. For subsequent false memories, the match of the retrieval cues should instead increase subsequent false alarms (see St Jacques & Schacter, 2013). However, the novelty of the viewpoint during memory retrieval, rather than the effectiveness of the retrieval cues alone, may impact memories; maintaining as well as actively shifting to a novel perspective should lead to subsequent reductions in true recognition memory and perspective accuracy. Alternatively, the subsequent memory distortions may be due to shifting perspective, such that shifting to viewpoints different from that shown in the photo cues may reduce subsequent true recognition memory and perspective accuracy, and potentially increase subsequent false alarms.

Experiment 1

Method

Participants

Thirty fluent English speakers were included in the experiment [18 women; mean age in years (*M*) = 20.70, SD = 2.71; mean years of education (*M*) =15.33, SD = 2.06]. They reported no history of psychiatric and/or mental health impairments, were not taking any medication that could affect cognitive function, and had normal or corrected to normal vision/hearing. They provided informed consent for a protocol approved by the School of Psychology at the University of Sussex.

Materials

Forty interactive 360º video events were filmed using a Ricoh Theta SC (Ricoh, Ota, Tokyo, Japan), a 360-degree spherical camera, at different 20 indoor and 20 outdoor locations unfamiliar to participants (e.g., experimenter’s garden). The videos consisted of unique real-life everyday events (e.g., grooming the horse; for an example video visit https://youtu.be/hVFTxj5u9PU; for a list of events see Appendix B). Depending on the nature and location of the particular event, videos were filmed at different heights by placing the cameras at eye level of a person standing (for activities that are typically performed while standing, e.g., playing volleyball), at the height of a person sitting on a chair (for indoor activities performed on a table, e.g., playing a board game) or in one case at the height of a person sitting on the floor (i.e., having a picnic in the park). Each version of each video event was also filmed from two different viewpoints that were 90° left or right of one another (see Figure 4.1 for an example) in order to enable us to manipulate the angle during retrieval in session 2. Participants were presented with video events from only one of the two angles in session 1. The angle each video event was presented from was randomly assigned and counterbalanced across participants.

In each video, one or two actors interacted with a *target* item (e.g., comb) by performing a specific action typical of an everyday life activity (e.g., using a *comb* to groom the mane of the horse). There were two versions of each video event. In each video the activity, the location and the actors were the same, but the *target* item presented differed (e.g., a *comb* vs. a *brush*). Participants saw only one version of each video event, and the alternative version was used to present the *misinformation* item in the later sessions. The two versions of the video were counterbalanced across participants. To create a fully immersive experience and to ensure that sufficient attention was directed to the target item, each video was designed to include a short interaction between the actor and the participant about the activity being performed. Specifically, at any point during the video actors directed their gaze to the camera (i.e., towards the perspective that the participant would experience the video from) and asked a specific question about the object being used by either pointing to it or moving it closer to the camera (e.g., do you think this is going to work?); a short period of time after each question was given to allow participants to verbally respond.

Videos were played in Whirligig, a VR media player, and displayed through an Oculus Rift DK2 VR Headset (Oculus VR, Menlo Park, California, United States). To equate the initial viewing angle (and to later measure changes in angle of view between encoding and retrieval in session 3) this was set to 0° in Whirligig for both tilt (up/down) and rotation (right/left) for the presentation of each video.

Procedure

The study involved three separate study sessions (see Figure 4.1).

Session 1**:** Participants watched forty 360º video events. Prior to each video event participants were prompted to sit or stand, after which the title of the video event was displayed (e.g., Snack on the Beach) for 10s, followed by the video event for 25s. Participants were instructed to verbally respond to questions asked by the actor, which was monitored by the experimenter in the room. An example video event was presented first in order to familiarise participants with the procedures. Each video lasted approximately 30s.

Session 2**:** Approximately one week later [mean delay (*M*) = 7.05 , SD = 0.89], participants were presented with titles and photos taken from 32 video events and asked to retrieve in detail their memory for the video depicted. The remaining 8 videos events were used in a baseline condition to assess potential changes in memory due to delay. During retrieval, participants were asked to maintain the same viewpoint depicted in the photo (maintain Condition) or to shift their perspective 90° to the left or right (shift Condition; see Figure 4.1). The photo cue was also manipulated by changing the angle such that it either matched or mismatched the original encoding angle from which participants viewed the video. Thus, there were four retrieval conditions: 1) maintain-match, 2) maintain-mismatch, 3) shift-match, and 4) shift-mismatch. For cues that matched encoding participants were instructed to i) *maintain* the same angle as shown in the photo cue (8 trials), thus maintaining the original encoding angle (*maintain-match*) OR ii) *rotate* 90° left or right (depending on the angle the video was taken from) from the angle shown in the photo cue (8 trials), thus shifting **away** from encoding to an alternative angle (*shift-match).* For cues that mismatched encoding participants could be instructed to i) *maintain* the angle shown in the photo cue (8 trials), thus maintaining an angle different from the original encoding angle (*maintain-mismatch*) OR ii) *rotate* 90° left or right from the angle shown in the photo cue (8 trials), thus shifting **back** to the original encoding angle (*shift-mismatch*). In order to investigate the influence of retrieval instructions on subsequent true and false memories, half of the photo cues (counterbalanced across retrieval condition) included the *target item* (i.e., the same object presented during Session 1), whereas the other half included a *misinformation item* (i.e., the object from the alternative version of the videos).

Participants were given a total of 30 s to retrieve each video event in as much detail as possible from the indicated angle. Photo cues along with the title and angle to adopt during retrieval were shown for 5 s, followed by another 25 s retrieval period where only the title and angle were displayed (see Figure 4.1). Immediately following each retrieval trial, participants were asked to provide subjective ratings on 5-point scales (1 = low to 5 = high) on the following characteristics: difficulty in retrieving the video event from the indicated angle, how consistently they could maintain the indicated angle, emotional intensity, sense of reliving, vantage point adopted while retrieving the event (own eyes and observer ratings given on two separate scales), and how vivid their memory was.

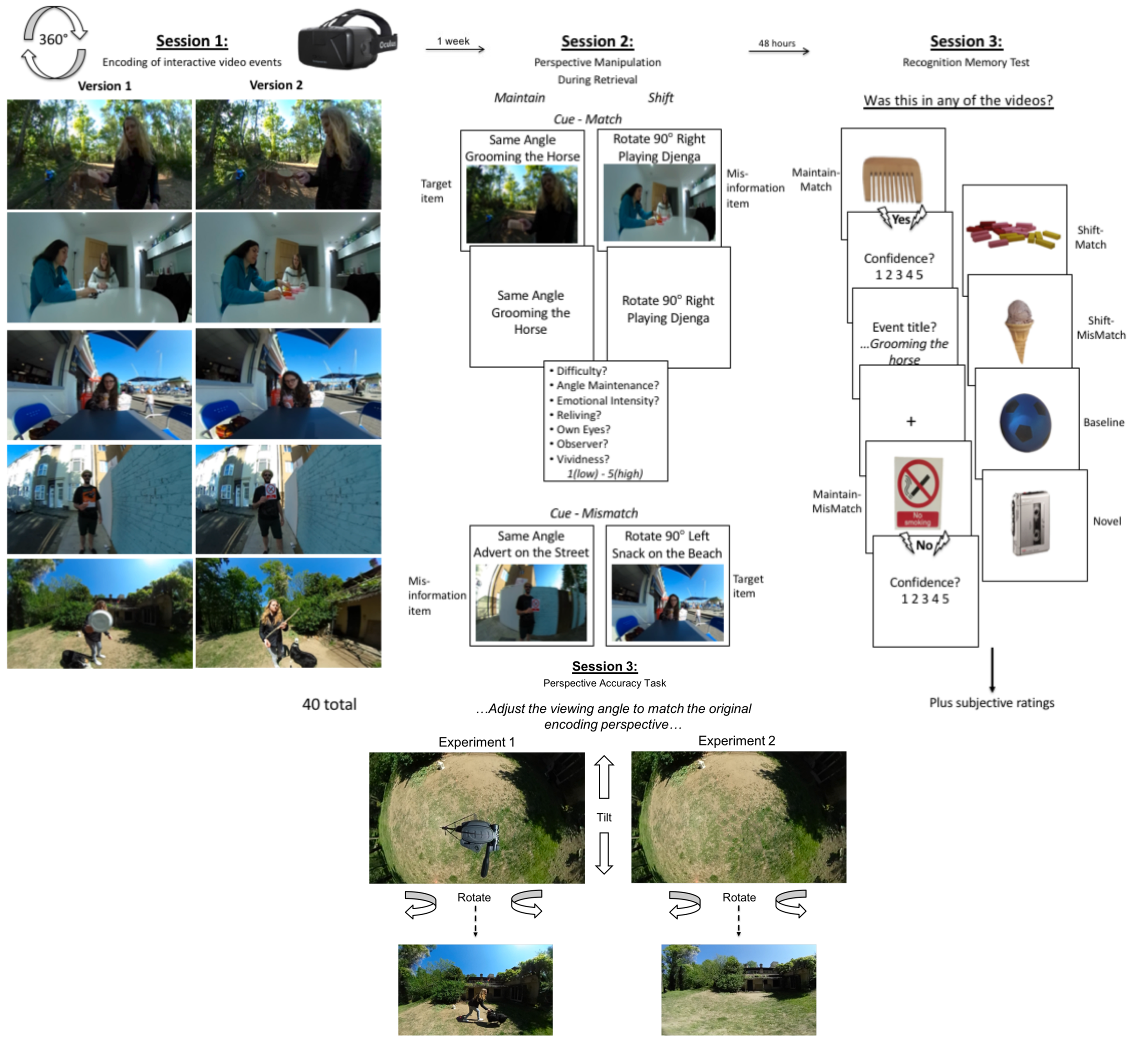

Figure 4.1 Experimental Design.

The study took place in three separate sessions. In Session 1, participants watched a series of 360-degree video events using a VR headset. In Session 2, they were asked to retrieve some of the video events cued by photos that either matched or mismatched the original encoding angle. For some trials, they were asked to maintain the angle of the photos (maintain-match and maintain-mismatch conditions); for other trials, they were asked to rotate 90-degree right or left from the angle shown in the photos. Critically, for cue match trials, they shifted away from encoding; for cue mismatch trials, they shifted back to original encoding angle. Half of the photos cues were presented with the target item (i.e., seen in session 1), whereas the other half were presented with a changed item (i.e., misinformation – not seen in session 1). After each retrieval trial, participants rated their memories on a series of characteristics. Session 2 of Experiment 2 was identical, except that participants were allowed 4 retrieval repetitions of each video event (instead of just one). In Session 3, memory was tested using a recognition memory test by showing pictures of target, changed and novel items; this was followed by additional subjective ratings. The perspective accuracy task was the final task. Participants were presented bird's eye views screenshots of the video events and asked to adjust the viewing angle to match the original encoding perspective. In Experiment 2, the screenshots were identical, except that the actors were removed.

<u>Session 3</u>: Two days later participants had a final memory test consisting of a recognition memory test, subjective ratings, and a perspective memory task. During the recognition memory test**,** participants were presented with 48 pictures of items: 20 *target* and 20 *misinformation* items along with 8 *novel* items that they had never seen before and were asked to indicate whether the object was shown during the videos presented in session 1 (see Figure 4.1 for example of items). They were also asked to rate how confident they were about their response on a 5-point scale (1 = low to 5 = high). Following the confidence rating and only after each 'Yes' response, participants were additionally asked to type the title of the event corresponding to the object. The order of presentation of objects was randomized across participants.

After the recognition memory test, participants were asked to provide subjective ratings about their memories for each of the video events. They were presented with the title along with a short description of each video event (e.g., grooming the mane of the horse) and asked to provide subjective ratings on a 5-point scale (1 = low to 5 = high) on each of the following characteristics: emotional intensity, sense of reliving, the visual perspective from which they remembered the event (separately for own eyes and observer), how vivid their memory was, and how accurately they felt their memory was (i.e., recalling all the details of the event exactly as they occurred). Both the recognition memory test and the subjective rating tasks were self-paced.

The final memory test examined the accuracy of their perspective for the original video events. Specifically, participants were presented with a birds eye view of 360-degree still shots taken from the videos and were asked to change the tilt and rotation of the image to match the original encoding perspective. The angle of view of the still shots was set to start from the following coordinates on the Whirligig VR Media Player: tilt = -110°; rotation = 0° (see Figure 4.1. for example of the bird's eye view of the still shot). Importantly, in order to avoid potential bias in the direction of the actors gaze, still shots were taken from moments of the videos when the actor(s) was not interacting with the participant/camera. Participants were presented with the title of each video event for 5s followed by still shots of the 360-degree environment through the Oculus Rift and then used the keyboard to tilt the image up/down and rotate it right/left. Errors for both tilt and rotation measures were calculated as the difference between the participant's response and the initial angle of view (i.e., 0° in session 1).

Results

Session 2

Subjective Ratings. To determine potential differences in the subjective ratings made during retrieval in Session 2, a series of 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVA were conducted on each subjective rating separately (for means and SD see Table 4.1). Bonferroni correction was used in all *post-hoc* analysis to control for multiple comparisons. There was a Cue x Perspective interaction on difficulty ratings, F (1,29) = 13.66, p = .001, partial η2 = .32. Follow-up analysis revealed that this interaction was explained by a greater ease in maintaining the angle shown in the photo cue when the cues matched versus mismatched encoding, $p < .001$. Further, for cues that matched encoding, participants found it more difficult to shift away from the original encoding perspective (i.e., shift-match) compared to maintaining the same encoding perspective (i.e., maintain-match), p = .01. For angle maintenance ratings, there was a main effect of Cue, F (1,29) = 4.82, p = .04, partial η2 = .14, with higher ratings for cues that matched encoding (M = 3.41, SD = 0.81) compared to cues that mismatched encoding (M = 3.26, SD = 0.70). There was also a main effect of Perspective, F (1,29) = 19.44, $p < .001$, partial η2 = .40, with greater ease in maintaining the same angle as shown in the cues (M = 3.57, SD = 0.79) relative to shifting to a different angle (M = 3.10, SD = 0.65). Similar to the findings with difficulty ratings, there was also a Cue x Perspective interaction, F (1,29) = 7.48, p = .01, partial $\eta 2 = .21$. Follow-up analysis showed that participants were less able to maintain the angle in the photo when the cues mismatched versus matched encoding, $p = .002$. For cues that matched encoding, they were less able to keep the angle in the photo in the shift perspective condition compared to the maintain perspective condition, $p < .001$. Interestingly, for both subjective ratings, there were no differences between the two shift conditions (i.e., irrespective of whether they shifted away or shifted back to encoding). Thus, these results suggest that adopting a perspective that is different from the original encoding perspective requires more effort compared to maintaining the original encoding perspective, and that actively shifting to a perspective that was never experienced before is similarly difficult to actively shifting back to the original encoding perspective.

Turning to visual perspective ratings (see Figure 4.2), there was a main effect of Perspective on own eyes ratings, $F(1,29) = 10.13$, $p = .003$, partial $\eta 2 = .26$, with higher ratings in the maintain perspective condition ($M = 3.56$, SD = 0.65) compared to shift perspective condition ($M = 3.27$, SD = 0.58). However, there was also a Cue x Perspective interaction, $F(1,29) = 14.65$, $p = .001$, partial $\eta 2 = .34$, which showed an increase in own eyes ratings for the maintain-match compared to the maintain-mismatch condition, $p < .001$. Own eyes ratings were also higher for the shift-mismatch condition relative to the shift-match condition, $p = .04$. Interestingly, the opposite effect was found for observer ratings. There was a main effect of Perspective, $F(1,29) = 5.53$, $p = .03$, partial $\eta 2 = .16$, with higher ratings in the shift ($M = 2.60$, SD = 0.70) relative to the maintain ($M = 2.31$, SD = 0.88) perspective condition. A Cue x Perspective interaction was also found, $F(1,29) = 8.60$, $p = .006$, partial $\eta 2 = .23$, revealing that participants gave higher observer ratings both in the maintain-mismatch relative to the maintain-match condition, $p = .03$, and in the shift-match compared to the shift-mismatch condition, $p = .02$. Thus, despite not explicitly instructing participants to adopt an own eyes or observer perspective, the manipulation of angle during retrieval still influenced the viewpoint of memories: actively shifting back to encoding (and retrieving from the same perspective as encoding) was associated with seeing the remembered event more from an own eyes perspective, while actively shifting to a novel perspective mirrored the adoption of an alternative perspective that was not experienced during encoding.

The main effect of Perspective was not significant on emotional intensity nor on reliving ratings (nor any interactions were found). Similarly, for vividness ratings, the main effect of Perspective was not significant, whereas the Cue X Perspective interaction was approaching significance, $F\,(1,29) = 3.78$, $p = .06$. Thus, adopting different perspectives during retrieval did not influence online subjective ratings of immersive memories.

Table 4.1. Means (with standard deviations) for subjective ratings in Session 2 perspective manipulation.

	Study 1				**Study 2**			
	Maintain		*Shift*		*Maintain*		*Shift*	
Subjective Rating	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*
Difficulty	2.13	2.60	2.63	2.43	1.80	2.19	2.50	2.39
	(0.70)	(0.65)	(0.73)	(0.61)	(0.62)	(0.64)	(0.59)	(0.58)
Angle Maintenance	3.80	3.34	3.02	3.18	4.23	3.65	3.24	3.41
	(0.79)	(0.73)	(0.63)	(0.67)	(0.50)	(0.62)	(0.66)	(0.65)
Emotional Intensity	2.25	2.14	2.24	2.20	2.49	2.41	2.31	2.32
	(0.75)	(0.69)	(0.67)	(0.60)	(0.86)	(0.89)	(0.67)	(0.75)
Reliving	3.19	2.98	2.91	3.03	3.64	3.41	3.16	3.24
	(0.64)	(0.67)	(0.56)	(0.62)	(0.71)	(0.79)	(0.55)	(0.58)
Own eyes perspective	3.82	3.30	3.13	3.41	4.19	3.74	3.34	3.55
	(0.55)	(0.65)	(0.43)	(0.68)	(0.48)	(0.53)	(0.58)	(0.62)
Observer perspective	2.13	2.48	2.78	2.43	2.23	2.59	2.97	2.70
	(0.86)	(0.88)	(0.58)	(0.77)	(1.09)	(0.86)	(0.69)	(0.84)
Vividness	3.49	3.23	3.26	3.28	3.92	3.64	3.42	3.46
	(0.62)	(0.67)	(0.57)	(0.52)	(0.52)	(0.60)	(0.53)	(0.54)

Session 3

Subjective Ratings. To examine changes in the phenomenology of subsequent memories, separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs were conducted on the difference score between the retrieval condition and baseline on each subjective rating of Session 3 (for means and SD see Table 4.2). There was a Cue x Perspective interaction on emotional intensity ratings, F (1,29) = 4.69, p = .04, partial η2 = .14. This interaction was explained by a decrease in emotional intensity in the shift-mismatch condition relative to both the shift-match, p = .03, and to the maintain-mismatch conditions, p = .03. This shows that actively shifting back to the encoding viewpoint did not increase the emotions associated with the original event, but also that emotional intensity was not reduced when retrieving from novel viewpoints.

There was a main effect of Perspective both on reliving ratings, F (1,29) = 8.49, p = .007, partial η2 = .23, and on accuracy ratings, F (1,29) = 5.03, p = .03, partial η2 = .15. Follow-up analysis indicated that reliving ratings were higher in the maintain (M = 3.21, SD = 0.72) compared to the shift (M = 3.05, SD = 0.72) perspective conditions; similarly, higher accuracy ratings were reported for maintain (M = 3.41, SD = 0.51) relative to shift (M = 3.28, SD = 0.52) conditions. The main effect of Perspective on vividness ratings was, however, not significant. Thus, actively shifting perspective (irrespective of whether shifting away or back to encoding) influenced some of the properties of memories only after a delay (e.g., no differences in reliving in Session 2). Not only did participants feel that their memories were less accurate (relative to maintaining the same angle as in the photo cues), but they also showed a decrease in the sense of re-experiencing their memories for the video events.

Own eyes and observer ratings were analysed separately. First, for own eyes ratings, there was a main effect of Perspective, F (1,29) = 6.09, p = .02, partial η2 = .17, with higher own eyes ratings when maintaining the same perspective compared to shifting perspective. There was no main effect of Cue or interaction between Cue and Perspective. Second, for observer ratings, the main effect of Perspective was not significant. The Cue x Interaction was also not significant F (1,29) = 2.13, p = .15, partial η2 = .07, however, inspection of the means showed that the findings were in the opposite direction as own eyes ratings with numerically higher ratings when shifting away from the original angle compared to maintaining the same angle as encoding. These results parallel the visual perspective ratings reported in session 2, at least for the own eyes ratings, but also show that differences in visual perspective are only partially maintained after a delay. Thus, although there were no differences between Cue types (i.e., match vs. mismatch), actively shifting perspective during retrieval still led to changes in the viewpoint from which the memory was recalled.

Table 4.2. Mean (with standard deviations) for subjective ratings in Session 3.

	Study 1					**Study 2**				
	Maintain		*Shift*			*Maintain*		*Shift*		
Subjective Rating	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*
Emotional Intensity	2.38	2.47	2.46	2.27	2.10	2.66	2.66	2.56	2.61	2.08
	(1.02)	(0.87)	(0.96)	(0.96)	(0.80)	(0.78)	(0.92)	(0.77)	(0.85)	(0.69)
Reliving	3.21	3.20	3.15	2.95	2.52	3.48	3.36	3.22	3.27	2.29
	(0.72)	(0.73)	(0.65)	(0.79)	(0.72)	(0.69)	(0.72)	(0.64)	(0.77)	(0.61)
Own eyes perspective	3.76	3.67	3.53	3.55	3.03	4.06	3.76	3.75	3.70	2.90
	(0.76)	(0.63)	(0.82)	(0.90)	(0.83)	(0.52)	(0.62)	(0.62)	(0.53)	(0.71)
Observer perspective	1.98	2.04	2.18	2.01	1.94	2.26	2.43	2.47	2.48	1.96
	(0.92)	(0.84)	(1.00)	(0.93)	(0.80)	(1.05)	(0.89)	(0.90)	(0.86)	(0.91)
Vividness	3.36	3.29	3.30	3.29	2.57	3.73	3.53	3.34	3.40	2.33
	(0.43)	(0.41)	(0.43)	(0.59)	(0.58)	(0.45)	(0.61)	(0.63)	(0.55)	(0.60)
Accuracy	3.43	3.40	3.33	3.23	2.60	3.48	3.40	3.18	3.21	2.20
	(0.55)	(0.48)	(0.40)	(0.62)	(0.53)	(0.54)	(0.61)	(0.54)	(0.65)	(0.63)

Note: BA = baseline

Recognition Memory Test. To examine recognition memory as a function of retrieval condition, analyses of hits and false alarms rated were conducted on the difference scores (retrieval condition minus baseline) in separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs (see Table 4.3 for proportion of hits and false alarms). However, there was no main effect of Cue nor of Perspective for hit rates nor for false alarms rates. Thus, adopting different viewpoints during retrieval did not contribute to differences in subsequent true and false memories.

Table 4.3. Mean proportion (with standard deviations) of Hits and False Alarms.

	Study 1					Study 2				
	Maintain		*Shift*			*Maintain*		*Shift*		
	Cue Match	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*
Hits	0.71	0.63	0.70	0.67	0.48	0.66	0.76	0.64	0.78	0.43
	(0.22)	(0.23)	(0.22)	(0.21)	(0.28)	(0.23)	(0.22)	(0.26)	(0.23)	(0.20)
False Alarms	0.33	0.30	0.41	0.32	0.20	0.44	0.37	0.41	0.45	0.14
	(0.23)	(0.20)	(0.27)	(0.24)	(0.18)	(0.27)	(0.25)	(0.24)	(0.30)	(0.20)

Note: BA = baseline

Perspective Accuracy Task. Changes in the angle of the tilt and rotation of the videos were examined to determine whether adopting different viewpoints during retrieval led to changes in the visual perspective of subsequent memories. Scores closer to 0^o reflected a greater similarity with the original viewpoint. Note that four participants had to be excluded from this analysis due to technical difficulties with Whirligig Media Player when recording responses, thus the following results are based on a total of $N = 26$.

Tilt and rotation difference error scores between each retrieval condition and baseline were entered in two separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs (see Table 4.4 for mean tilt and rotation error scores). For rotation error scores, there was a significant Cue X Perspective interaction F (1,25) = 6.13, p = .02, partial η2 = .20. Follow-up analysis revealed that there were greater errors in the maintain-mismatch compared to the shift-mismatch condition, p = .049. The difference in rotation error scores between the maintain-match and maintain-mismatch condition was approaching significance, p = .06. These results show that shifting back to encoding protected subsequent memories from changes in perspective accuracy compared to maintaining an angle different from encoding (see Figure 4.3A). There were no differences in tilt errors between the conditions.

Table 4.4. Mean error score (with standard deviations) of Tilt and Rotation of perspective accuracy task.

	Study 1					**Study 2**				
	Maintain		*Shift*			*Maintain*		*Shift*		
	Cue Match	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*	*Cue Match*	*Cue MisMatch*	*Cue Match*	*Cue MisMatch*	*BA*
Tilt	16.37	16.71	16.46	17.23	15.85	20.52	21.00	20.06	19.44	19.63
	(8.85)	(8.22)	(9.90)	(9.69)	(7.29)	(10.76)	(11.78)	(10.39)	(10.73)	(10.81)
Rotation	17.29	21.19	19.34	16.84	20.73	17.33	28.75	21.33	32.46	21.86
	(8.23)	(12.31)	(6.71)	(9.59)	(12.70)	(7.77)	(12.65)	(9.58)	(17.19)	(10.68)

Note: BA = baseline

Experiment 2

Although our angle manipulation led to some changes in the phenomenological properties of the memories (which persisted even after a delay), it is possible that one retrieval attempt may have not been a strong enough manipulation to see effects of visual perspective on subsequent memory. Previous studies reporting subsequent memory changes as a result of shifting visual perspective have typically used four retrieval repetitions (e.g., Butler et al., 2016; St Jacques et al., 2017). Additionally, in Chapter 2, I showed that repeatedly shifting perspective reduced subsequent memory accuracy compared to repeated retrieval from an own eyes perspective. However, the current study did not find any significant effects of perspective during retrieval on subsequent memory accuracy (i.e., recognition memory). Thus, based on this evidence, in Experiment 2 the number of retrieval repetitions during session 2 angle manipulation was also increased to four.

Further, actively shifting back to encoding (i.e., when the cue mismatched the encoding viewpoint) protected memories from subsequent changes in perspective compared to maintaining a novel viewpoint. However, actively shifting to a novel viewpoint did not contribute to changes in subsequent perspective accuracy. One possible limitation is that the presence of the actors in the screenshots might have facilitated participants' perspective; people may have used the actors in the video screenshots to adjust the viewpoint thereby removing potential further differences between perspective conditions. These issues were addressed in Experiment 2.

Method

Participants

Thirty fluent English speakers were included in the experiment [18 women; mean age in years (*M*) = 21.45, SD = 3.11; mean years of education (*M*) =15.81, SD = 1.83]. They reported no history of psychiatric and/or mental health impairments, were not taking any medication that could affect cognitive function, and had normal or corrected to normal vision/hearing. They provided informed consent for a protocol approved by the School of Psychology at the University of Sussex.

Procedure

The study procedure was identical to Experiment 1, except that four retrieval repetitions were included during session 2 instead of a single retrieval [mean delay session 1 - session2 (*M*) = 6.33, SD = 1.15]. Participants retrieved each video event four times in an interleaved fashion. Additionally, for the perspective accuracy task in session 3 we removed the actors (and any object central to the video scene) from the still shots to reduce the possibility that participants used this information to adjust the viewpoint to match their position in the video. Thus, each still shot of the videos only showed the spatial context/environment of the video event.

Results

Subjective Ratings

Session 2. To examine potential differences in the subjective ratings made during retrieval in Session 2, we conducted a series of 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVA on each subjective rating separately (for means and SD see Table 4.1).

The ANOVA on difficulty ratings revealed a main effect of Cue, F (1,29) = 7.61, p = .01, partial η2 = .21, with greater difficulty during retrieval when cues mismatched encoding (M = 2.29, SD = 0.61) compared to cues that matched encoding (M = 2.15, SD = 0.70). There was also a main effect of Perspective, F (1,29) = 15.01, p = .001, partial η2 = .34, with greater difficulty in the shift Perspective condition (M = 2.44, SD = 0.59) relative to the maintain Perspective condition (M = 2.00, SD = 0.65). We also found a Cue x Perspective interaction, F (1,29) = 11.94, p = .002, partial η2 = .29. Follow-up analysis revealed that participants found it more difficult to maintain the angle shown in the photo cue when the cues mismatched versus matched encoding, $p < .001$. Further, for cues that matched encoding, it was more difficult to shift compared to maintain the perspective in the cues, $p < .001$. The findings for angle maintenance ratings were similar to the difficulty ratings. We found a main effect of Cue, F (1,29) = 25.61, $p < .001$, partial η2 = .47, with better angle maintenance for cues that matched (M = 3.74, SD = 0.77) versus mismatched (M = 3.53, SD = 0.64) encoding. There was also a main effect of Perspective, F (1,29) = 23.45, $p < .001$, partial η2 = .45, with greater ease when maintaining (M = 3.94, SD = 0.63) compared to shifting (M = 3.33, SD = 0.65) perspectives. However, we again found a Cue x Perspective interaction, F (1,29) = 20.03, $p < .001$, partial η2 = .41. Follow-up analysis showed that participants were less able to maintain the perspective in the photo when the cues mismatched versus matched the encoding perspective, $p < .001$. Again, for cues that matched encoding, they had better angle maintenance in the maintain perspective compared to the shift perspective condition, $p < .001$. For both ratings, we did not find any differences between the two shift conditions (i.e., irrespective of whether they shifted away or shifted back to encoding). These results replicate and extend those of Experiment 1 by showing that even when increasing the number of retrieval repetitions, participants found it more difficult to maintain a novel perspective compared to maintaining the same encoding perspective, but that repeatedly shifting to a novel perspective was similarly difficult to repeatedly shifting back to the original encoding perspective.

Turning to visual perspective ratings (see Figure 4.2), there was a main effect of Cue on own eyes ratings, F (1,29) = 8.02, p = .008, partial η2 = .22, with higher own eyes ratings for cues that matched encoding (M = 3.76, SD = 0.68) compared to cues that mismatched (M = 3.64, SD = 0.58) the encoding angle. There was also main effect of Perspective, F (1,29) = 15.93, p < .001, partial η2 = .36, with higher own eyes ratings when maintaining (M = 3.96, SD = 0.55) compared to shifting perspective (M = 3.44, SD = 0.60). However, these main effects were qualified by a Cue x Perspective interaction, F (1,29) = 17.89, p < .001, partial η2 = .38. Post-hoc analyses indicated that the interaction was explained by higher own eyes ratings in the maintain-match compared to the maintain-mismatch conditions, p < .001, as well as in the shift-mismatch relative to the shift-match condition, p = .02. Similar to Experiment 1, the opposite effect was found for observer ratings. There was a main effect of Perspective, F (1,29) = 7.88, p = .009, partial η2 = .21, with higher observer ratings when shifting (M = 2.84, SD = 0.77) compared to maintaining (M = 2.41, SD = 0.99) the perspectives. There was also a Cue x Perspective interaction F (1,29) = 11.49, p = .002, partial η2 = .28, which showed that the maintain-mismatch condition was associated with higher observer ratings compared to maintain-match condition, p = .003. Participants also gave higher observer ratings in the shift-match relative to the shift-mismatch condition, p = .01. Thus, these findings show that repeated retrieval while shifting back to or maintaining the original encoding perspective increased own eyes perspective ratings, while shifting to or maintaining a novel perspective led to an increase in observer perspective ratings.

Similar to Experiment 1, retrieval did not influence online differences in emotional intensity; there were no main effects nor an interaction. However, unlike Experiment 1, the ANOVA revealed a significant main effect of Perspective on reliving ratings, F (1,29) = 3.12, *p* = .005, partial η2 = .24, , showing that memories retrieved while maintaining (*M* = 5.52, SD = 0.75) compared to shifting (*M* = 3.20, SD = 0.56) had a greater degree of reliving. This was qualified by a Cue X Perspective, *F* (1,29) = 12.02, *p* = .002, partial η2 = .29. Repeatedly retrieving memories in the maintain-match condition increased vividness and reliving ratings relative to memories retrieved in the maintain-mismatch condition (*p* = .02). Reliving ratings were also higher for memories retrieved in the maintain-match compared to the shift-match condition, *p* < .001. Identical effects were found on vividness ratings; there was a main effect of Perspective, *F* (1,29) = 12.05, *p* = .002, partial η2 = .29, explained by a significant interaction, *F* (1,29) = 12.02, *p* = .002, partial η2 = .29. Thus, these results show that repeated retrieval while maintaining a novel perspective as well as actively shifting to a novel perspective reduced the sense of reliving of memories and these memories were also less vivid.

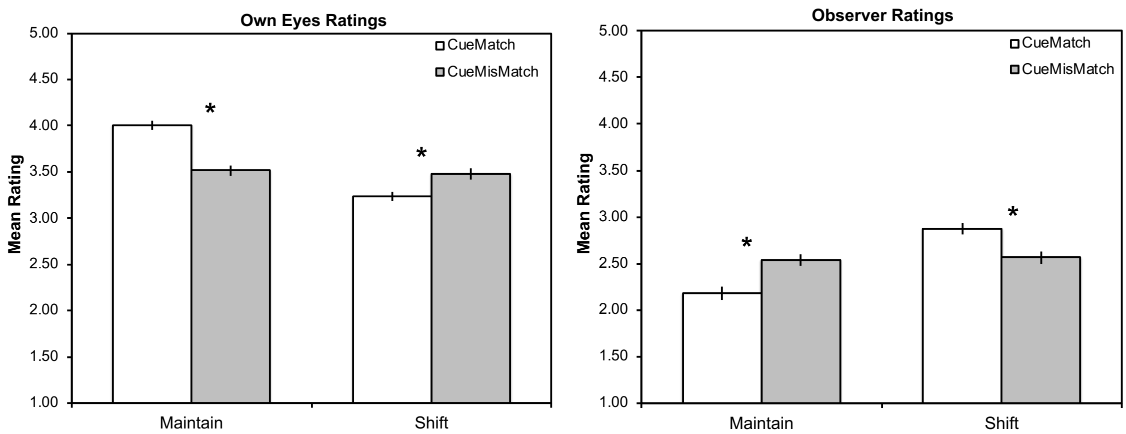

Figure 4.2 Visual perspective ratings in Session 2 perspective manipulation.

Data are collapsed across Experiment 1 and Experiment 2. Maintaining an angle in the cue that matched encoding and actively shifting back to encoding increased own eyes ratings during retrieval, whereas maintaining an angle that mismatched encoding and actively shifting to a novel viewpoint increased observer ratings. Error bars represent within-subject standard error.

Session 3

Subjective Ratings. To examine changes in the phenomenology of subsequent memories, separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs were conducted on the difference score between each retrieval condition and baseline on each subjective rating (for means and SD see Table 4.2). There were no differences in emotional intensity. However, similar to Experiment 1, there was a main effect of Perspective both on reliving ratings, F (1,29) = 5.00, p = .03, partial η2 = .15, and on accuracy ratings, F (1,29) = 9.20, p = .01, partial η2 = .24. Follow-up analysis indicated that reliving ratings were higher in the maintain perspective (M = 1.13, SD = 0.70) compared to the shift perspective (M = 0.96, SD = 0.55) conditions; similarly, higher accuracy ratings were reported for maintain (M = 1.24, SD = 0.75) relative to shift perspective (M = 0.99, SD = 0.55) conditions. The ANOVA performed on vividness ratings also revealed a main effect of Perspective, F (1,29) = 11.49, p = .002, partial η2 = .28, with higher level of vividness for the maintain (M = 1.31, SD = 0.71) relative to the shift (M = 1.04, SD = 0.57) perspective conditions. Thus, these results replicate and extend the findings of Experiment 1 and show that repeatedly shifting perspective (irrespective of whether shifting away or back to encoding) influenced some properties of subsequent memories; participants felt that, even after a delay, the sense of re-experiencing for the original memory was reduced and that these memories were also less vivid and perceived as less accurate. Repeatedly shifting perspective did not, however, influence the emotions with which memories were subsequently experienced.

Turning to visual perspective ratings, there was a main effect of Cue on own eyes ratings, F (1,29) = 4.91, p = .04, partial η2 = .15, with higher own eyes ratings for cues that matched (M = 1.00, SD = 0.64) versus cues that mismatched (M = 0.83, SD = 0.69) the encoding angle. However, this main effect was qualified by a Cue x Perspective interaction,

F (1,29) = 14.79, p = .001, partial η2 = .34. Follow-up analysis showed that participants gave higher own eyes ratings in the maintain-match condition compared to both the maintain-mismatch and shift-match conditions, both p_s < .001. The Cue X Perspective interaction on observer ratings was not significant nor any main effects were found for observer ratings. Thus, repeated retrieval while maintaining the same perspective as encoding increased own eyes ratings relative to both repeated retrieval while maintaining a perspective different from encoding and actively shifting to a novel viewpoint.

Recognition Memory Test. To examine whether repeated retrieval from different perspectives had an effect on subsequent true and false memories, two separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs were conducted on the difference score in hits and false alarm rates between each retrieval condition and baseline (see Table 4.3 for proportion of hits and false alarms). For hit rates, there was a main effect of Cue, F(1,29) = 8.75, p = 0.01, partial η2 = .23, with a higher proportion of hits for cues that mismatched (M = 0.77, SD = 0.22) compared to cues that matched encoding (M = 0.65, SD = 0.22). No main effects nor an interaction were found on false alarm rates. Thus, these results suggest that memories cued with photos that mismatched encoding increased subsequent true memories, but that adopting different perspectives during retrieval did not influence subsequent false memories.

Perspective Task. To determine potential differences in subsequent visual perspective accuracy as a result of adopting different angles during retrieval when the actors were removed from the video screenshots, changes in the angle of the tilt and rotation of the videos were examined. Similar to Experiment 1, scores closer to 0^{o} reflected greater similarity with the original viewpoint. One participant had to be excluded from this analysis due to technical difficulties with Whirligig media player during recording of responses, thus the following results are based on a total of N = 29.

Two separate 2 (Cue: match, mismatch) x 2 (Perspective: maintain, shift) repeated measures ANOVAs were conducted on the difference error score between each retrieval condition and baseline on tilt and rotation. For rotation error scores, there was a main effect of Cue, F (1,28) = 26.64, $p < .001$, partial η2 = .46, reflected by greater errors when the cues mismatched (M = 8.74, SD = 16.06) compared to when cues matched the encoding angle (M = -2.53, SD = 10.67; see Figure 4.3B). The main effect of Perspective approached significance, F (1,28) = 3.92, p = .06; this main effect suggested that participants made greater rotation errors in the shift (M = 5.03, SD = 14.42) compared to the maintain condition (M = 1.18, SD = 14.87). The Cue X Perspective interaction was not significant. These results suggest that the nature of the retrieval cue influenced the accuracy of subsequent memory perspectives, such that memories repeatedly retrieved with photos that mismatched encoding were less accurate compared to photos that matched encoding.

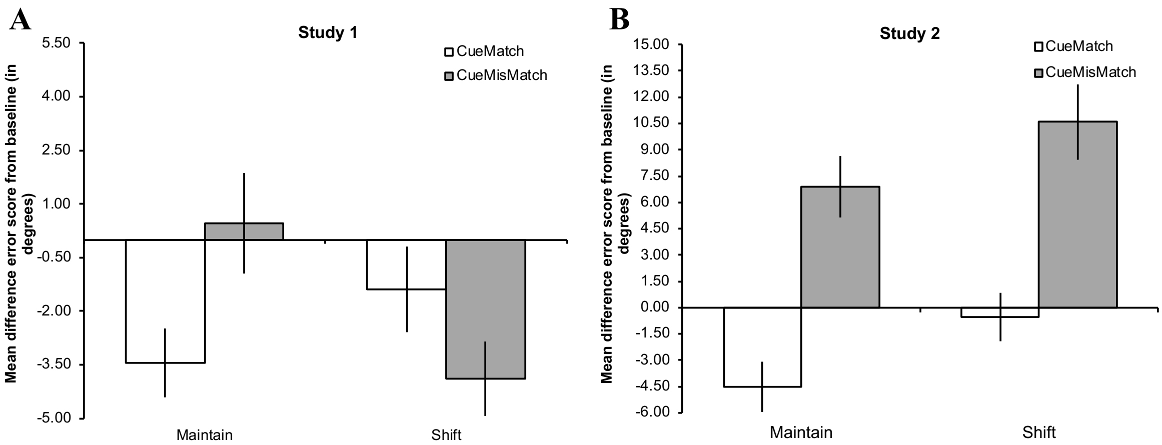

Figure 4.3 Subsequent visual perspective accuracy.

Graphs reflect absolute rotation error scores. Rotation error scores were calculated as the difference score between the perspective condition and baseline. (A) In Experiment 1, maintaining a novel perspective (i.e., maintain-mismatch) led to greater rotation error scores compared to actively shifting back towards the encoding viewpoint (i.e., shifting from a cue that mismatched encoding). (B) In Experiment 2, participants made greater rotation errors for photo cues that mismatched compared to those that matched the encoding viewpoint. Error bars reflect within-subject standard error.

Experiment 1 and Experiment 2

Online changes. To better understand how repeated retrieval from different perspectives might have influenced changes in the phenomenology of memories, vividness, reliving and visual perspective (i.e., own eyes and observer perspective separately) ratings were entered in a separate mixed ANOVAs with Cue and Perspective as the within-subject factors and Experiment as a between-subject factor.

There were no effects on reliving ratings. For vividness ratings, there was an Experiment X Perspective interaction, $F(1,58) = 4.17$, $p = .046$, partial $\eta 2 = .07$. Follow-up analyses indicated that the interaction was driven by higher vividness ratings in the maintain perspective condition in Experiment 2 relative to Experiment 1, $p = .01$, and when maintaining compared to shifting perspective in Experiment 2, $p < .001$. There were no other significant main effects or interactions on vividness. Thus, repeated retrieval while maintaining the perspective in the photo cues increased online vividness ratings compared to one retrieval attempt.

Further, for the visual perspective ratings (see Figure 4.2), there was a Cue X Perspective interaction on own eyes ratings, $F(1,58) = 31.39$, $p < .001$, partial $\eta 2 = .35$. Own eyes ratings were higher in the maintain-match compared to the maintain-mismatch condition, $p < .001$, and the shift-mismatch condition compared to the shift-match condition, $p = .003$. There was also a Cue x Perspective interaction on observer ratings $F(1,58) = 19.43$, $p < .001$, partial $\eta 2 = .25$. Observer ratings were higher in the shift-match compared to the shift-mismatch condition, $p < .001$, as well as in the maintain-mismatch compared to the maintain-match condition, $p < .001$. However, there were no interactions with Experiment for either perspective rating. Thus, even after repeated retrieval and regardless of the match or mismatch of the retrieval cue, manipulating the angle during retrieval still affected the particular visual perspective from which memories were remembered.

Subsequent phenomenology of memories. Findings from study 1 showed that there were no differences in subsequent vividness ratings (i.e., in session 3). When examining difference scores (retrieval condition – baseline) on vividness ratings across both studies, the mixed ANOVA revealed a main effect of Perspective, F (1,58) = 8.13, p = .01, partial η2 = .12, with overall higher vividness ratings for the maintain (M = 1.03, SD = 0.69) versus the shift (M = 0.89, SD = 0.59) perspective condition. This was also qualified by a Perspective X Experiment interaction, F (1,58) = 5.22, p = .03, partial η2 = .08. Follow-up analysis indicated that, relative to one single retrieval of Experiment 1, repeated retrieval of Experiment 2 increased vividness ratings both in the maintain condition, p = .001, and in the shift perspective condition, p = .02. Repeated retrieval therefore led to greater differences between maintaining and shifting perspectives; it not only reduced vividness during retrieval (i.e., in session 2) but its effects persisted even after a delay.

Actively shifting perspective during retrieval also differentially affected the visual perspective from which immersive memories were later experienced (see Figure 4.4). The analysis on subsequent own eyes rating revealed a main effect of Perspective, F (1,58) = 9.39, p = .003, partial η2 = .14, with overall higher own eyes ratings when maintaining the same perspective in the cues (M = 0.85, SD = 0.71) compared to shifting (M = 0.67, SD = 0.65) perspective. For observer ratings, there was a marginal significant main effect of Perspective, F (1,58) = 4.05, p = .049, partial η2 = .07, with higher observer ratings for actively shifting perspective (M = 0.23, SD = 0.78) compared to maintaining the angle in the photos (M = 0.34, SD = 0.80). There were no differences between Experiment 1 and Experiment 2 on either visual perspective rating. Thus, maintaining the perspective in the photo cues increased subsequent own eyes ratings, whereas actively shifting perspective mirrored the adoption of an observer perspective on subsequent memories.

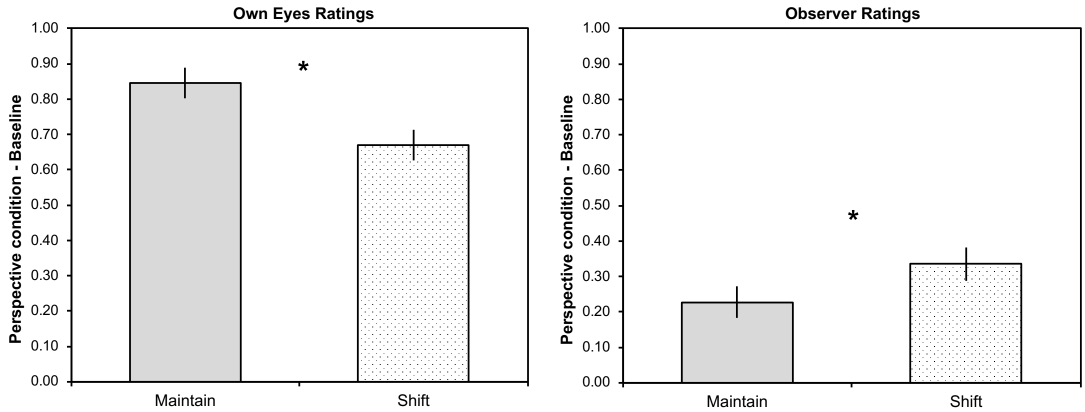

Figure 4.4 Visual perspective ratings of subsequent memories.

Graphs are collapsed across Cue type (match, mismatch) as well as across Experiment 1 and Experiment 2. Visual perspective ratings in session 3 were calculated as the difference score between the perspective condition and baseline. Maintaining the perspective shown in the cue increased subsequent own eyes ratings relative to actively shifting perspective, but actively shifting perspective increased subsequent observer ratings relative to the maintain perspective condition. Error bars represent within-subject standard error.

Recognition memory task. When examining how repeated retrieval influenced subsequent true and false memories compared to one single retrieval, the mixed ANOVA (conducted on the difference scores between each retrieval condition and baseline) with Experiment as the between-subject factor revealed a significant Cue X Experiment interaction, F (1,58) = 9.38, p = .003 partial η2 = .20, partial η2 = .14, reflected by higher hit rates for cues that mismatched encoding in Experiment 2 relative to Experiment 1, p = .03. No effects were found on false alarm rates.

Repeated retrieval also had an effect on subsequent recognition memory relative to baseline. A mixed ANOVA with the experimental conditions (maintain-match, maintain-mismatch, shift-match, shift-mismatch) as the within-subject factor and Experiment as the between-subject factor revealed a main effect of retrieval condition, F (1,58) = 14.13, $p <$ .001, partial η2 = .20, showing higher hit rates in all retrieval conditions compared to baseline, all $p_s < .001$. The main effect was, however, explained by a Condition X Experiment interaction, F (1,58) = 2.80, p = .03, partial η2 = .05. Follow-up analysis indicated that hit rates were higher in all retrieval conditions compared to baseline in both studies (all $p_s < .05$), except for the maintain-mismatch condition. This difference was significant in Experiment 2, $p < .001$, but not in Experiment 1, $p = .21$; hit rates were higher in the maintain-mismatch condition in Experiment 2 compared to Experiment 1, $p = .04$, suggesting that repeated retrieval protected memories from changes related to the nature of the retrieval cue. The increase in hit rates for memories in the shift-mismatch condition (i.e., when shifting back towards encoding) was approaching significance, $p = .06$. Additionally, there was a main effect of condition on false alarms, F (1,58) = 11.25, $p < .001$, partial η2 = .16, with higher false alarm rates in all retrieval conditions compared to baseline (all $p_s <$ .001). No other effects were found. Thus, repeated retrieval did not influence subsequent false alarms for memories retrieved in session 2 relative to memories that were not rehearsed, but it did influence whether subsequent true memories in the maintain-mismatch condition differed from baseline.

Subsequent perspective accuracy. The two studies were compared to see whether repeated retrieval and removing the actor cue from the videos screenshots affected subsequent perspective accuracy (performed on difference rotation error scores between each retrieval condition and baseline). The mixed ANOVA revealed a main effect of Cue, F (1,53) = 19.07, $p < .001$, partial η2 = .27, showing greater rotation errors for cues that mismatched encoding (M = 3.80, SD = 15.00) compared to cues that matched (M = -2.48, SD = 10.74) the original encoding angle. However, this was reflected by a significant Cue X Experiment interaction, F (1,53) = 14.87, $p < .001$, partial η2 = .22, explained by greater rotation errors for cues that mismatched encoding in Experiment 2 compared to Experiment 1, $p = .002$. There was also a Perspective X Experiment interaction, F (1,53) = 4.11, $p = .048$, partial η2 = .07. Follow-up analysis revealed greater rotation errors in the shift perspective condition in Experiment 2 compare to Experiment 1, $p = .01$; no differences were found in the maintain perspective conditions between the two experiments, p = .40. No other main effects nor interactions were found. This shows that removing the actors from the video screenshots and repeated retrieval while cued with photos taken from a novel perspective as well as actively shifting perspective led to greater decreases in perspective accuracy of subsequent memories.

To better understand how each retrieval condition contributed to subsequent changes in perspective accuracy, a mixed ANOVA was conducted with the experimental conditions (maintain-match, maintain-mismatch, shift-match, shift-mismatch, baseline) as the within-subjects factor and Experiment as the between-subject factor. There was a significant main effect of Experiment, F (1,53) = 6.26, p = .02, partial η2 = .10, with greater rotation errors in Experiment 2 (M = 24.35, SD = 13.06) compared to Experiment 1 (M = 19.08, SD = 10.17). The main effect of Condition was also significant, F (4,212) = 6.94, p < .001, partial η2 = .12, with fewer rotation errors in the maintain-match (M = 17.31, SD = 7.92) condition compared to both the maintain-mismatch (M = 25.18, SD = 12.95), p < .001, and the shift-mismatch (M = 25.07, SD = 16.06) conditions, p = .003. There was no difference between the maintain-match condition and shift-match, p = .13, however inspection of the means revealed that rotation error scores were numerically higher in the shift-match (M = 20.39, SD = 8.33) compared to the maintain-match condition. The difference between maintain-match and baseline was also not significant, p = .098. The main effects were explained by a Condition X Experiment interaction, F (4,212) = 7.14, p < .001, partial η2 = .12. Follow-up analysis revealed that in Experiment 1 there were no differences in rotation error scores across experimental conditions. In Experiment 2, participants made fewer rotation errors in the maintain-match condition compared to both the maintain-mismatch and the shift-mismatch conditions, both p_s < .001. The difference in rotation errors between the maintain-match and shift-match was not significant, p = .17. Further, the difference with baseline was not significant for the maintain-match, p = .31, nor for the shift-mismatch condition, p = 1.00.

However, greater rotation errors were found in the shift-mismatch condition compared to both the shift-match condition, $p < .001$, and baseline, $p = .001$. In Experiment 2, relative to Experiment 1, there was in fact an increase in rotation error scores in the maintain-mismatch condition, $p = .03$, and in the shift-mismatch condition, $p < .001$, but there were no differences between the two studies in the maintain-match, $p = .99$, and in the shift-match, $p = .38$, conditions. Thus, repeated retrieval and removing the actors from the video screenshots had a greater impact on the angle manipulation when the angle in the photo cues mismatched encoding relative to when it matched encoding. Moreover, actively shifting away from a cue that mismatched encoding (i.e., back towards the encoding perspective) led to greater errors in subsequent perspective accuracy, but maintaining the same perspective as encoding still protected memories from later changes in perspective.

General Discussion

The paradigm developed in the current study demonstrates that immersive memories are a viable substitute to autobiographical memories to study visual perspective. Subject to phenomenological changes similar to real-world memories, immersive memories enabled me to vary and control the encoding viewpoint during retrieval, to examine subsequent true and false memories, but also to develop for the first time an objective measure to investigate subsequent perspective accuracy. Further, this study aimed to better understand how active shifts in perspective versus the effectiveness of the retrieval cues in eliciting memories for the video events could influence these memories online and after a delay. Across two experiments, I show that active shifts in perspective, rather than the match or mismatch of the retrieval cues alone, can reshape the phenomenology of immersive memories and lead to more permanent changes in the qualities of subsequent memories. Even in the absence of visual perspective instructions, actively shifting to alternative viewpoints differentially impacted the visual perspective from which memories were experienced online and later remembered. Moreover, although shifting perspective did not contribute to differences in subsequent true and false recognition memory (probably due to some limitations in the nature of the task used as addressed below), shifting perspective did contribute to changes in the accuracy with which the original visual perspective was later retrieved. These findings and their implications will be discussed below.

One aim of the current study was to examine whether shifting to different viewpoints influenced subsequent true (i.e., hit rates) and false (i.e., false alarm rates) recognition memory. Previous evidence has documented the effectiveness of photographic review in enhancing accurate recall (e.g., Koutstaal et al., 1999; Schacter et al., 1997) and producing false recollection of events or details of events (e.g., Schacter et al., 1997). Here I show that, compared to video events that were not retrieved (i.e., baseline memories), participants' memories were more accurate, but also more likely to falsely recall that items were part of the original video events when they were only presented in photographs. However, contrary to predictions, shifting perspective did not contribute to reductions in subsequent hit rates nor there was an effect on subsequent false alarms as a result of retrieving from different viewpoints. For subsequent true memories, the findings of Experiment 2 revealed instead that repeated retrieval while cued with photos that mismatched the encoding perspective increased subsequent memory accuracy (i.e., higher hit rates) compared to retrieval cued with photos that matched the encoding perspective. This result is surprising in that it is the opposite effect of what St Jacques & Schacter (2013) previously found; memories cued with photos taken from the same perspective as encoding increased subsequent true (and false) recognition memory. It also contrasts Chapter 2's findings where I showed that memories cued by a novel perspective reduced subsequent memory accuracy. Thus, interpreting this result on the basis of a potential impact of shifting perspective would be difficult. Instead, one possibility is a novelty effect driven by the distinctive nature of the retrieval cue (i.e., the different perspective from which it was shown) that may have enhanced memorability of items in these photos relative to items that were shown in photos taken from the same perspective as encoding. The novelty effect refers to enhanced memory performance for novel compared to familiar (or previously repeated) stimuli (Tulving & Kroll, 1995) and typically occurs at encoding; for example, a novel word (or the word presented in a different colour or font) becomes particularly distinctive within a list of words, leading to increased memory performance for that word (e.g., Hunt & Lamb, 2001; Tulving & Rosenbaum, 2006; but see McDaniel, Dornburg, & Guynn, 2005 for evidence on distinctiveness effects when manipulating conditions at retrieval). Studies have shown that this effect can also be replicated when words are studied after exposure to novel compared to familiar contexts, such as images of scenes (Fenker, Frey, Schuetze, et al., 2008) and virtual reality environments (e.g., Schomaker, van Bronkhorst, & Meeter, 2014). For example, Schomaker et al. (2014) compared active exploration of familiar and novel virtual reality environments on subsequent recall for words. They found memory enhancement for words that were learnt after exploration of the novel compared to the familiar environment. As Schomaker (2019) states 'any effect of novelty may be caused by the nature of the unexpected novel environment, rather than novelty per se'. In the current study, despite the items were not novel (i.e., they were previously encoded in the video events), presenting photos taken from a novel perspective may have led to a similar effect of novelty resulting in the observed enhanced recognition memory performance for target items.

There are also some potential limitations, and differences between this and other studies, that may explain the subsequent recognition memory's findings (both hit and false alarm rates). For example, targeting memory for single items of the video events in the final recognition memory test may have reduced the impact of shifting visual perspective on subsequent memory accuracy (i.e., masking any effect). St Jacques and Schacter (2013)'s photos used during perspective manipulation depicted museum stops that participants experienced, and the later recognition task showed either the same photos used in the perspective manipulation (i.e., target photos) or photos of alternate stops of the tour (i.e., lure photos). Moreover, in Chapter 2, I showed that shifting visual perspective reduced subsequent overall accuracy when performance was assessed using questions eliciting different category details of the memories for the mini-events. Shifting visual perspective may therefore play a larger role in memory when different memory elements are tested (such as the different category details used in Chapter 2) rather than one individual detail within the memory (e.g., an object only). Similarly, research on the *change perspective* technique of the Cognitive Interview and on retrieval-induced suggestibility, as well as the classic misinformation paradigm, often use cued-recall (i.e., questions about details of the witnessed event rather a recognition task) for the final memory tests and/or to introduce misinformation (e.g., Chan & Langley, 2011; Chan & LaPaglia, 2011; Wilford, Chan & Tuhn, 2014; Memon, Cronin, Eaves, & Bull, 1993; Wells, Memon, & Penrod, 2006; Memon & Higham, 1999; but see Memon, Zaragoza, Clifford, & Kidd, 2009 for a recognition task in the final memory test). These potential limitations should be addressed in future research by adapting similar paradigms and testing formats when examining the influence of shifting visual perspective on subsequent true and false memories.

Despite this lack of effect of shifting perspective on subsequent memory accuracy, a novel finding of the current study was that actively shifting to alternative viewpoints during retrieval of immersive 360° memories modulated the visual perspective experienced during retrieval, and continued to influence subsequent visual perspective even when perspective was not directly manipulated. St Jacques and colleagues (2017) showed that explicitly instructing participants to repeatedly retrieve memories from an observer perspective contributed to changes in the visual perspective from which dominant own eyes memories were later remembered. Similarly, Butler et al. (2016) instructed participants to adopt an own eyes and observer visual perspective and found that repeated retrieval from an observer perspective increased subsequent observer perspective ratings, whereas repeated retrieval from an own eyes perspective (and no retrieval, i.e., baseline memories) led to smaller increases in subsequent observer ratings. Here I showed that, despite not explicitly instructing participants to adopt an own eyes or observer visual perspective, manipulating the viewpoint from which memories were retrieved influenced the visual perspective of immersive memories. Across two experiments, maintaining the same perspective as encoding as well as shifting back towards the encoding vantage point (i.e., when the photo cue mismatched the encoding angle) increased online ratings of the own eyes perspective, whereas maintaining a novel viewpoint and actively shifting to a novel viewpoint increased observer perspective ratings. The differences in visual perspective ratings associated with the nature of the retrieval cues partially persisted after a delay, but only after repeated retrieval. In particular, results of Experiment 2 demonstrated that repeated retrieval while maintaining the same perspective as encoding increased subsequent own eyes ratings compared to both maintaining a novel perspective (i.e., when the photo cue mismatched encoding) and to shifting to a novel perspective (i.e,. when the photo cue matched encoding), but it did not influence subsequent observer perspective ratings. However, when comparing results of the two studies, it was found that maintaining the perspective shown in the photos increased own eyes ratings of subsequent memories, whereas actively shifting perspective increased observer ratings, but there were no differences between cue types. Thus, the overall pattern of results suggests that actively shifting perspective, rather than the match or mismatch of the retrieval cues, likely drove the differences in the visual perspective from which immersive memories were experienced online and after a delay (i.e, when perspective was not directly manipulated). These findings extend those of previous chapters of this thesis and show that memories encoded in 360° environments are a viable way to study visual perspective in memory, where changes in viewpoint during encoding are more similar to real-world memories because encoded within different environmental contexts. Critically, manipulating the viewpoint from which these immersive memories were later retrieved also contributed to changes in the way visual perspective was experienced during immediate recall, but even after a delay.

Immersive 360° video events used in the current study allowed me to also investigate changes beyond subjective reports of visual perspective, extending to the accuracy with which the original encoding perspective was later remembered. In Experiment 1, I showed that actively shifting back towards encoding (i.e., when the cue mismatched encoding) protected memories from subsequent changes in perspective accuracy compared to maintaining a novel perspective. However, in Experiment 2, it was found that participants' perspective was overall less accurate for memories cued with photographs that mismatched the encoding viewpoint. Thus, the mismatch of the retrieval cues rather than retrieval from a novel viewpoint had a greater impact on subsequent visual perspective accuracy in Experiment 2.

One possible mechanism explaining the differences in accuracy in Experiment 2 is retrieval-induced distortion due to the encoding-retrieval mismatch of the photo cues. For example, Bridge & Paller (2012) had participants learn unique position of objects on a computer screen in a first study session. They were then given two cued-recall tests, one immediately after initial learning and one in a second study session 24 hours later. In a final cued-recall test (2 days after session 1), results showed that participants placed the objects closer to locations retrieved during session 2 than to the original study locations. As the authors discuss, retrieval not only facilitated memory for the object-location associations for those objects that were placed in the correct location during session 2, but erroneous retrieval of object location in session 2 biased (and distorted) the final memory. Similarly, in the current study, reductions in perspective accuracy might reflect a distorted memory for the original perspective such that participants adjusted the angle of view of the video events to more closely match that shown in the photos during session 2 rather than the initial encoding vantage point.

However, when considering the overall pattern of findings across both studies, the nature of the retrieval cues alone cannot easily explain these effects. First, in Experiment 1, although actively shifting to a novel viewpoint (i.e., when the photo cue matched encoding) did not contribute to decreased perspective accuracy compared to other conditions, participants still made greater rotation rotation errors when maintaining a novel angle compared to actively shifting back towards encoding (i.e., when the photo cue mismatched encoding). Second, when comparing the two studies, it was also found that shifting perspective increased overall subsequent rotation errors compared to maintaining the perspectives in the photo cues (in Experiment 2 relative to Experiment 1). Thus, if it was only the nature of the mismatch of the retrieval cues to drive subsequent differences in visual perspective accuracy, one would expect to find no differences between the maintain and shift perspective conditions. To sum, although it is not possible to fully rule out that the effectiveness of the retrieval cues in eliciting memories may have influenced subsequent visual perspective accuracy (i.e., given the findings of Experiment 2), these results show that also actively shifting perspective still contributed to reductions in perspective accuracy.

One question that still remains to be further explored from the current findings is whether the novelty of the shift in perspective may also drive subsequent changes in perspective accuracy. When conducting additional analyses comparing the two studies, maintaining the same perspective as encoding protected memories from subsequent changes in perspective compared to maintaining a novel perspective (or actively shifting back towards encoding). However, contrary to predictions, retrieval from this original encoding perspective did not increase subsequent perspective accuracy compared to actively shifting to a novel viewpoint. Critically, inspections of the means in both studies showed that rotations errors were numerically lower for memories retrieved while maintaining the encoding perspective relative to shifting to a novel perspective. Some methodological limitations might explain this lack of an effect. For example, in Experiment 1 the presence of the actor in the video screenshots of the perspective task may have facilitated participants' perspective (removing more subtle differences in conditions where the cue matched the encoding viewpoint, i.e., when actively shifting to a novel viewpoint); in Experiment 2, removing the actors from the video screenshots (and potentially repeated retrieval) might have instead contributed to greater difficulty in recovering the encoding viewpoint when memories were cued from a novel perspective during retrieval (thus increasing the overall difference in rotation errors between cue types). Moreover, the novel aspect of the current study was the direct comparison between actively shifting to a novel perspective and actively shifting back towards the original encoding perspective. However, despite the subjective ratings in session 2 demonstrated that retrieval in these two conditions was equally difficult, including a condition where participants actively shifted away from a cue that *mismatched* encoding may have introduced a potential confound in this experimental design. Participants may have either failed to rotate back to the original encoding viewpoint during session 2 or the mismatch of the retrieval cued may have biased subsequent perspective of memories; in the context of the perspective accuracy task, participants may have remembered this 'novel' perspective shown in the photo cue rather than the original encoding perspective they were instructed to rotate to. Isolating the novelty of the shift in perspective in future experimental designs may potentially overcome this problem and better inform research on visual perspective on the influence of shifting to a novel perspective on subsequent perspective accuracy. Despite these shortcomings, this study shows for the first time that retrieval from different viewpoints (and potentially actively shifting away from the perspective in photos) can also contribute to changes in more objective measures of visual perspective.

The novelty of the shift in perspective did, however, influence the phenomenology of memories. Another novel finding of the study was in fact that actively shifting perspective during retrieval of immersive 360° memories encoded in the lab contributed to phenomenological changes similar to real-life memories. A growing body of research has demonstrated long-lasting modifications in the phenomenology of memories when shifting perspective, such that memories are less vivid and associated with lower sense of reliving and emotional intensity compared to memories retrieved from an own perspective (e.g., Berntsen & Rubin, 2006; Butler et al., 2016; Robinsons & Swanson, 1993; Sekiguchi & Nonaka, 2014; Vella & Mould, 2014). Further, in Chapter 2, I showed that explicitly instructing participants to adopt an observer perspective during retrieval reduced the vividness of memories encoded in the lab both when cued with photos showing the particular visual perspective to adopt (i.e., Experiment 1) but also when the photo cues were removed (i.e., Experiment 2). St Jacques & Schacter (2013) reported differences in reliving for memories that were cued with photos taken from different viewpoints, and no explicit instructions of visual perspective were given to participants. Here, I extend these findings by showing that, despite the lack of visual perspective instructions, it is the novelty of the shift in perspective rather than the match or mismatch of the retrieval cues to drive differences in the phenomenology of memories. In particular, showing photos taken from the same angle as encoding and instructing participants to shift away from the angle in the cue (i.e., to a new viewpoint not experienced during encoding) led to a decrease during retrieval in reliving and vividness of immersive memories compared to maintaining the same perspective as encoding. Crucially, differences in vividness online and in subsequent memories only emerged after repeated retrieval from alternative viewpoints. When comparing the two studies, it was in fact found that repeated retrieval led to greater differences in vividness between maintaining and shifting perspectives. Butler and colleagues (2016) showed that repeatedly retrieving memories from an own eyes perspective was associated with higher sense of recollection and vividness of memories compared to repeated retrieval from an observer perspective. They suggest that repeatedly retrieving memories from the same perspective as they were initially encoded likely aided the maintenance of visual information of the original event, whereas adopting a novel perspective led to a reduction of the visual information available during retrieval. This loss of visual information might even persist over time such that when asked to reconstruct their memories from the same encoding perspective on a final retrieval attempt, participants could not remember memories with the same amount of visual details as they originally experienced the events. Here, active shifts in perspective reduced subsequent vividness and sense of recollection of memories compared to maintaining the perspectives shown in the photo cue. Thus, the retrieval cues influenced subjective ratings during immediate recall, but after a delay repeatedly shifting perspective contributed to reductions in vividness and sense of reliving of immersive memories.

These findings have implications in forensic settings and contribute to research investigating the recall techniques of the Cognitive Interview used for eyewitness testimony (Geiselman et al., 1984). Previous studies revealed mixed findings on the change perspective technique and showed that instructing eyewitnesses to adopt the perspective of someone else at the event is not so effective to enhance memory recall (e.g., Memon & Higham, 1999; Memon, Cronin, Eaves, & Bull, 1993; Wells, Memon, & Penrod, 2006). Here, I show that active shifts in perspective can alter the phenomenology of memories and may potentially lead to distortions, in particular the accuracy with which the original perspective is later remembered. Moreover, this study demonstrates for the first time that memories for complex events encoded in immersive 360° environments are a viable substitute to study the properties of real-world memories and to manipulate visual perspective, resulting in phenomenological changes similar to personal memories of one's past. Immersive 360° videos may therefore be experimentally tractable tools for research in these applied settings. For example, research could re-create crime scenes within realistic and perceptually-rich environments to study eyewitness testimony and better understand the effectiveness of the mnemonic techniques used in the Cognitive Interview.

Conclusion. This study contributes to our understanding of how changing visual perspective during retrieval reflects one of the ways in which the phenomenology and other properties of memories can be modified over time. By manipulating the encoding-retrieval match and mismatch of the retrieval cues and comparing actively shifting to a novel perspective with actively shifting back towards the original encoding perspective, I show that active shifts in perspective are responsible for more persistent modifications of the subjective qualities of memories. Using immersive memories, it was possible to demonstrate that changes in perspective are not limited to subjective reports of the visual perspective experienced, but also extend to more objective measure of perspective accuracy. The current study also shows for the first time that immersive memories are a viable method to study visual perspective in memory, resulting in phenomenological changes similar to real-world memories that can persist event after a delay.

Chapter 5. General Discussion

Spontaneously adopting an own eyes or observer visual perspective when remembering our past might reflect two different modes of presentation of the same event (McCarroll & Sutton, 2017), however the act of deliberately shifting to an observer visual perspective does not simply represent 'the experiences occurring at the time of the event' (McCarroll & Sutton, 2017, p.13). Constructing a perspective different from the original encoding perspective during remembering requires updating one's egocentric reference frame and re-locating one's self in the spatial context of the remembered event, which in turn influences the way we later recall our past. The primary goal of this thesis was to develop novel methodologies to examine how adopting alternative egocentric perspectives during retrieval influences the accuracy with which subsequent memories are remembered. In this chapter, I will discuss how manipulating visual perspective for memories encoded in the lab replicated and extended previous findings on the influence of visual perspective on memory, thereby addressing the theoretical contributions of these finding to the literature in visual perspective. I will then propose some of the mechanisms by which visual perspective might operate. The importance of using naturalistic paradigms to study visual perspective in memory will then be discussed; here, I will outline the strengths of these paradigms and how they can inform research in memory but also suggest some possible ways in which future research could address some of their limitations. In the remaining sections, I will then discuss the practical applications of the current findings in the real-world and propose how future research could extend some of the questions that this thesis raises.

5.1. The current findings and their theoretical contributions

A handful of studies have demonstrated that retrieval is an active process that can modify and update memories (e.g., Anderson, 2003; Anderson, Bjork, & Bjork, 1994; Schacter et al., 2011; St Jacques & Schacter, 2013), and that manipulating the quality of reactivation during retrieval can contribute to long-lasting changes in the accuracy of memory recall (St Jacques & Schacter, 2013; St Jacques, Montgomery, & Schacter, 2015; St Jacques, Olm, & Schacter, 2013). However, as discussed across the chapters of this thesis, only one study (St Jacques & Schacter, 2013) had directly manipulated visual perspective (to modulate memory reactivation) by presenting participants with photographs of memories taken from different viewpoints. In the current thesis, visual perspective was also cued using photographic cues taken from different viewpoints, but, extending St Jacques & Schacter and previous literature on visual perspective, I showed that the subsequent memory effects found across the chapters cannot be easily explained by the effectiveness of the retrieval cues to reactivate memories. Instead, the act of shifting one's viewpoint from the original encoding perspective contributed to subsequent changes (and impairments) in memory. Specifically, Chapter 2 addressed this by varying the effectiveness of the retrieval cue to elicit memories; in Experiment 1, participants were shown photographs of the particular viewpoint to adopt, whereas in Experiment 2 the photo cues were removed thereby reducing the match between encoding and retrieval. Across both studies, I showed that shifting to an observer perspective impaired subsequent accuracy of memories. In Chapter 3, the influence of shifting visual perspective was examined by varying the type of instructions that participants received during retrieval. All participants were shown photographs taken from an own eyes or a novel perspective (that included or excluded the participant's self), but one group was explicitly instructed to adopt an own eyes or observer visual perspective whereas the other did not receive any visual perspective instructions. The impact of visual perspective instructions was documented in online changes of the phenomenology of memories (i.e., during perspective manipulation), such that only the group that received explicit instructions of visual perspective showed a reduction in the vividness and sense of reliving of memories when shifting to a novel perspective. Critically, shifting visual perspective during retrieval also contributed to changes in how participants recalled the spatial context of later memories; there was a reduction in egocentric accuracy (i.e., the way spatial relations of objects were computed with respect to oneself), but not allocentric accuracy (i.e., object-to-object relations). In Chapter 4, I directly examined the influence of the retrieval cues compared to that of actively shifting to alternative viewpoints *away* from the angle in the photo, thereby comparing actively shifting to a novel viewpoint to shifting back towards the original encoding viewpoint. The findings showed that the match or mismatch of the retrieval cues did influence the accuracy with which the original visual perspective was later remembered (possibly due to the nature of the task - see Chapter 4 for interpretation of this finding), but actively shifting perspective during retrieval still led to changes in subsequent visual perspective that extended beyond subjective reports of the visual perspective experienced, such as its accuracy. Shifting perspective, however, did not contribute to subsequent differences in true (i.e., hit rates) and false memories (see Chapter 4 discussion).

Shifting visual perspective during retrieval also contributed to changes in the phenomenology of memories encoded in the lab. In particular, I demonstrated that adopting a novel perspective reduced the vividness of memories (Chapter 2, 3, 4), sense of reliving (Chapter 3, and 4) and emotional intensity (Chapter 3) with which memories were experienced online, in line with studies that have shown similar effects using personal memories of one's past (e.g., Sekiguchi & Nonaka, 2008; St Jacques et al., 2017; for review see Rice, 2010; but see Butler et al., 2016 for a comparison with lab-based memories). Retrieval-related changes in the phenomenology of memories were also partially maintained after a delay. Although shifting visual perspective did not affect some of the qualities of the memories (i.e., vividness and reliving) in Chapter 2 and 3, possibly due to the nature of these memories (see section 5.3.1), the visual perspective manipulation of Chapter 3 biased the visual perspective of subsequent memories. Memories retrieved while shifting to novel perspectives increased subsequent observer perspective ratings. Similarly, active shifts in perspective during retrieval of immersive memories (Chapter 4) biased later visual perspective experienced (i.e., increased observer perspective ratings), but also attenuated the vividness and sense of reliving of these memories. Note that these effects were due to actively shifting perspective not due to the influence of the match or mismatch of the retrieval cues (i.e., no differences between cues that matched or mismatched encoding) – the differential impact of the retrieval cues was only reported in the online subjective ratings (see Chapter 4 for a discussion on this).

This thesis also demonstrated that the changes in the online subjective experience of memories due to shifting perspective can predict later modifications in the qualities and properties of memories, as it has sometimes been shown (e.g., St Jacques et al., 2017). For example, in Chapter 2, I showed that online differences in vividness between memories retrieved from an own eyes and observer visual perspective predicted the subsequent decrease in memory accuracy between the two perspective conditions. In Chapter 3, it was found that the reductions in emotional intensity, but not in vividness, for memories retrieved from novel perspectives (relative to own eyes memories) predicted the subsequent increase in observer perspective ratings. This suggests that adopting novel perspectives during retrieval can potentially lead to more persistent modifications in the phenomenology and properties of memories.

While the current thesis presented some novel findings on the influence of visual perspective on different types of memory accuracy, it is important to acknowledge that some of the effects have not been replicated across the three empirical chapters (particularly the results on accuracy for memory details in Chapter 2 and 3, the recognition memory findings in Chapter 4 along with some of the session 3 ratings results in each study – see summary of findings above). It is in fact possible that the large number of measures collected in each experiment along with other factors may have contributed to the inconsistent findings across studies and potentially led to unreliable results. Firstly, the sample size of each empirical chapter was relatively small. Given the novelty of the research question and paradigm used, sample size of Chapter 2 was determined on the basis of previous behavioural studies in the visual perspective literature that also collected a large number of measures and/or used similar naturalistic paradigms (e.g., Butler et al., 2016; McIsaac & Eich, 2002; St Jacques & Schacter, 2013). These studies used a sample size of approximately $N = 30$ - 40. However, in the current research, testing a sample of this size was challenging; the nature of the paradigms and experimental tasks along with the relatively long duration of the multiple experimental sessions (total of about 5-6 hours per participant over the course of approximately one week) limited the number of participants that could be recruited for the experiments of Chapter 2. Further, for Chapter 3 and 4, a sample size estimation was conducted.[5] The projected sample size was $N = 14$ suggesting that the lack of an effect on subsequent memory accuracy in Chapter 3 cannot easily be explained by low statistical power; instead, despite the paradigm used was similar to that of Chapter 2, it is likely that the changes made to the experimental tasks in Chapter 3 (as discussed in detail in the chapter) contributed to the inconsistent findings across the two chapters. By contrast, for Chapter 4, it is not possible to rule out that statistical power could have affected the subsequent recognition memory results. In fact, although the number of trials in each empirical chapter was relatively small (8 trials per experimental condition), in Chapter 2 and 3 each trial in the analysis comprised a complex event that was tested in multiple ways (e.g., in Chapter 2 participants' memory was tested using 15 short-answer questions per mini-event - i.e., 120 data points per condition for a total of 360 short-answer questions); in Chapter 4 the actual number of data points was comparatively lower (i.e., each trial in the analysis comprised an event that was tested in one way only, i.e., memory for the object). This could explain why the two empirical studies in Chapter 4 failed to find differences in subsequent true and false memories due to shifting perspective.

These issues along with the limitations of each study design (as discussed in each relevant chapter) emphasise the need for future research to assess the reliability and replicability of these findings to better understand the role of visual perspective on different types of memory accuracy. The novel paradigms and methods developed in the current thesis to study visual perspective and memory in the laboratory may, nonetheless, provide some innovative avenues to extend the novel findings presented here and other research on the influence of visual perspective in memory.

In the following section, I will discuss some possible mechanisms by which visual perspective may operate. In particular, from this thesis' and other findings, memories retrieved from an observer perspective could be interpreted in Fernandez's (2015) words as beneficial distorted memories, where this novel perspective might serve two functions in memory: one is to reconstruct our past to build a coherent narrative, while the other is to help to preserve the content of our past.

5.2. The adaptive function of the observer visual perspective in memory

This thesis contributes to our understanding of retrieval-related changes of memories and shows that adopting novel perspectives during retrieval reflects one of the way in which memories can be modified and updated over time. In particular, the reconstructive processes involved when retrieving from a perspective different from the default own eyes perspective has 'detrimental' consequences for the accuracy of subsequent memories. In Chapter 1, I presented some of the functions of the observer perspective in memory as suggested by previous researchers (i.e., cognitive distancing strategy: McIsaac & Eich, 2004; representational tool: Libby and Eibach, 2011). Based on the findings of this thesis, I propose that the observer perspective might not only serve in cases of highly emotional life events (see McIsaac & Eich, 2004), but also for the normal functioning of our memory system whereby it operates by altering which aspects of the past remain available for later retrieval to potentially reduce storage demands. Thus, the modifications of memories retrieved from this novel perspective can be considered as the consequence of 'adaptive constructive processes' (Schacter & Addis, 2007; Schacter, Chiao, & Mitchell, 2003; Schacter et al., 2011; see also Bernstein & Loftus, 2009). Memories retrieved from a novel perspective may, for example, become more abstract or gist-like representations of the original event as a result of reconstructive mechanisms likely involved when re-organising the mental images that arise during retrieval from a new perspective. In the following two sections, I will propose two (adaptive) mechanisms by which visual perspective may operate by discussing how shifting visual perspective 1) may create gist-like or abstract representations within memory and 2) how the subsequent memory effects presented in this thesis might be the result of active retrieval processes that can sometimes lead to forgetting.

5.2.1. Gist-like/abstract representations

Modifications of memories over time can be a consequence of the natural transformation of memories, such that the subjective qualities of memories are attenuated whereby we do not experience them with the same emotional intensity, vividness nor we relieve them as intensely. These can sometimes lead to semantic or gist-like representations of the original event (e.g., Moscovitch et al., 2006; Winocur & Moscovitch, 2011). Visual perspective can also be the result of natural transformations of memories, as demonstrated by findings that recent memories are more often retrieved from an own eyes perspective, whereas remote memories are more typically retrieved from an observer perspective (e.g., Nigro & Neisser, 1983; Piolino et al., 2006; Robinson & Swanson, 1993; Talarico, LaBar, & Rubin, 2003). However, the current thesis and previous findings (e.g., Akhtar et al. 2017;

Berntsen & Rubin, 2006; Butler et al., 2016; Robinson & Swanson, 1993; Vella & Moulds, 2014; St. Jacques, Szpunar, & Schacter, 2017), suggest that the effects of adopting different visual perspectives during remembering are bidirectional. In other words, the observer visual perspective is not just the result of natural modifications in memories; instead, the act of deliberately shifting from an own eyes to an observer perspective during recall of recent memories (encoded in the lab) can also be 'responsible' for changes similar to those observed due to the natural course of time alone and can extend to other memory properties, such as their accuracy. Thus, the processes involved in deliberately imagining oneself from an external perspective during retrieval might in turn lead to similar semantic or gist-like transformations of the original memory.

Research on episodic future thinking (as well as the work from Libby and colleagues reviewed in Chapter 2, section 2.1 on the association between visual perspective and abstract and concrete representations of events, e.g., Libby, 2003) might lend further support to this latter claim. It has in fact been demonstrated that the constructive mechanisms (and associated brain network) supporting the ability to remember the past are also recruited when imagining the future whereby elements of prior experiences are combined together to form possible future scenarios (i.e., *constructive episodic simulation hypothesis*; Schacter & Addis, 2007). Szpunar (2010) suggests that these abilities rely on both episodic and semantic memory, and more recently Irish and colleagues showed that individuals affected by semantic dementia show impairments in future simulations, despite intact abilities in retrieving recent episodic memories (e.g., Irish, Addis, Hodges, & Piguet, 2012a, 2012b; see for a review Irish & Piguet, 2013). Thus, this seems to suggest that imagining possible future scenarios may rely more on semantic processing compared to remembering. Critically, the adoption of an observer perspective has been associated with the simulation of future events. For example, McDermott et al. (2016) investigated the role of visual perspective by comparing the frequency of observer perspective taking when remembering personal past events and when simulating future possible events (i.e. *episodic future thought*). Overall, they found a higher proportion of observer perspectives relative to own eyes for both autobiographical memories and episodic future thought. A comparison between the two tasks also revealed a higher frequency of observer perspective taking when imagining future events. Similar findings were reported by D'Argembeau and Van der Linden (2004), who demonstrated that the temporal distance of past and future events can also influence the visual perspective adopted. In particular, subjective ratings of observer visual perspective (relative to own eyes ratings) were higher both when remembering remote events and imagining scenarios occurring in a distant future as opposed to recent past and future. Given the evidence on the association between episodic future thinking and semantic memory, one might argue that constructing an observer perspective might also rely on more semantic processing compared to adopting an own eyes perspective.

Imagining new (fictious) experiences has also been shown to activate the same brain network associated with episodic remembering and episodic future thinking (for review see Hassabis & Maguire, 2007). Hassabis and Maguire (2007) have in fact proposed that a key process underlying remembering, imagination and episodic future thinking is scene construction, achieved by the retrieval and integration of sensory and semantic components to form a coherent scene organised in its spatial context. Seeing oneself from an external perspective during remembering might recruit similar imagination processes, necessary to construct a new scene to re-organise and update the spatial context of this new perspective.

To sum, the literature reviewed above shows that the observer perspective is the preferred perspective recruited in processes that rely more on semantic processing, such as imagining possible future scenarios but also during imagination of actions in terms of their abstract properties. According to Wheeler, Stuss, and Tulving (1997) classical distinction, episodic memory refers to personally experienced events and is associated with *autonoetic consciousness,* i.e., the sense of re-experiencing or mentally travelling back in one's past and one's awareness of a past event that is distinguished from other types of awareness, such as imagining. Semantic memory (i.e., general knowledge or facts about the world and ourselves) is characterized by *noetic consciousness*, i.e., the absence of a sense of re-experiencing (or relieving) of the past. They also state that the knowledge provided by semantic memory 'is that from the point of view of an observer of the world rather than that of a participant' (p. 349). This distinction has similarities with the distinction between own eyes and observer perspective. Findings of the current thesis and other findings show that shifting to a novel perspective can change the nature of memories by reducing their accuracy and leading to a decrease in the phenomenological properties that typically characterise *autonoetic consciousness* (i.e., remembering). It follows that the result of constructing a novel perspective during remembering might reflect a more abstracted representation [or semantic in Szpunar's (2010) terms] of the memory compared to memories that are retrieved from an own eyes perspective, influencing the memory elements that are retained and later retrieved, whereby only the general or concrete information are merged together to create a coherent story of the event.

Akhtar et al. (2017) found that that memories, initially experienced from an own eyes perspective, contained fewer episodic details when retrieved from an observer perspective one week later. These findings provide further evidence supporting the idea that memories retrieved from an observer perspective are less rich in details compared to the own eyes perspective. However, there is no direct evidence yet on the distinction between episodic and semantic details in memories retrieved from either visual perspective. More research is therefore needed to understand whether shifting perspective during retrieval leads to more abstract representations of our past and/or whether the nature of memories retrieved from a novel perspective can be considered a form of semantic memory compared to memories retrieved from one's own eyes. For example, the Autobiographical Interview (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002) provides an effective scoring system to differentiate between episodic and semantic details. Developing a measure that could also account for concrete and abstract representations (perhaps similar to that of Libby, 2003) might help better understand the mechanisms by which visual perspective operates.

5.2.2. Inhibitory mechanisms of retrieval from an observer perspective

Research has shown that active retrieval of previously encoded material can lead to improved memory performance (e.g., Chan, McDermott, & Roediger, 2006; Karpicke & Roediger, 2008; Schacter et al., 1997; see also Roediger & Butler, 2011 for a review), but it can increase erroneous recall of information rendering memories prone to distortions (e.g., Chan & Langley, 2011; Koutstaal et al., 1999; Roediger, Henry, Jacoby, & McDermott, 1996; St Jacques & Schacter, 2013; Schacter et al., 2011) and can sometimes even lead to forgetting (Anderson, 2003; Anderson, Bjork, & Bjork, 1994; see for meta-analysis Murayama, Miyatsu, Buchli, & Storm, 2014).

For example, research has suggested that adaptive mechanisms are responsible for forgetting such that certain memory details are selectively suppressed to allow later retrieval of related information, that would not otherwise be accessible (e.g., Wimber, Alink, Charest, Kriegeskorte, & Anderson, 2015; Wimber, Baüml, Bergström, et al., 2008; see for a review Storm & Levy, 2012). In the classic retrieval-induced forgetting paradigm, participants study a series of items belonging to different categories; during a retrieval phase they then rehearse half of the items from half of the practiced categories (i.e., Rp+), whereas the other half of items from the same practiced categories are not rehearsed during this session (i.e., Rp-). In the final recall phase, retrieval performance is overall better for previously retrieved items from practiced categories compared to items from categories not practiced and not retrieved during the second session (i.e., Nrp). Crucially, recall performance is better for nonpracticed items of nonpracticed categories compared to nonpracticed items of practiced categories. In other words, retrieval of a subset of items causes the forgetting of other nonretrieved but related items.

Studies have also examined RIF beyond word-lists (for reviews see Anderson, 2003; Storm, Agnello, Buchli, et al., 2015). For example, studies looking at RIF for autobiographical memories (e.g., Barnier, Hung, & Conway, 2004; see also Hauer, Wessel, Merckelbach, Roefs, & Dalgleish, 2007; see for review Storm, Agnello, Buchli, et al., 2015) have showed that recall of a subset of autobiographical memories related to a specific retrieval cue (e.g., broad category cues: positive or negative emotional valence; narrower category cues: ‘happy’ or ‘horrified’) leads to poorer recall of unpracticed memories related to the same retrieval cue compared to baseline memories (i.e., not associated with the same cue nor practiced). Critically, both positive and negative memories showed RIF. Similarly, memories retrieved from an own eyes or observer visual perspective might also be susceptible to retrieval-induced forgetting to different extents. Based on the adaptive function of the observer perspective discussed in this chapter (and the findings of this thesis), one possibility is that memories retrieved from this perspective might be more susceptible to RIF compared to memories retrieved from an own eyes perspective. While there is a lack in the literature of a direct investigation of retrieval-induced forgetting as a function of adopting different visual perspectives at retrieval, the findings of the current thesis suggest that the observed effects might partly be explained by RIF, such that adopting a novel perspective leads to forgetting of memory elements (Chapter 2) and the spatial relations of objects with respect to one’s self (Chapter 3), compared to retrieval from an own eyes perspective[6].

Although the current effects can be attributed to active retrieval from the new perspective, it is important to note that a clear RIF effect was not observed in the current studies. In fact, there were no differences in subsequent memory effects between memories retrieved from novel perspectives and baseline memories (i.e., not retrieved in session 2). Research in RIF has proposed that inhibitory mechanisms are responsible for forgetting (e.g., Anderson, 2003; Anderson, Bjork, & Bjork, 1994); retrieval interference between items of the practiced category (Rp+) with retrieval of nonpracticed items of the practiced category (Rp-) might inhibit and render less accessible the recollection of Rp- items compared to items that are not related and have not been retrieved. Given the lack of difference with baseline memories, it is difficult to account for the current findings purely on inhibitory mechanisms. However, as discussed in Murayama et al. (2014)'s metanalysis, another interpretation of RIF is increased competition during the final test; increased retrieval practice of Rp+ items strengthens these items, thus causing interference with the non-strengthened Rp- items and leading to forgetting of these latter items. Similarly, retrieval practice from the default own eyes perspective may strengthen the availability of memory details from this perspective, whereas the additional cognitive effort required to update one's egocentric reference frame to construct a novel perspective may reduce the strength of these memories. One might speculate that the increased retrieval competition between strengthened and non-strengthened memories reduces later availability (and forgetting) of details for memories retrieved from a novel perspective (i.e., less strengthened). However, it still remains to be directly investigated whether retrieval competition (and/or possibly inhibitory mechanisms) are responsible for the subsequent memory impairments due shifting perspective.

For example, this could be addressed by examining the differential impact of each visual perspective on the type of details recalled. Although in Chapter 2 and 3 visual perspective did not influence the types of details on the delayed recall task (i.e., when perspective was not directly manipulated), other studies have found such an effect when participants freely recalled memories while adopting an own eyes or observer visual perspective (Eich et al., 2009; McIsaac & Eich, 2002; Akhtar et al., 2017; but see Bagri & Jones, 2009). McIsaac and Eich (2002) demonstrated that recall from an own eyes perspective was associated with more statements reflecting internal aspects of the event (i.e., the subjective perception of the it), whereas retrieving from an observer vantage point was associated with the more objective details of the memory (i.e., physical appearance, actions, spatial relations among objects). However, relatively little is known about the mechanisms behind this distinction. Research looking at eyewitness memory has documented the RIF effect for details relevant to naturalistic events (García-Bajos, Migueles, & Anderson, 2009; MacLeod, 2002; Migueles & García-Bajos, 2007). Migueles and García-Bajos (2007; Experiment 2) presented participants a video of a robbery and later examined RIF effects on the perpetrator's characteristics. They found that asking participants questions about a subset of the offender's characteristics during retrieval (e.g., facial characteristics) led to decreased recall of other characteristics of the same individual (e.g., clothing). RIF has also been examined when manipulating other conditions during retrieval. Saunders, Fernandes, and Kosnes (2009) showed that manipulating mental imagery by asking participants to imagine a subset of actions either performed by themselves or performed by another individual can lead to retrieval-induced forgetting. Macrae and Roseveare (2002), instead, included a manipulation to elicit self-referential processing; they had participants learn a list of gifts and practiced some of these while imagining that either themselves, or a close friend or someone else bought them. They found that RIF was eliminated for information that was relevant (and encoded) with respect to the self (but not when imagining other people buying the gifts), suggesting that self-relevance might protect memories from forgetting. It would be of interest for future studies to better understand whether adopting an own eyes or observer visual perspective during retrieval practice might lead to similar RIF effects on the types of details one recalls for memory for events. Based on the few findings to date, one possibility is that certain memory elements are emphasised more during retrieval from one perspective relative to taking a different perspective. Alternatively, adopting an observer perspective might facilitate recall of the more objective details while inhibiting the more internal aspects of the memory (and vice-versa). Further, given the role of the self in visual perspective, it would be of interest for future research to examine whether the own eyes and observer visual perspective may differentially contribute to facilitation and/or inhibition of self-relevant material. Creating real-world memories using ecologically valid naturalistic paradigms can be effective tools to better understand the mechanisms of visual perspective in memory when accuracy needs to be verified, as discussed in the next section.

5.3. Methodologies used to manipulate visual perspective

5.3.1. Immersive 360° videos experience

The naturalistic paradigms of rich and complex events encoded in the lab developed for this thesis contributed to the growing literature on the influence of visual perspective by integrating outcome measures, such as subjective reports, with more objective measures to verify memory accuracy as a result of shifting perspective. In this section, I will address how these methodologies could inform future research by considering their strengths and limitations to elicit and examine visual perspective in the laboratory.

Visual perspective plays an important role in autobiographical memory; not only is visual perspective one of the ways in which autobiographical memory is related to the concept of self (Gillihan and Farah, 2005), but, when retrieving a memory for an event, we also inevitably create a visual image of the event context as seen from a particular visual perspective (Rubin & Umanath, 2015) (see also Chapter 1 section 2). Although lab-created memories might be preferable when examining subsequent changes in the phenomenology of memories as a function of visual perspective (Butler et al. 2016), the above-mentioned conditions need also to be considered when developing paradigms that aim to translate the findings in the real-world. As mentioned in Chapter 1, strict experimental control might in fact compromise ecological validity (e.g., subjective experience of autobiographical memories versus lab-created memories). For example, real-world memories are typically never encoded from one single vantage point (i.e., different events might be encoded in different environmental contexts and settings), rather different events are experienced within diverse and perceptually rich environments and settings. By contrast, memories encoded in the lab are typically encoded from one single vantage point and the visual image created when recalling these might not substantially change across events. The results of Chapter 2, and Chapter 3, partially support this interpretation. In particular, in Chapter 2, there were no differences in the phenomenology nor the visual perspective of subsequent memories for events encoded in the lab. These memories were in fact later experienced from an own eyes perspective, regardless of the perspective adopted during retrieval, in line with Butler et al. (2016) who reported similar increases in own eyes ratings for memories encoded in the lab relative to autobiographical memories. In Chapter 3, although there were no differences in subsequent sense of reliving, vividness nor own eyes visual perspective ratings due to shifting perspective, including a condition where the participant's physical self was shown in some of the photos used to manipulate visual perspective increased subsequent observer perspective ratings (relative to memories that were not subject to the perspective manipulation, i.e., baseline). The fact that these differences were only reported when memories were elicited with explicit reference to the self at the time of the event suggests the fundamental role that the self potentially plays in lab-created memories.

Self-referential processing is a key property of episodic memory retrieval (Tulving, 2002) and the sense of self-relevance that lab-created memories elicit might be attenuated compared to autobiographical memories (i.e., not only are events encoded in 'impersonal' lab settings, but even the nature of the material encoded/type of event might not have a particular personal relevance to the participants). As Cabeza et al. (2004) suggest, one way that might heighten self-referential processes in lab-created memories is the sense of 'immersion' and the idea of being an active agent of the event context (see also Kisker, Gruber, & Schöne, 2019; Schöne, Wessel, & Gruber, 2019). The changes in phenomenology of immersive 360° videos of Chapter 4 due to shifting perspective successfully replicated the findings reported in the literature on autobiographical memories. Even in the absence of visual perspective instructions (which might have influenced demand characteristics in Chapter 2 and 3 as well as in Butler et al. 2016), cueing participants with photos taken from alternative viewpoints and instructing them to either maintain or shift to alternative perspectives still biased the visual perspective from which immersive memories were experienced, both during immediate recall but also after a delay when visual perspective was not directly manipulated. Other qualities of memories were also affected by shifting perspective such as the sense of reliving and vividness of immersive memories.

Although the sense of agency was ensured in the mini-events paradigm (i.e., participants were agents in the events retrieved) and the mini-tasks were created to be complex and unique, it is possible that these were too 'unique' for information to be relevant to oneself. By contrast, the video events used in Chapter 4 varied in visuospatial details (i.e., recorded from unique outdoor and indoor locations), and their nature approximated more to real-world events experienced in one's everyday life (e.g., making breakfast) than the mini-events used in the previous chapters. Moreover, the mini-events used in Chapter 2 and 3 involved minimal viewpoint change, as these were all rather 'static' and performed while sitting in the same location in the laboratory. More similar to real-world memories, immersive 360° videos were more dynamic, the viewpoint from which they were encoded varied across events, thus being richer in visuospatial details compared to the mini-events performed in the lab.

Shifting visual perspective might therefore have a stronger impact when visual perspective plays a larger role in memory. The use of immersive virtual reality technologies to create memories in controlled laboratory settings is one important and novel contribution of the current thesis to the study of visual perspective and memory. Research has increasingly used naturalistic paradigms to study memory in controlled laboratory settings such as standard 2D videos and more real-world paradigms where participants are active agents of the events (e.g., Bird et al., 2015; Cabeza et al., 2004; Koustaal et al., 1999; Schacter et al., 1997; St Jacques & Schacter, 2013). The findings of the current thesis (in particular those of Chapter 4) emphasise the importance of eliciting memories that approximate the real-world to study visual perspective in the laboratory. Immersive videos can be used as viable substitute to autobiographical memories when studying visual perspective, enabling research to overcome most of the problems posed by standard 2D videos and real-world paradigms (as discussed in Chapter 1, section 3), while providing evidence on the influence of shifting visual perspective on properties of memories that can be potentially translated on personal memories of one's own past.

To date, one key limitation of 360° videos (relative to real-world memory paradigms) is that they do not allow the possibility to actively navigate or interact with objects in the environment. It has been shown that active versus passive navigation in virtual reality environment differentially influences memory performance, with active navigation typically increasing subsequent memory recall (e.g., Hahm, Lee, Lim et al., 2007; Sauzéon, Arvind Pala, Larrue et al., 2011; Sauzéon, N'Kaoua, Arvind Pala, Taillade, & Guitton, 2016). In these studies, the virtual environments allowed 360° exploration, but also translational movements (up/down, forward/backward), whereas the 360° videos used in Chapter 4 did not allow translation movements, which might have potentially affected the immersive experience and subsequent memory performance – although participants could explore a three dimensional environment the lack of movement still limited exploration of objects and/or surroundings from different angles. Currently, some head-mounted virtual reality devices allow movement within Virtual Reality environments (e.g., Oculus Quest), and it was announced in 2018 that some devices (e.g., Samsung S9) might also be able to support translational movement in the future (Redohl, 2018), although this still remains to be verified. If the opportunity to actively navigate within panoramic immersive environments is introduced, 360° videos will indeed be the viable substitute to autobiographical memories to study visual perspective in ecologically valid, while controlled, laboratory conditions.

5.3.2. Photographs and visual perspective

From an experimental standpoint, this thesis extends studies that have used photographs as a way to study memory in the laboratory (e.g., Cabeza et al., 2004; Koutstaal, et al., 1999; Schacter et al., 1997; St Jacques, Conway, & Cabeza, 2011; St Jacques, Rubin, LaBar, & Cabeza, 2008; St Jacques & Schacter, 2013; Weiser, 2004; see also Wade et al., 2002; see for reviews Chow & Rissman, 2017; Silva, Pinho, Macedo, & Moulin 2016) by showing that these can be effective retrieval cues to verify memory accuracy while manipulating visual perspective. However, in the real-world, the findings of the current thesis emphasise the importance of better examining the influence of reviewing personal photographs on visual perspective of memories.

Photographs that we review in everyday life are taken from different viewpoints, from an own eyes perspective whereby we see the captured event from the same perspective as it was originally encoded, or from a viewpoint different from the encoding perspective (e.g., selfies or photographs of ourselves taken by others). In Chapter 3 I showed that reviewing photographs of ourselves can bias the particular visual perspective from which memories are later remembered (note that the same effect was observed for memories retrieved with photos of the novel viewpoint that did not include the participant’s self, but see Chapter 3 for discussion on this). Although Chapter 4 did not directly address the idea of seeing one's self in a photo (i.e., photographs included the actors of the video events but not the participant's self), a similar pattern was observed in the maintain perspective condition where participants were asked the retrieve the event while maintaining the same angle shown in the photo cues (note that the findings on actively shifting away from the angle in the photos are not relevant for the purpose of discussion in this section, but see previous section for discussion on this). Reviewing photographs of events taken from a novel perspective biased the visual perspective from which memories were experienced during retrieval; observer perspective ratings increased relative to photographs taken from the same viewpoint as encoding. The subjective qualities of memories were also affected when reviewing photographs taken from a novel viewpoint (see also St Jacques & Schacter, 2013). Thus, these findings coupled with the subsequent memory impairments demonstrated in this thesis emphasises the importance of better understanding how personal photographs of past life events (e.g., childhood photographs, family snapshots, 'selfies', etc.) can influence the way we remember these 'reviewed' memories.

Another line of research has shown that the mere act of taking photos can decrease what we remember about the photographed event (photo-taking impairment effect, e.g., Henkel, 2014; Soares & Storm, 2018), but that 'zooming in' on specific aspects of a scene engages attentional processes that can improve recall for specific details about the objects being captured and their location (e.g., Henkel, 2014). More recently, Niforatos et al. (2017) examined the effects of photo capturing modalities on memory performance, motivated by studies on the photo-taking impairments effect (e.g., Henkel, 2014) and studies showing that memory recall is typically reduced if people know they will have future access to the photos taken (e.g., Sparrow, Liu, & Wegner, 2011; see also Storm, Stone, Benjamin, 2017). In particular, a group of participants performed a campus tour while taking photographs manually (i.e., using smartphones) whereas another group had photographs taken automatically (i.e., using a wearable camera). They examined memory accuracy one week after the campus tour, before and after reviewing the same photographs taken during the tour. They found a photo-taking impairment of the manually taken photographs relative to automatic photos when memory was measured one week after the campus tour (probably due to encoding disruption caused by the distraction of taking the photograph); by contrast, when memory performance was measured *after* reviewing photographs, they showed a recall facilitation for those that were manually taken over photographs that were captured with wearable camera. These findings demonstrate that taking photographs does impair memory performance, but that reviewing photographs that have been taken manually can boost subsequent memory. These studies have only looked at photographs taken from an own eyes perspective (i.e., capturing photos while looking out at the scene from one's own eyes), but it would be of interest to examine the act of taking photos of ourselves and how these different photo capturing modalities might impact memory.

Hyman (2013) writes in his article, 'selfie was the word of the year for 2013' and Google statistics reported that 93 million selfies were posted and/or sent in 2014 (Brandt, 2014), yet little is known about how selfies (i.e., seeing ourselves from an outside perspective) can impact our memories for the original event. For example, do we remember that event while maintaining the perspective shown (i.e., an observer perspective)? This might influence our memory for the original event such that we could have a memory for the photograph rather than a memory for the event as it originally occurred. Alternatively, do we put ourselves in the shoes of our past self when reviewing photographs, which inevitably involves an active shift in perspective? To date, studies have only examined how selfies can impact self-perception and have showed that people who often take selfies perceive themselves as more likeable and attractive in their own photos compared to photos taken by others (e.g., Re, Wang, He, Rule, 2016; Diefenbach & Christoforakos, 2017), but how the perception of themselves in selfies and others' photos influences memory still remains to be addressed. The current thesis suggests that the visual perspective from which these 'reviewed' memories are experienced is biased, which might in turn affect their properties and the accuracy with which we remember the captured event. Moreover, photographs can also include other people (e.g., friends and family). The photographic modalities of selfies can also involve other people, such that photos of ourselves might be taken by a friend. Understanding how the presence of other people in personal photographs might affect visual perspective and other properties of memories is another interesting avenue for future research. Yet, to examine this, one question that still remains to be addressed in the literature of visual perspective is whether adopting one's egocentric perspective share mechanisms similar to adopting another individual's perspective. This will be discussed in the next section where I focus on the implications of the findings of this thesis in legal settings.

5.4. Forensic implications and future research

5.4.1. Egocentric versus 'Other's' perspective

The Cognitive Interview (CI), a protocol developed following requests of police officers and legal professionals to improve interrogation practices, relies on four mnemonic techniques designed to enhance recall of information about witnessed events (i.e., report everything, context-reinstatement, change order, and change perspective – see Wells, 2006 for a detailed description of each of these), with the *change perspective* (i.e., taking the perspective of someone else at the crime scene) technique as one of the most controversial component of the CI; it is suggested to be useful for traumatised individuals as a way to distance oneself from the stressful event (Fisher, Brennan, & McCauley, 2002), but its effectiveness is still controversial.

The benefits of CI over other interviewing techniques used by police officers (e.g., structured interviews that do not rely on the four mnemonic techniques) have been reported when the four mnemonics are examined together (e.g., Centofanti & Reece, 2006; Geilseman et al., 1984; Milne & Bull, 2002). However, when the benefits of the four memory retrieval techniques are examined individually, it appears that the *report everything* and the *content-reinstatement* are the two most effective and most often used compared to the *reverse order recall* and the *change perspective* (e.g., Boon & Noon, 1994; Clifford & George, 1996; Kebbell et al., 1999). One study has reported that the *change perspective* is not any less effective than the other mnemonics, yet overall recall when taking someone else's perspective was still numerically lower compared to recall elicited by the other 3 retrieval techniques (Milne & Bull, 2002). By contrast, Boon & Noon (1994) reported that a combination of the *report everything* + *change perspective* techniques led to a significant decrease in memory accuracy compared to a combination of *report everything* with *reverse order recall* or *context reinstatement.* Not surprisingly, officers have reported that its use is infrequent as well as being rated as the least useful technique (Kebbell, Milne, & Wagstaff, 1999). As noted by Milne and Bull (2002), the CI is typically longer to administer compared to standard police interviews, highlighting the importance to verify whether all of the four techniques are effective to enhance recall. Retention intervals between the crime and the interrogations have also been shown to affect recall accuracy, in particular when it comes to identification of perpetrators (Shapiro & Penrode, 1986; for a review see Wells et al., 2006). Eyewtiness might in fact be interviewed multiple times over the course of days or months. For this reason, it is also important to establish how the CI mnemonics might influence subsequent recall of information.

The findings of this thesis provide evidence in favour of the argument that changing perspective might not be so beneficial for memory recall. As I demonstrated, not only is the subjective experience of memories to be affected, but also the amount of details one can recall as well as the accuracy with which the original perspective is subsequently recalled are reduced following a shift in perspective. From an eyewtiness interrogation standpoint, it is clear that the changes in the way the original event is remembered could be detrimental in the reconstruction of a crime scene. Critically, one important distinction with research in these applied settings is that here I manipulated egocentric perspective rather than taking another individual's perspective. Chapter 3 provided the first piece evidence that adopting a novel perspective might recruit mechanisms similar to taking the perspective of someone else in a scene, at least in the case of spatial perspective-taking. However, little is still known about similarities and/or differences between these two types of perspective taking.

Buckner and Carroll (2006) argue that self-projection is the ability to project oneself from the immediate present to simulate imagined alternative perspectives, with the ability to adopt someone else's perspective (i.e., theory of mind) as one of the ways in which we can mentally project ourselves in alternative situations. The ability to adopt different visual perspectives during remembering can also be considered another form of self-projection whereby the individual can simulate a past event (or future events as discussed earlier) from different visual perspectives with reference to oneself. Both types of perspective taking inevitably require a shift from an own eyes perspective to a novel vantage point, requiring a remapping of the spatial context of the memory to be mentally projected into a different vantage point thereby seeing the event from a different viewpoint. Directly examining whether shifting to another individual's perspective contributes to similar impairments in susbequent memories as those found when shifting one's egocentric perspective would be of importance to potentially solve the controversial findings on the *change perspective* mnemonic, perhaps leading forensic applied settings to the removal of the technique thereby decreasing the duration of interrogation processes. Moreover, eyewitness testimony typically relies on memory for other people rather than oneself. Thus, another open question that would help better inform forensic settings is whether adopting alterantive visual perspectives differentially influences the accuracy of recall for events that include other people other than onself. This might also impact the types of details recalled about the witnessed event.

5.4.2. Central and peripheral details

Crimes can be complex and attention can be drawn to details that are more central to the scene during the original encoding of the event (e.g., *weapon focus effect,* see for a meta-analysis Steblay, 1992), at the expense of peripheral details that might still result critical for legal investigations. Recall of central and peripheral items have been examined in relation to retrieval-enhanced suggestibilty to misinformation (e.g., Wilford, Chan & Tuhn, 2014); some have demonstrated that memory for central items is less suscetible to misinformation compared to memory for peripheral items (Paz-Alonso & Goodman, 2008), whereas others have shown that memory for central as well as for peripheral items can be affected by misleading information (e.g., Saunders, 2009; see also Dalton & Daneman, 2006). No research has yet addressed how retrieval from different perspectives might influence item centrality. Adopting novel perspectives might not be so beneficial for overall accurate recall of information, but it might differentially affect the type of details one remembers about one's past. McIsaac and Eich (2002) demonstrated that the particular visual perspective one adopts affects the distinction between internal and external (i.e., objective) details recalled, but it might also extend to a different categorisation of memory details, such as central and peripheral.

One of the overarching assumptions of constructing a novel perspective is the remapping of the spatial context of the memory, where the individual has to imagine themselves from an external viewpoint, thus changing and potentially expanding one's field of view. The act of shifting to this novel viewpoint might differentially affect the availability of central and peripheral details on later recall. For example, the re-conctruction of the spatial context when adopting a novel perspective and distancing oneself from the event might increase access to those items that are not so central to the event scene. As discussed by Wilford et al., (2014), the best way to determine item centrality (i.e., what factors determine if an item can be considered central or not to an event) has yet to be agreed. For example, if we adopted the definition of item centrality based on their importance in a witnessed event (e.g., Loftus, 1979), one's own physical appearance or the visual details of objects and surroundings are not so central to the witnessed event itself, thus suggesting that shifting perspective might increase recall of peripheral details. However, this latter interpretation is open to discussion; McIsaac and Eich (2002) used memory for mini-tasks that were performed by participants and did not involve any other people. Details that were categorised as objective included also physical actions performed, physical appearance and visual details of objects, which might be considered central for the type of events recalled by participants. Better understanding how visual perspective can influence the types of details recalled and whether these fall into the central and peripheral distinction could not only extend research on the influence of visual perspective on memory recall, but also provide further empirical evidence for legal settings and the effectivness of the *change perspective* technique.

5.5. Conclusion

This thesis contributes to the growing literature on visual perspective by showing that the effects of shifting to a novel viewpoint, not experienced during original encoding of the event, extend beyond the subjective qualities of memories and it influences the accuracy with which these memories are later remembered. Visual perspective is not just a mode of presentation of a past event (McCarroll & Sutton, 2015), but deliberately shifting from an own eyes to an observer visual perspective reflects one of the ways in active retrieval can re-shape the way we remember our past. I suggested that adopting an observer perspective during retrieval might be the result adaptive constructive processes that alter which aspects of the past remain available for later retrieval, such that it creates abstract (semantic) or gist-like representations of our past and that mechanisms rimilar to retrieval-induced forgetting might be responsible for the subsequent memory effects observed in this thesis. The study of visual perspective has mainly focused on its effects on autobiographical memories. Here, I show that immersive 360 ° techonologies are an effective and ecologically valid experimental tool to verify the accuracy of memories. Photographs are also effective tools to manipulate visual perspective, but the implications of the findings of this thesis in the real-world suggest that these might not be so beneficial for memory. Moreover, bridging the gap between the mechanisms of shifiting one’s own viewpoint versus taking another person’s perspective could be useful for the faciliation of interrogation processes in eyewitness testimony, as outlined in light of the forensic implications of the current findings.

Notes

[1] Adopting a more liberal approach showed similar effects to the conservative one, thus only analyses using the conservative approach are reported in detail here.

[2] A separate One-Way ANOVA also revealed that there was no difference in the size of the difference in memory accuracy between the non-shifted and shifted conditions.

[3] Photographs were also taken at the end of each mini-task for each participant (to control for possibility that participants remembered the arrangements of objects at completion of each mini-event). However, photos of objects used in the PowerPoint task reflected objects *before* the start of each mini-task, which may have led participants to arrange the objects as they were initially presented to them rather than their position at the end of the task. For example, in ‘Polish the Shoes’, participants had to remove shoes from their boxes and put them on top of the skateboard at the end of task; similarly, the brush had to be removed from the tin foil. In the spatial accuracy task, shoes were inside boxes and brush wrapped in tin foil (i.e., reflecting the start of the mini-task). Future research could overcome this potential limitation by presenting participants with photos of objects *after* the completion of the mini-tasks.

[4] Repeated measures ANOVAs were also conducted on the two instruction groups on emotional intensity and reliving ratings. Similar differences between the own eyes and observer-self conditions emerged for the group that received visual perspective instructions. Given the impact of visual perspective instructions on the phenomenology of memories, it would be of interest for a future study to adopt a within-subject design to better understand how the physical self in the observer perspective contributes to changes in the properties of memories.

[5] Sample size of Chapter 3 and 4 was estimated performing a power analysis using G*Power 3.1 based on the subsequent memory accuracy findings of Chapter 2, Experiment 1. Given that the main interest in this research was how adopting an own eyes and observer visual perspective during retrieval influenced subsequent memory accuracy, sample size estimation was based on the within-group comparison between these two experimental conditions (i.e., non-shifted and shifted perspective conditions). The effect size observed for this comparison was d = .83. Assuming an alpha level of .05 and a suggested power of .80, the estimated sample was N = 14, suggesting that the sample size used in the experiments of Chapter 3 and 4 was sufficient to detect an effect of at least d = .83.

[6] Findings of Chapter 4 showed that actively shifting perspective reduced subsequent visual perspective accuracy compared to maintaining the perspective shown in the photo cue, but the novelty of the shift in perspective did not contribute to subsequent reductions in perspective accuracy. One might still argue that actively shifting perspective still led to ‘forgetting’, but as discussed in the chapter, further research is needed to isolate the effects of actively shifting to a novel viewpoint.

Appendices

Appendix A: Titles and brief descriptions of the mini-events paradigm in Chapter 2 and 3. Note: mini-events 25-32 were only included in Chapter 3.

1) Shred the Documents: Shred the paper and pack the objects in the bag.
2) What's in the Container? Have a go and guess what's in the containers.
3) Create Play Doh: Form a "beach" scene with play doh and send a message.
4) Dress the Balloon: Make the balloon into a person and take a photograph.
5) Recite the Poem: Record yourself as you recite and act out the poem.
6) Build a Tower: Build the tallest tower you can with the materials.
7) Wrap the Present: Gift-wrap the bell with the materials provided.
8) Play the Guitar: Assemble the guitar and use it to copy a tune.
9) Marble Game: Flick the marbles into the openings in the cups and keep score.
10) Polish the Shoes: Prepare the shoes with polish and do a trick.
11) Frog Pond: Free the frogs into the pond and feed them.
12) Hidden Treasure: Find the treasure and hide it in the sand.
13) The Fun House: Make your way through the activities in the fun house.
14) Fishing Expedition: Collect the fish and prepare sushi.
15) Tangram Puzzle: Fashion a cat from the puzzle pieces.
16) Make a Book: Make a book and write a story.
17) Arrange Flowers: Create a flower garden.
18) Paint Art: Design a piece of artwork.
19) Drawing to Music: Draw the items on the cards and listen to music.
20) Chemistry Recipe: Create a volcanic eruption.
21) Geo Board: Add the pushpins to the board to create a shape.

22) Fold the Box: Fold the box while making the ball bounce.

23) Prepare a Pizza: Prepare a bespoke pizza.

24) What’s the Loudest?: Make sounds and order them from lowest to highest pitch.

25) Playing Table Basketball: Create a catapult to play basketball.

26) Afternoon Tea: Set the table and prepare tea.

27) Baking Bread: Use the ingredients to bake some bread.

28) Card Castle: Follow the diagram to create a castle with cards.

29) Binocular Exploration: Create a binocular and explore the patterns.

30) A Day At the Farm: Prepare the animals in the farm for the night.

31) Make-Up Artist: Use the ingredients to prepare a natural make-up for the unicorn.

32) Create a Picture Frame: Create a home-made frame for the photo.

Appendix B: Titles and brief descriptions of the 360-degree video events (Chapter 4).

1) A Day at the Playground. Riding the swing

2) Advertising on the Street. Putting up something on the street

3) Birthday Party. Lighting the candles

4) Christmas Rehearsal. Singing Jingle Bells

5) Cleaning the Floors. Freshing up

6) Cleaning the Windows. Removing stains

7) Delivery. Knocking the door

8) Exercise at Outdoor Gym. Upper body exercising

9) Exploring Sussex Downs. Walking in the grass

10) Feeding the dogs. Feeding two dogs

11) Fixing the bike. Fixing the wheel of the bike

12) Gardening. Taking care of the flowers

13) Going on a Hike. Picking up something from the car

14) Grocery Shopping. Realising the shop is closed

15) Grooming the horse. Grooming the mane of the horse

16) Hanging out the Washing. Hanging clothes

17) Hanging something on the wall. Decorating the walls

18) Ironing. Getting rid of wrinkles

19) Jumping a Mini-Circuit. Getting ready to jump

20) Knitting. Knitting

21) Learning a language. Repeating vocabulary

22) Learning how to Juggle. Juggling

23) Looking for chestnuts. Exploring in the grass

24) Lunch at the café. Eating

25) Lunch at the pub. Deciding what to eat

26) Making breakfast. Pouring tea

27) Making the bed. Putting pillows

28) Organising the Folder. Organising papers

29) Picnic in the park. Setting for a picnic

30) Playing a Game . Deciding who wins

31) Playing Djenga. Making the tower fall

32) Playing with dogs. Running with the dog

33) Portrait on the beach. Portraying the sea

34) Reading at the Library. Reading

35) Recycling. Recycling in the boxes

36) Snack on the Beach. Having a snack

37) Table Tennis match. Playing table tennis

38) Volleyball Practice. Playing volleyball

39) Washing the car. Cleaning the car

40) Welcoming a Friend at the Station. Getting ready to leave

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