Tablet Computers and Technological Practices Within and Beyond the Laboratory

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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.

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Summary

In this thesis I examine emergent technological practices relating to tablet computers in scientific research laboratories. I ask four main questions: To what extent can tablets be considered scientific instruments? How do tablets help to construct technoscientific imaginaries? What role do tablets play in the construction of technoscientific subjectivities? Can tablets, positioned as popular everyday computing devices, be considered in terms of expertise in the context of laboratory science?

To answer these questions, research is presented that examines the situated practices of scientists using tablet computers. I use textual analysis to examine the marketing discourses relating to laboratory-specific tablet apps and how their material structure defines scientific community and communication. Ethnographic research into the way that tablets are being introduced as part of a new teaching laboratory in a large UK university is presented, focusing on how institutional power affects the definition of the tablet. A second ethnographic research case study addresses how two chemists define their own scientific subjectivity by constructing the tablet as a futuristic technology. In a third large ethnographic research case, I consider the way that tablets can be used in practices of inclusion and exclusion from sites of scientific knowledge.

I draw on literature from media and cultural studies and science and technology studies, arguing that the two fields intersect in ways that can be productive for research in both. This serves as a contribution to knowledge, demonstrating how research into identity, politics and technologies can benefit from a focus on materiality drawn from the two disciplines.

I contribute to knowledge in both fields by developing two key concepts, 'affordance ambiguity' and 'tablet imaginary'. These concepts can be applied in the analysis of uses of technology to better understand, firstly, how technologies are made meaningful for users and, secondly, how this individual meaning-making affects broader cultural trends and understandings of technologies.

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Chapter 1. Introduction: Genealogy of the Tablet

"…slates had to be balanced awkwardly across the knees and cradled with one arm" (Davies, 2005: p.66)

Introduction

When discussing research into tablet computers, people occasionally ask "oh, what are they?" At first, I would tell people that tablet computers "are touchscreen devices, usually around the size of a thick sheet of paper. They almost all connect to the Internet and can be used for various work and leisure activities. Many use a stylus to recreate the sensation of writing with a pen or pencil; most can use fingertip input". All of these descriptions are useful, but convey only a vague definition of this new media object. After many frustrating attempts to clarify what a tablet computer is, I found the simplest reply to be, "like the iPad". Almost everybody has heard of that.

The tablet computer is a culturally constructed object, and to define it requires due attention to its cultural meanings. That is why "like the iPad" is a useful quick definition. Those three words say nothing about the physical object, but they contain huge amounts of cultural meaning. These cultural meanings are the focus of this chapter. The tablet computer is treated as a physical, material object which embodies cultural meanings. It is these cultural meanings that allow the tablet to make sense as an object. Crucially, these meanings are contextual – they rely on a particular set of knowledges, beliefs and practices that are more or less common sense within a culture.

It is not necessary to have expert knowledge of computer engineering to know that to move pictures on a tablet computer, you simply swipe your finger across the screen. Anybody who watches television probably knows that already – it is featured in advertising

for touchscreen devices such as tablets and mobile phones. For the tablet to 'make sense' as an object, this kind of cultural knowledge is required. Because it is common sense, this cultural knowledge is difficult to appreciate, difficult to see. It is probably most visible when absent. A good example in the case of tablet computers is found in German comedy sketch show *Knaller Frauen*, where a grey-bearded man unwittingly uses a tablet computer as a chopping board, proceeding to slide the chopped onions into a saucepan, and his tablet computer into the dishwasher, much to the horror of his daughter[1]. Part of the comedy in this sketch derives from how ludicrous it is for somebody not to have the necessary cultural knowledge to understand the object, and value it in the accepted way. Of course, his grey beard gives the game away – there is no place for old men amongst the perpetual novelty of technology. The point is that objects only 'make sense' when we are aware of the relevant cultural meanings and behave accordingly. It doesn't make sense to use the object in other ways. Without the accepted cultural knowledge and values, the old man is presented as ridiculous; his actions shocking and hilarious. Examining how the object *makes sense* can therefore expose the cultural knowledge and values upon which it relies. In this way, it can be shown how meaning emerges from the interrelation of objects and their contexts.

This links back to the problem of defining the tablet computer: it is clearly not enough to say "like an iPad". The iPad is evidently a popular product: according to Apple, in the 2011 financial year (October 2010 to September 2011), over 32 million iPads were sold[2]. In the financial year ending October 2014, the figure was over 67 million[3]. Yet, iPads are just one particularly well-marketed example of tablet computers. In fact, there are well over 40

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[1] From Series One of *Knaller Frauen*, found on http://www.youtube.com/watch?v=gUCpOYdG8hM [Accessed 3rd May 2012].
[2] http://www.apple.com/pr/library/2011/10/18Apple-Reports-Fourth-Quarter-Results.html [Accessed 30th April 2012].
[3] http://www.apple.com/pr/library/2014/10/20Apple-Reports-Fourth-Quarter-Results.html [Accessed 26th November 2014].

different makes and models of tablet computer available to buy in the UK today. A Wikipedia page comparing tablet computers lists 160 different consumer devices and a further 27 specialist devices[4]. To say that tablet computers are "like the iPad" is clearly doing a disservice to the many other manufacturers that produce tablets. Furthermore, the cultural and market dominance of the iPad applies to a particular cultural moment. The instability of such dominance is illustrated by Atkinson's 2008 article subtitled 'the rise and fall of the tablet computer' that "traces the early development of pen computing, the appearance, proliferation, and disappearance of the tablet computer, and explores possible reasons for the demise of this particular class of product" (Atkinson, 2008: p.3). Two points can be drawn from this: firstly, the phrase 'tablet computer' referred to something other than the iPad at the time, highlighting the changes in terminology. Secondly, the fact that the tablet computer was 'dead' in 2008 appears almost comical when read from the perspective of even two years later. This is not to criticise Atkinson's work, but to point out that the necessarily temporary and incomplete definitions given to such devices must be acknowledged without being seen as a barrier to critical research.

More importantly, to describe tablet computers as 'like an iPad' is to ignore the experience of the millions of people who own and use tablet computers made by different manufacturers; using them in a variety of ways according to their own preferences, and their tablet's particular capabilities. There are two ways of answering the question, "what is a tablet computer?" A dictionary definition describes the object, but it does not indicate much about what the object means to its users. For the users of these devices, the meaning of the object is something very complex indeed. Their tablet computer may mean 'status'; it may mean 'working from home'; it could mean 'playing games on the train'. The case studies that form the main body of this thesis involve the Samsung Galaxy Tab 10.1, the

[4] http://en.wikipedia.org/wiki/Comparison_of_tablet_computers [Accessed 6th April 2015].

iPad Mini and the Google Nexus 7 being used in science laboratories. For some of the participants, this tablet means freedom to work outside of prescribed hours. For others, it means the unwanted task of learning how to use an unfamiliar technology. In each case, the meaning of the tablet computer is bound up in the local context, in which new technologies are being introduced to the workplace. The truth is that for any technological object, *what it means* is likely to be an intricate and personal combination of experiences, thoughts, feelings and ideas. In this thesis, I will draw on and develop the Foucauldian notion of discursive materiality to describe the way that the material characteristics of technological devices are not neutral and unambiguous, but are defined by particular discourses.

Before addressing the case studies in subsequent chapters, this chapter answers the question "what is a tablet computer?" in detail by giving a genealogy of the tablet. The ethnographic approach taken in this thesis demands that I take account of the ways that I am creating the conditions for understanding this object. Research participants consistently treated me as a tablet computer expert. The fact that I was observing their work and interviewing them about tablets inevitably gave the impression that I was knowledgeable about tablets, and occasionally participants tried to draw on this imagined expertise by asking me what they should use their tablets for. While I never engaged with such questions directly, my own understanding of tablets is relevant to the way that the case studies were chosen and developed.

The tablet computer that we see today has a long cultural heritage. This is not to say that it is the latest iteration of an evolving object called the tablet. The idea of a genealogy goes against the notion of linear history. The genealogy of the tablet begins from the present, and works through historical objects that today are associated with the tablet computer. While not aiming to produce a cultural genealogy on the scale of Foucault (1989), much of the methodology here is inspired by his archaeological technique, which

examines particular historical contexts, and asks what made certain kinds of knowledge possible in that moment (Foucault, 1989: p.35). In this regard, historical tablets will be examined, focusing on the relationship between these material objects and particular cultural meanings and types of knowledge. These objects are chosen because they resonate today when we speak about tablets. One example is the practice of calling the pen-like computer input device a 'stylus'. The use of the word 'stylus' rather than 'pen', which is undoubtedly a more familiar object to current users of tablets, is one indication of the influence that these historical objects have on the current meaning of the tablet. Yet it must be remembered that the resonances that are observed in the current meaning of tablet do not come *from history*. The significance of these objects in our current meanings reflects a history constructed in the present.

This chapter constructs the tablet computer as a material and symbolic object, by tracing its relationship to various historic objects. Firstly, references to historical objects are given to demonstrate their continuing cultural resonance in understandings of tablet computers. Secondly, different concepts associated with those objects are examined: the relationship between the symbolic and material in the stone tablets of the Ten Commandments; the notion of permanence and ephemerality as observed in clay writing tablets; and ideas of intellectual ownership and pedagogy in writing slates in schools. Finally, the way that this impacts upon our understandings of tablet computers is examined. Over the course of the chapter, the tablet computer will be described as a physical item with particular properties, incorporating various symbolic meanings with significant implications for how the object is understood.

The Ten Commandments

When I searched for the word 'tablet' on Google in 2012, the first result at the top of the page was an advertisement for the Apple iPad. Other than advertisements, the first

webpage result was for the website of *the Tablet*, a British Catholic weekly newspaper. The filters used by search engines to determine relevant results mean that no set of search results is definitive (Pariser, 2011). Nevertheless, the connection between tablet computers and religious publications seems instructive. Searching 'tablet' on Google in 2015, *the Tablet* website is still in a prominent fourth position, albeit now underneath website results for retailers Amazon.co.uk, Argos.co.uk and PCWorld.co.uk. Searching 'tablet' in 2015 using DuckDuckGo generates adverts for various tablet computers, above website results for Amazon.com, BestBuy.com, ConsumerReports.com and a website for *Tablet Magazine*: "a new read on Jewish life". Although a new media device and religious publications might seem unrelated, the cultural connection between the two is surprisingly strong. The symbolic link between the iPad and the word of God handed down on stone tablets has not been lost in popular culture. Staff were "whipped up into an evangelical frenzy" during the opening of a new Apple store in Covent Garden, London in 2011 according to BBC programme *Secrets of the Superbrands*[5]. The front page of the *Economist* in January 2010, a few days after the launch of the iPad, featured a mock-biblical image of the late Steve Jobs, CEO of Apple, holding the new iPad aloft[6]. The biblical theme has also been extended to Jobs's successor Tim Cook, who appears on the October 2014 cover of Management Today[7] as a martyr being prayed for by a cherubic depiction of Jobs. In fact, pictures of Moses holding an iPad are so numerous on the Internet that the image has become cliché. The comparison is clear: the tablet computer, particularly the iPad, is seen as a powerful material object offered to the people by an authoritative figure.

In this section, I argue that the tablet computer and the stone tablets of the Ten Commandments are material objects with significant symbolic meanings. The way that the

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[5] http://www.bbc.co.uk/news/business-13416598 [Accessed 19th April 2012].
[6] http://www.economist.com/node/15393377 [Accessed 18th April 2012].
[7] http://www.managementtoday.co.uk/news/1313403/apples-tim-cook-martyr-visionary/ [Accessed 7th April 2015].

physical objects imbue these meanings is examined in terms of the religious practices associated with tablets. It is shown how, as objects, tablets only make sense in the context of particular cultural beliefs; and that the culture can only be experienced as normal when those objects are used in everyday life, perpetuating those beliefs.

In the Judeo-Christian tradition, Moses receives stone tablets from God on Mount Sinai:

> And the Lord said unto Moses, Come up to me into the mount, and be there: and I will give thee tables of stone, and a law, and commandments which I have written; that thou mayest teach them (Exodus 24:12)[8]

The stone tablets of the Ten Commandments are made by God, inscribed by God, and contain the written words and instructions of God. In one respect, they are symbolic objects which are powerful because they represent the covenant between God and the chosen people – an agreement that will see the Israelites overcome their enemies and inherit fertile land (Exodus 34:11). In this sense, the stone tablets do not hold any power in and of themselves; they represent the laws and commandments by which the Israelites will gain power (i.e. gain superior land, overcome enemies on Earth; spiritual salvation in heaven). At the same time, they are also material objects, inscribed with words that are a literal guide for Moses on how to live (Exodus 34: 10-26). The interplay between the tablets as both symbolic and material objects continues throughout.

Despite being made of stone, the fragile materiality of the tablets is soon brought into play. When Moses descends Mount Sinai, he finds his people blaspheming in his absence. In a rage, he casts the tablets to the ground, where they break (Exodus 32:15-19). It may be argued that this is symbolic: Moses breaks the tablets in the same instance that he finds his people breaking the covenant. Yet their existence as material objects continues to be

[8] Biblical quotes are taken from The King James bible throughout. [Bible (1954) *Published as 'The Bible: The Authorized Version'*. The British and Foreign Bible Society.]The Oxford English Dictionary notes that the word 'table' reflects the translation from various sources. In more recent translations of the Bible, 'tablet' is used.

crucial. Later, when God has forgiven Moses, he commands Moses to hew "two tables of stone like unto the first" (Exodus 34:1), which God will inscribe with the same words as before. It is not simply a case of reaffirming the agreement: the stone tablets are required to make this agreement stick. It is not enough to have an agreement, or to live by the rules and customs decreed by God: the authority of this holy pact requires that it is literally written in stone. There is something in the materiality of the stone tablets that is necessary to guarantee or confirm the covenant. The fact that the stone tablets are man-made, being remade by Moses, indicates that physically they are not holy objects in and of themselves. This implies that the tablets are only symbolically powerful: they represent the covenant which will ensure the spiritual and physical well-being of the Israelites. But if they were merely symbolic, why were they remade at all? The fact that the tablets were re-made suggests that their physical existence is required in some way to support the covenant. Again, the symbolic and the material interweave. It seems that the question of the stone tablets being *either* powerfully symbolic *or* powerful material objects is misleading; they are both.

In the Judaeo-Christian tradition, the stone tablets are physical objects that prove the existence of God. Moses could not inscribe stone, so these miraculously inscribed tablets are a physical link between humans and God. Note in the context of the Exodus story, the need for physical proof of God's existence is perfectly reasonable. The Israelites do not even wait for Moses to come back down from Mount Sinai before they start worshipping golden idols (Exodus 32:8). They are not yet faithful in the sense of having unquestioning belief. The stone tablets, though, are physical proof of something miraculous, which in turn proves the existence of a divine being who can perform miracles. As strange as it sounds, though, as material objects that can prove that God exists, the tablets are not powerful. Proving that God exists is not the same as salvation. The Israelites will not benefit unless they live according to the covenant. The knowledge that God exists – which is the only

knowledge that the stone tablets as physical objects can offer – does not grant any power whatsoever. There is no suggestion that physically holding the tablets will make you powerful, or redeem you, or anything of the sort. Their power derives from what they symbolise: the covenant that promises those who obey it physical and spiritual well-being. So, the symbolic power of the objects is predicated on the belief in the existence of God, *which relies on the physical stone tablets*. As physical objects, the stone tablets prove the authority of God as a divine being. Symbolically, they represent the power of the covenant to ensure material prosperity and spiritual salvation. This power is nothing without the authority to back it up; and the authority is meaningless without the power it guarantees. Thus, the materiality and the symbolism of the tablets are interrelated. As symbolic objects the tablets are potentially powerful; but it is their materiality that allows them to be imbued with that symbolic power.

As material objects, therefore, the stone tablets are central to an entire way of life. They signify the belief in God and the authority of the holy way of life as laid out in the covenant between God and Moses. This dictates not only how to live in practical terms, but also what to think, feel and believe. The tablets are one locus of the object/context relationship that allows the rules, regulations and accepted beliefs of entire societies to make sense. This interrelation means that if the nature of the object changes, so must the beliefs and practices. This is demonstrated in the differences in how the stone tablets are understood in different branches of Abrahamic religions, even though they all take the story of the stone commandments from the same historical source, in the Jewish Torah. Differences in how the tablets are materiality understood, in forms of Judaism, Christianity and Islam, are related to differences in the beliefs and everyday practices of those religions.

A more strongly material interpretation of the authority of the written word of God is present in the Islamic tradition. The tablets also appear in the Qur'an, which tells a similar story to the Judeo-Christian story of Moses at Mount Sinai. In this case, Musa receives

tablets from Allah inscribed with "instruction and explanation for all things" (7:145)[9]. Musa descends the mountain, and is angry to find his people sinning (7: 150). In this case, however, he merely 'throws down' the tablets (ibid.), with no suggestion that they break. Later, once his anger has subsided, he picks up the tablets once more "and in their inscription was guidance and mercy for those who are fearful of their Lord" (7:154). In this tradition, then, the tablets are made by God and inscribed with God's words.

As such, the stone tablets as material objects are both authoritative and powerful. Not only are they miraculous objects – proof of the existence of God – but they are also literally inscribed with instructions on how to live a holy life. The key to salvation is not left to the symbolic covenant: it is written down on the tablets themselves. In this case, the physical stone tablets are both authoritative and powerful. The word of God is not an abstract concept: it is literally written down, and Musa only finds peace when he reads the words. In the Islamic tradition, then, the stone tablets are powerful material objects.

More importantly than the appearance of tablets in the story of Musa is the Qur'an itself. The Qur'an is said to exist in its perfect form in heaven (known as *al-Lawh al-Mahfuth)*, where it was written by Allah. It is said to have been recited to Muhammad in two stages. Some of the scripture was given to Muhammad when he met the prophet Musa during an ascent through heaven (32:23). The rest was sent down over the course of some months, divided into sections so that Muhammad could recite it to people over a prolonged period (17:106). The true Qur'an, though, remains in heaven preserved on a stone slate or tablet (85:21-2). Allah not only wrote the Qur'an, but also takes responsibility for its preservation in heaven (15:9). The Qur'an, then, is the ultimate material object. Its

[9] The quotations I use are from the Saheeh International version of English meanings of the Qur'an. [Qur'an (2001) *THE QUR'AN. English Meanings Revised & Edited by Saheeh International.*. Riyadh: Abul-Qasim Publishing House.]There are obvious difficulties in quoting text from the Qur'an: primarily the belief that Arabic is sacred, so the Qur'an is untranslatable; also the linguistic problem of translating words between two languages whose grammar is so different. I give the Sura/Chapter and verse so that the text can be consulted in the Qur'an proper.

authority and power are complete: it was written by God, is preserved by God in heaven, and contains all possible knowledge (6:38). The Qur'an as Preserved Slate is the ultimate authority: it does not merely represent the word of God; it *is* the word of God.

In Christianity, a change comes about in the New Testament, where the sanctity of the stone tablets is questioned. Paul writes that the teachings of Christ should be "[…] ministered by us, written not in ink, but with the Spirit of the living God; not in tables of stone, but in fleshy tables of the heart" (II Corinthians 3:3). Paul goes on to ask, "But if the ministration of death, written and engraven in stones, was glorious […] how shall not the ministration of the spirit be rather glorious?" (II Corinthians 3: 7-8). Here, it is the symbolic, not the material, that takes precedence. The disciples reject the authority of the written word – in this case, the Jewish Torah – and proclaim the authority of their own teachings. The suggestion is that the word of God should be understood and acted upon as a matter of the soul, not as a set of written teachings.

The different understandings of what the tablets mean in various branches of Islamic and Christian traditions show the interrelation between object and context. A particular understanding of the stone tablets dictates corresponding practices in everyday life. In Islamic traditions, the stone tablets are holy material objects, and the Qur'an is therefore treated as a holy object, and Arabic as a holy and untranslatable language. Other material objects can be imbued with great significance, as with the statues of leaders of Islamic countries – where anybody who attacks or defaces the statue will face the same punishment as if they had attacked the person. In some Christian interpretations, an attachment to material objects is treated as blasphemous, as this overemphasises the material, to the detriment of the symbolic.

This section has shown how the material and symbolic aspects of the stone tablets are interrelated. Tablets were depicted as objects dependent on a system of cultural beliefs to render them meaningful. In turn, the tablets imbue everyday practices with meanings that

support the overall system of beliefs. The same questions of materiality and symbolism, and the relation of objects to contexts, are present in the tablet computer. Using a tablet computer requires knowledge and appreciation of technological practices which that be learned and adhered to. Although evidently different from the religious practices which require people to act in certain prescribed ways, the tablet computer demands particular behaviours of its users. Disco (2005: p.33) notes how personal digital assistants (PDAs), a proto-tablet computer, require the user to change their habits and behaviours to suit the device. The same applies to the tablet: set up to receive notifications of email, appointments, news stories, Tweets, Facebook messages and so on, the tablet requires the user to attend to these tasks. It does not make sense to own a tablet and not do these things. Note that the idea of it 'making sense' to use a tablet for certain prescribed tasks is heavily dependent on the discourses that dictate which tasks are seen as normal. It is not to say that the tablet can *only* be used in these ways; but as illustrated by the sketch of the elderly man using an iPad as a chopping board, culturally there are certainly 'wrong' ways to use a tablet. It does not make sense to use the tablet as a chopping board. Because of the expense of the device, the way that the tablet software encourages you to 'share' at every opportunity, and the fact that you typically have to set up a sharing account before you can use the tablet, it does not make sense to own a tablet and not make use of its email, social networking functions and other similar facilities. The user literally buys into the way of life that makes the tablet make sense. At the same time, the context in which the tablet is meaningful is upheld by those practices. Once you habitually use your tablet to check emails on the go, a culture in which instant response to emails is demanded becomes naturalised.

This is one way of explaining why the stone tablets of the Ten Commandments are bound up in the present meaning of a tablet. Buying a tablet really does involve accepting particular beliefs, adopting a particular value system, and carrying out certain ritualistic

everyday practices. Of course this is not the case for every single tablet user, but the religious comparison persists in the imagery of Moses holding a tablet computer because it represents a common experience. With tablet computers, the object only makes sense within a particular context – the reward for buying into the everyday practices afforded by the tablet computer is the sense belonging to an exclusive community. In this case, a community founded on the sharing of status updates, photos, Tweets, interesting newspaper articles, digital game scores, and countless other tablet services. Equally, certain aspects of the context in which the object is found – for example, the expectation for people to reply immediately to emails – only make sense when the tablet or other similar objects are used in everyday life, exercising and perpetuating those beliefs.

The following section looks at a different historical object that is often brought into play when talking about tablet computers. Clay tablets are examined in order to question the notion of permanence and transience in writing technology.

Clay Tablets

The previous section constructed the stone tablets of the Ten Commandments as symbolic and material objects to argue that object and context are interrelated, and rely on each other to be experienced as meaningful. This section focuses on the idea of permanence in relation to writing tablets, and how this affects our current understandings of tablet computers.

The tablet computer is characterised by its touchscreen interface. It differs from the personal computer or the laptop because it does not have a physical keyboard. This allows the devices to be small enough to be usefully portable. To work without a keyboard, proto-tablet computers such as PDAs like the Palm Pilot used a stylus to input individual handwritten letters in a small box on the touchscreen. The device recognised the stylus strokes and then digitised them so the letter appeared on the screen much like a PC. In

practice, however, this stylus handwriting input method rarely worked smoothly. Baron (2009: p.68) suggests that nineteenth century office clerks skilled in standardised handwriting script may have been able to use a PDA easily, but the individuality of handwriting today means that users effectively have to learn how to write in the accepted style. Consequently, a PDA does not really use 'handwriting recognition'; it recognises a particular script which is likely very different from the user's handwriting.

Although the common input method for tablets is now a touchscreen QWERTY keyboard, the stylus remains an important object in how today's tablets are understood. As the competition between the two main tablet producers shows, using a stylus is not simply about the best input method; it also represents a sense of loyalty and belonging to the brand. In a keynote speech to launch the original iPad in January 2010, Steve Jobs championed Apple's touchscreen interface and taunted potential competitors with the line, "if you see a stylus, they blew it". In February 2012, a Samsung advert[10] during the Superbowl hit back, depicting Apple customers looking miserable in a queue. When a passer-by using a new Samsung Galaxy Note lets a man in the queue try the new device, the person in the Apple queue says, "It's got a pen? This is awesome". In a jibe at the Apple 'fanboy' culture, a woman in the queue looks impressed and says, "I don't know what I believe in anymore". Later, we see the Samsung device being used to take a photo of fans posing with a famous American Football player, who then autographs the picture on-screen, using the stylus. Of course, this is intended to show the benefits of having a stylus input; playing on a feeling that handwriting is more personal than typing (Baron, 2009: p.69). But is having a digital autograph written with a stylus on a touchscreen comparable with a signature materially inscribed on a writing surface? Blanchette (2012) outlines the various abstractions that are necessary in efforts to create digital equivalents of written

[10] http://www.nfl.com/superbowl/46/commercials#video=09000d5d826a0d3b [Accessed 10th May 2012].

signatures, noting that the perceived purpose of written signatures becomes defined in the encoding of intended digital equivalents. Blanchette's focus on legal evidence does not account for the emotional and cultural aspects of signatures in the form of autographs. Could the virtual autograph of the Football player be treasured in the same way an autograph in a physical medium might be? This section examines questions of permanence in relation to clay writing tablets, and how this notion is being challenged by tablet computers.

The first clay tablets were used for accountancy in the fourth millennium BC, with pictograms used to represent the type and number of different assets such as land, labour and animals (Robson, 2009: p.67). Scribes wrote these details on both sides of "refined clay tablets, about the size of a credit card but around 1cm thick, incising the signs for the objects they were recording with a pointed stylus and impressing the numbers with a cylindrical one" (ibid.). Clay for writing had to be prepared in the same way as for pottery; it had to be sieved and strained to remove stones and impurities, and kneaded to remove air bubbles and increase its elasticity (Robson, 2009: p.70).

The clear advantage of using clay tablets rather than relying on memory was that they offered a permanent and fixed storage medium. This is essential for keeping records of accounts. The contrast with the digitally-rendered virtual signature of a football star on a tablet computer is clear. The virtual inscription has no material substance (although clearly having a material effect, the light produced by pixels): the tablet uses pixel recognition to trace the movement of the stylus relative to fixed points on the screen. This pattern is then rendered on pixels, displaying the signature on the screen. An inscription on clay left a tangible imprint, laid into the very material of the document. If clay can be called a predecessor to paper, it was also a predecessor to ink: it formed the entire material existence of a written document. Robson (2009: p.69) argues that "in early Mesopotamia cuneiform literacy had been primarily a tool for controlling the ownership and rights to

assets and income". We can speculate that ownership of clay tablets would therefore be a mark of a family or dynasty in control of assets and income. The on-going physical presence of these objects would therefore presumably be an important material support for the symbolic power they represented.

As cuneiform writing became more complex, and developed from pictograms to marks representing word sounds, other types of documents could be created. The scribe could use cuneiform to commune with the gods, to create intellectual culture, and create legal documents (ibid.). Once cuneiform writing became a prestige medium in this way, the scribe came to be held in high honour (Roemer, 2009: p.88). Clay tablets were stored in archives or libraries with shelf markers corresponding to record systems (Robson, 2009: p.70). This represents a significant change in the purpose of clay writing. The earliest accounting tablets feature pictograms squeezed onto a surface in no particular order, suggesting that they were written to keep personal records, not intended for an audience (Baron, 2009: p.89). For the later tablets stored in libraries, however, readability must have been important, as the tablets would have been read by more than just the original scribe. The clay tablet would therefore be a permanent record of the scribe's work which could be read by anybody with the required training in cuneiform script.

Much of the materiality of clay writing tablets suggests that their main advantage was the permanent – or at least long-term – storage of information. The permanent and dependable physicality of clay was superior to the more fallible storage medium of human memory. There are aspects of clay tablets, however, which go against the sense of permanent storage of information. Despite the material object being well-suited to fixing information, other uses of clay tablets show that the flexibility of clay as a material could also be beneficial. Clay is rewriteable and reusable, as long as it has not been fired. When the information on a particular clay tablet stored in a library was out of date, the clay was soaked and recycled as new writing material, or used as building material (Robson, 2009:

pp.70-72). Cuneiform tablets were designed to be permanent as long as they were useful. Although in practice tablets were often recycled, their archival storage suggests that they were required at least to have the potential to be permanent in the sense of storing information indefinitely.

Aside from matters of accountancy and law, which required a permanent storage medium to record transactions and prevent disputes, an interesting aspect of the permanence of clay tablets is found in the intellectual culture written in clay. Once cuneiform became a sign of prestige and was used for narrative texts of many kinds, literate knowledge was produced and maintained in scribal schools. Robson (2009: p.72) describes an archaeological discovery of one such school, in which clay tablets included "epic stories of legendary heroes like Gilgamesh and Lugulbanda, myths about gods and their deeds, hymns to gods, kings, and temples, debates, dialogues, and humorous stories about scribal students". We might think that these stories were being committed to the permanent storage of clay in order to preserve them, but Robson disagrees; arguing that these stories were not written down to be read at a later date. Cuneiform writing was used as a means of improving the process of memorising aspects of the oral tradition. Clay tablets were used for writing *but not reading*: two processes we might regard today as fundamentally linked. "There is no early Mesopotamian evidence of reading for pleasure, or even creating or using tablets as reference works: the intellectual tradition was almost entirely composed of knowledge internalized through repeated copying, recitation, and memorization" (Robson, 2009: p.73).

Clay tablets make us rethink the notion of permanence in relation to writing devices. Although the medium is well-suited to providing permanent storage of written information, the storage aspect may well have been incidental to much of the writing that actually took place. Clay tablets *did* store written information, but it does not always follow that they were used for this purpose. Robson suggests that it was only during the Iron Age

in the later second millennium BC that writing media including cuneiform tablets "began to reflect concerns with textual stability" (2009: p.81). Until that time, the "intellectual tradition was predominantly one of oral transmission, with repeated copying for memorization, in which tablets functioned essentially as ephemera (ibid.). In other words, although the material practice of clay inscription did inherently store information, it does not necessarily follow that clay writing was concerned with preservation, storage or endowing written information with permanence.

If clay writing tablets offer us a mixture of permanence and ephemerality, how do they compare with tablet computers? In many ways, the two objects appear to be opposites. The act of writing on clay tablets involves a permanent, material process, using a reed stylus to inscribe signs and symbols into a pliant medium. Although the medium creates physical storage of readable symbols, it is not intended to store information. It is intended to aid and improve memory: the information is stored in the mind of the scribe. As Freud comments in his note on the mystic writing pad (Freud, 1925), as long as writing and storage of information are achieved by the same process, physical devices will only be able to support one process or the other. Thus, the clay tablet is infinitely re-writeable (presuming we can keep recycling the clay), but stores no information. A clay tablet can store information by being baked, but this prevents any further writing. The tablet computer, though, can achieve what the mystic writing pad and the clay tablet cannot: it can infinitely write and infinitely store. Writing on a tablet computer leaves no physical trace: the stylus neither scores nor paints the surface. The surface is therefore infinitely re-writeable, and the act of writing is an ephemeral process: no physical storage of the symbols occurs. Storage is achieved in a separate and – given enough local or cloud-based storage in computer memory – theoretically infinite format. In fact, the efficacy of computer storage media presents the converse problem that it is very difficult to erase or delete information once it has been stored. Kirschenbaum (2012) outlines the USA

Department of Defense strategy for 'sanitising' or removing data stored on computer hard drives:

> The options range from simple overwrites (recording random or arbitrary bits on top of existing information) to various levels of degaussing (using magnetic fields to neutralize the polarity of the magnetic media, thereby sanitising it), to Option M, available for all optical and magnetic media: 'Destroy – Disintegrate, incinerate, pulverize, shred, or smelt' (Kirschenbaum, 2012: pp.25-26).

As well as illustrating the persistence of computer storage, this vivid image of destruction highlights the inescapable materiality of storage, even that which appears ephemeral.

If clay tablets can be described as 'ephemera' because they do not store information, then how should we think of tablet computers, which can store potentially infinite information? Interestingly, tablet computers may be just as ephemeral as clay tablets in this regard. Although local storage – i.e. information stored digitally on the physical hard drive inside the computer – means that tablets do physically 'contain' information, much of the information that tablet computers use is stored in cloud-based systems. The phrase 'cloud computing' refers to data and processes that the user accesses locally, but which are run and stored on servers at remote locations which could be anywhere in the world. To give an example of what this means in practice, we can recall the football star signing an autograph for a fan on a tablet computer. The football star uses the stylus to sign and does not leave a physical signature; no mark is left on the screen. The computer generates a piece of digital information that can render the movements of the stylus visually on a screen to represent the signature. In the case of cloud computing, that piece of digital information is sent over the Internet to a server elsewhere in the world, where it is recorded. The information is never 'known' to the computer itself. The tablet computer is only involved at the precise moment that the stylus is touching the screen. To access the photo, the fan retrieves the information from the remote server. The tablet computer may never have anything to do with that signed photograph other than receiving and

transmitting a digital code in the second that it takes for an autograph to be signed. In fact, given its complete separation of writing and storage, the tablet computer could be said to be *more* ephemeral than the clay writing tablet in this regard.

A final point on ephemerality and permanence comes when we consider the life of a tablet computer in comparison to a clay writing tablet. The earliest clay tablets are 6000 years old, and we are able to read and understand what they say. This requires expert knowledge and perhaps some educated guesswork, but nevertheless the medium is robust enough to exist for thousands of years and still deliver readable stored information. The speed with which computer technology changes means that storage media become obsolete in decades rather than millennia. The iPad went through three models in its first two years. The clay writing tablet was a prestige medium for around 2000 years. As will be seen in later chapters, the notion of permanence and ephemerality is remarkably important to users of tablet computers. The complexities of writing and storage on tablets complicate the relationship that users have with their tablets, in particular the ways in which they trust the technology to look after their information. This is often expressed in terms of location, with users who do not trust the immaterial and ephemeral writing processes asking *where* their information *is*.

This section has explored ways in which the material properties of tablets affect our understanding of writing. In the following section, I will turn this problematic on its head, examining how pedagogic discourses can affect our understanding of the material properties of tablets. Specifically, I will ask how different classroom objects come to be accepted as suitable and normal at particular times, but rejected as unsuitable or even harmful at other times. The rise, fall, and re-emergence of tablets in the classroom is taken as evidence that discourses affect how we understand material objects.

Pedagogy

In March 2012, a *Wired* magazine article featured Russian entrepreneur Alex Shustorovich's plans to place his proprietary tablet computer in every school in Russia. His aim is that children will use the tablets "to learn, do their homework, revise for exams and – soon – order lunch from the school cafeteria" (Silver, 2012). The double-page spread that opens the article juxtaposes a photograph of Mr Shustorovich in a classroom of children holding their tablet computers aloft, alongside an image of a traditional slate tablet. Other examples of tablets being adopted in educational contexts appear in the press fairly regularly[11]. The article is absolutely clear about the power that this system could give to Shustorovich: "E-OK will make Shustorovich hugely influential. If the scheme scales across the country, he will control the platform that will increasingly be the way Russian children study and prepare for exams – as well as buy and consume music, games and movies" (Silver, 2012). More than this, the tablets are also planned to be used in tracking health data of children, with "a range of children's statistics, from chronic conditions such as epilepsy rates to simple weight and blood-pressure measurements – all of which go in the E-OK system, to be accessed only by the [Government health] ministry and the student's doctor" (Silver, 2012). This example shows how classroom objects are chosen not simply because of their suitability for teaching and learning activities. A much wider range of social factors must be taken into consideration if we are to understand the role of the material objects of the classroom.

As material objects, there are some striking similarities between the writing slate and the tablet computer. Writing about mid nineteenth century Australia, Davies notes, "Prior

[11] http://www.pattayamail.com/business/ict-ministry-contracts-to-buy-chinese-tablets-for-thai-students-12665 [Accessed 29th May 2012]; http://www.metro.co.uk/news/880698-ipad-for-every-pupil-at-penzance-school-a-waste-of-300-000 [Accessed 29th May 2012]; http://www.metro.co.uk/news/881256-will-turning-to-tablet-computers-to-educate-pupils-kill-handwriting [Accessed 29th May 2012]; http://www.dailymail.co.uk/news/article-2045896/What-financial-crisis-Essex-secondary-school-gives-1-200-pupils-free-iPad-2s.html [Accessed 29th May 2012]

to the advent of school desks with built-in table tops, slates had to be balanced awkwardly across the knees and cradled with one arm" (2005: p.66). Users of tablet computers will no doubt be familiar with this awkward and often painful stance. Davies also notes that "Smaller pocket slates were also available by the later nineteenth century, measuring 3 x 5 inches" (2005: p.64) – evoking the current development of smaller tablet computers known as 'notes', or 'phablets'; a portmanteau of phone and tablet. Shustorovich's tablets are particularly indicative of the link to old slate tablets as they include a stylus; reminiscent of the slate pencil. It is interesting to trace the rise, fall and re-emergence of slate-like objects. What makes them normal, accepted classroom objects at one time, and unsuitable and excluded at another?

The choice of objects in the classroom cannot be explained simply by the preferred teaching methods of the day. As well as teaching and learning practices, ostensibly external social factors can be identified as influences for the material culture of the classroom. Using the example of slate tablets in schools, I argue for an expanded understanding of 'pedagogy' to allow us to articulate the many factors that dictate which objects are seen as suitable classroom materials at a particular time. In the case of slate tablets in the nineteenth and twentieth centuries, these factors include discipline and hygiene. Expanding the concept of pedagogy to include *any* factor that influences the choice of material objects in the classroom gives the concept a critical power. An analysis of how this expanded pedagogy dictates the material culture of the classroom allows us to identify the relationship between classroom objects and social control. Without this critical aspect, a narrow pedagogy explains the appearance of new classroom objects simply as a natural progression in which the latest and most suitable teaching and learning objects are inevitably brought into the classroom. These issues will be addressed by examining the use of slate in the classroom in the nineteenth century, the replacement of slate by paper in the twentieth century, and finally the recent re-emergence of slate-like classroom objects: tablet

computers. By examining the internal logic by which these devices lose and gain reputation as worthy classroom objects, I make a connection between classroom objects and social discourses. Firstly, I examine what we might call the orthodox explanation for the rise and fall of slates as classroom objects: the explanation that states that classroom objects are accepted or rejected simply due to how well they carry out the favoured teaching and learning practices of the day. Then, I argue that 'expanded pedagogy' allows us to critically analyse this process, by observing a wider variety of factors; in this case, discipline and hygiene.

Slate is "a fine-grained argillaceous (clayey) rock with frequent mica and quartz inclusions, which splits or cleaves readily into thin slabs" (Davies, 2005: p.63). Slate pencils were made of a softer slate, so that when scored across the surface of the slate they would leave a white mark on the dark background (Davies, 2005: p.64). The material characteristics of writing slates means they are particularly suitable for writing but not recording. For much of the nineteenth and twentieth centuries, rote learning was regarded as the most effective learning method in Britain, Ireland, Australia and elsewhere (Coleman, 1998, Davies, 2005, Lawn, 2005). Slates are well-suited to an educational system that requires repetition of facts. Thus, slates were seen as a perfectly suitable, even obvious, classroom object at the time.

In late Victorian England, the importance of mechanical knowledge for the increasing number of workers in industry meant that school education began to move towards the 'object lesson' as the primary method of elementary teaching (Lawn, 2005: p.146). Object lessons (Lawn, 2005, Wylie, 2012) were premised on the idea that students could only 'know' objects by direct experience of them, so for example the hardness of glass can only be known by touching it (Lawn, 2005: p.151). The intimate learning practices of the object lesson represented an understanding of knowledge as personal, gained through an individual's experience. During the period that the object lesson was introduced, the use of

the slate began to decline. According to the narrow pedagogical interpretation, this was because the material properties of slates no longer suited the teaching and learning requirements of the day.

Wylie (2012: p.260) argues that the rise of the blackboard as a classroom object can be explained by its suitability for preferred teaching and learning practices. She explains the decision in 1844 in England to provide state funding for blackboards in terms of teaching and learning practices: rote learning is combined with the notion of the teacher as an exemplar, with the further advantage of saving time by reducing individual instruction (Wylie, 2012: p.261). The pedagogical practice of copying a perfect example also extended to teacher training itself, with teaching manuals designed on the principle of imitation so that teachers were taught by the same method as their students (Wylie, 2012: p.270). McGregor observes the relationship between material objects and teaching and learning practices in the storage spaces in schools, which house discarded objects representing discarded pedagogies (McGregor, 2004: p.356).

According to the narrow definition of pedagogy, the recent re-emergence of slate-like objects in the form of tablets can be explained by the material characteristics of tablet computers, which suit current pedagogical requirements. The material properties of tablet computers combine the best of both pencil-and-paper and slates. As noted earlier, unlike Freud's Mystic Writing Pad (Freud, 1925), the tablet computer allows both infinite rewriting and infinite recording – it fulfils the function of slate and of paper. This flexibility of tablet computers matches the currently favoured pedagogical approach which promotes flexible accommodation of different learning styles, and regards good teaching as that which allows for different ways of learning. In this way, the introduction of tablet computers to the classroom appears to be 'common sense'.

In a limited understanding of pedagogy, the use, decline and reintroduction of slates or tablets as a classroom object can be explained simply by the extent to which these

objects' material properties suit the preferred teaching and learning practices of the time. The question of economy is often raised in conjunction with the introduction of new classroom objects. Accounts of the emergence of new classroom technologies such as slate, paper and indeed tablet computers often mention that the replacement of old technology coincided with a new cheapness of the replacement technology (Warren, 1810, Davies, 2005, Lawn, 2005, Silver, 2012). This contributes to a feeling that there is a natural progression, whereby new technologies come along at just the right time – that it is inevitable that new classroom objects naturally fulfil the teaching and learning requirements, and it is just a matter of time before they are cheap enough to be used on a large scale. I argue that this idea is misleading if not simply incorrect. The move to replace slates with paper in Britain, Ireland and Australia, for example, occurred towards the end of the nineteenth century, even though mass-produced paper was still generally more expensive than slate well into the twentieth century (Davies, 2005: p.64, Lawn and Grosvenor, 2005: p.11). All of which goes to show that we should rethink the 'common sense' perspective that new classroom objects simply fit with the preferred teaching and learning practices of the time and become popular when they become cheap enough. The remainder of this section argues that a much more complex understanding can be gained if we expand the concept of pedagogy to include the influences of discipline and hygiene on the choice of slates.

The relationship between school discipline and social control has been dealt with elsewhere by canonical texts (for example: Althusser, 1971, Foucault, 1977). Material objects in the classroom mediate power relations between students and teachers, which are reiterated later in life in a multitude of other hierarchies of power. Using expanded pedagogy, the suitability of slates as classroom objects can be explained in terms of their disciplinary function. Lawn and Grosvenor give the example of a slate cleaning drill, which "involved sponges, a yardstick, a shallow tin, a cupboard and a series of movements by the

teacher and child. A simple system constructed for a critical purpose, it had to maintain discipline, establish routine and be effective" (2005: p.13). Along with desks, which physically restrain students and demarcate the classroom space (Martínez, 2005), slates were mediators of power relations. In some schools, slates were only used for elementary teaching, although they continued to be used for arithmetic by older pupils (Davies, 2005: p.66). The symbolism of learning objects is made clear by an autobiographical source writing about his school experience in Ireland in the 1870s: "'When I was ten years of age I was in the second book […] but until I passed into the third book I would not be looked upon as a scholar'" (Coleman, 1998: p.192). The use of slates for different exercises was thus a marker of a student's status. The slate did not only mediate cultural power relations between students and teachers: an autobiographical source speaking about schooldays in Ireland in the late nineteenth century mentions how a teacher, so flustered by the presence of a school board inspector, had to ask for help with some figures on the slate (Coleman, 1998: p.189). In this case, the slate becomes a mediating object of the teacher's inferiority to the inspector. The slate-cleaning drill and the association of slates with *elementary* learning are two examples of how the slate tablet was a useful object for the expanded pedagogic function of the establishment of hierarchies of power and the practice of discipline.

The decline of slate can also be explained in terms of its disciplinary function. As well as mediating hierarchies and power relations, slates could be used to mediate resistance to those hierarchies: sometimes violently so. Coleman's collection of autobiographical accounts of schooldays in Ireland 1850-1922 abounds with violent stories of pupils throwing slates at teachers, in one case even heating a slate in the fire before picking it up with a glove and handing it to the teacher (1998: p.187; pp198-9). Considering this potential of slates to embody resistance to pedagogically-favoured hierarchies, it is easy to imagine teachers favouring a move to paper, which still symbolically mediated the power relation between themselves and students, but did not carry the material risks of the slate.

Because it seems 'natural' to want to remove potentially harmful objects, the change from slate to paper also appears a natural one. Yet it only appears natural by fitting in with this accepted pedagogic discourse. Of course, it is more than likely that the rhetoric of 'safety' would be focused on making the classroom safer *for children*.

As well as discipline, hygiene played an important discursive role in the replacement of slate by paper. Although the work of microbiologist Louis Pasteur and renowned physician Robert Koch might seem unrelated to the choice of teaching materials, Davies (2005: p.66) cites their work and the wider public health movement of the time as a primary factor in the removal of slates from classrooms: "As pupils so often neglected to bring a cloth with which to clean their slates, the easiest method was to spit on the surface and wipe it with a sleeve"(2005: p.66). Today it is common to observe a similar process being employed to remove fingerprints from phone and tablet screens. In the late nineteenth century classroom, because slates were communal, this practice promoted the spread of disease. In a context in which the prevention of disease is seen as common sense, it also seems common sense to remove slates from the classroom. The internal logic of pedagogy is expressed in the choice of material objects of learning. Interestingly, Davies also notes (2005: p.66) how some school authorities in Australia worried that the brightness of paper could negatively affect children's eyesight. We can speculate that the discourse of germ prevention was more powerful than that of optical health, leading to slates being removed and paper becoming commonplace. The relevant dominance of these discourses affects the perception of the material properties of these objects. Rather than slate being thought of as (healthily) un-shiny, it was thought of as (unhealthily) germ-ridden.

Using expanded pedagogy, an examination of slates revealed the importance of the discourses of hygiene and discipline in the choice of classroom objects. Similarly, an expanded pedagogy allows us to use the emergence of digital technologies such as tablet computers today, to critique the social discourses that operate to make these objects

suitable. In tablet computers, the discourse of 'hi-tech' can be identified. Using tablet computers in educational contexts today instils a familiarity with new technologies which it is believed will prove useful in the increasingly-technological world of work. In this context, 'hi-tech' tablet computers are suitable classroom objects; fitting into a cultural discourse that associates new technologies with progress. Further to this, the idea that tablet computers can replace text books and printing fits with a discourse of paper reduction, playing on both economic and environmental factors which are regarded as increasingly important. The fact that slate-like objects are re-emerging as suitable classroom objects today indicates a different hierarchy of discourses.

This section has shown how the discourses which operate in a particular space, in this case the classroom, affect choices regarding the use of objects in that space. In the final section, I examine mobile productivity devices including the tablet computer, asking how the everyday use of these objects affects our understanding of space. Specifically, I argue that the everyday use of these technologies forces us to reconsider how we understand the workplace.

Personal Productivity

In this section I describe tablet computers as the latest in a category of objects that I call 'mobile productivity devices', including Filofaxes and Personal Digital Assistants. I argue that the everyday use of these objects allows a specifically work-related concept, productivity, to become fluid; being transferred into non-work contexts. This is observed in the notion of 'personal productivity', which describes a general way of operating in which the whole of a person's life is judged in terms of productivity. Two implications of this technologically-mediated ubiquitous productivity are examined. Firstly, how this affects our understanding of work (and non-work) and specifically *the workplace*. Secondly, how this

new understanding of the workplace forces us to reconsider how we might understand or critique resistance to dominant discourses.

Tablet computers can be described as mobile productive devices because they are designed to be carried everywhere, and contain both information related to a person's work and also to a person's domestic and everyday life. Shopping lists sit alongside task lists, and leisure activities are noted down in the same schedule as work activities. In conflating information about work and home, these objects mark a shift in which the notion of productivity moves out of the workplace and becomes a universally-valued concept. The iPad marks what Jordan describes as computing 'after the desktop': no longer based on the work/home distinction; and the replacement of the desktop metaphor of user interfaces in favour of apps and cloud computing (2015: p.155). These two features of 'after the desktop' computing are clear in the structure of app stores. A search in 2012 for "personal productivity" in the Google Play Store – the digital shop for apps, books and videos for tablet computers and other mobile devices running the Android operating system – returns around 100 digital book results, including *"Personal Productivity Secrets: Do What You Never Thought Possible with Your Time and Attention*", "*Lifehacker: The Guide to Working Smarter, Faster, and Better*", "*Ready For Anything: 52 Productivity Principles for Work and Life*", and the somewhat outlandishly titled "*Careergonomics: A Practical Guide for Mastering Personal Development and Employment Success in the 21st Century*". The same search returns at least 1000 apps, including one named simply "Personal Productivity", which costs £0.93 and promises tablet users that, "These Hidden Techniques Will Literally Elevate You Up The Ladder Of Success By Helping You Achieve Much More In Less Time!" The importance of personal productivity to users of tablet technology is made clear by the categories into which the Play Store divides its apps: alongside 'Books and Reference', 'Media and Video', 'Music and Audio', there is a whole category devoted to apps for 'Productivity'. Kluitenberg identifies the

"promise of efficiency in a variety of daily tasks" as that feature of 'the app universe' "that holds millions of people under its spell" (2015: p.103).

As a material object that is carried around on one's person and promises to improve personal productivity, the tablet computer has a cultural heritage of a few decades. Although invented in 1910 and branded in 1921 (McMurdo, 1989), the object that I refer to here when I say 'Filofax' – a mobile device for personal productivity – has its cultural origins in the early 1980s when it was a marker of 'yuppie' culture. A satirical obituary in Time Magazine in April 1991[12] in the USA stated that 'Yuppie' was born in 1983 and died in 1991. Sales of Filofaxes reflect this rise and fall: from £47,000 in 1978, Filofax's UK turnover peaked in 1987 at £12.9 million (McMurdo, 1989: p.362). It is for this reason that I choose the Filofax of the 1980s as a cultural origin for the tablet computer as an object of personal productivity: this period marks a cultural change in which, as I argue below, the understanding of productivity alters.

In the late 1980s, electronic mobile personal productivity devices began to appear, such as the Psion Organiser and later the Palm Pilot. Although these devices were competitors to paper-based systems, there was some integration, as with Filofaxes that could hold a Psion Organiser (McMurdo, 1989: p.363). According to the internal logic of these objects, the combination of paper-based Filofax and electronic PDA offered the best of both worlds, with the advantages of paper as a writing medium complemented by electronic data storage. The combination of the easy input of pen-on-paper with electronic data storage systems is portrayed as a naturally advantageous concept, expressed through a series of increasingly optimal technological solutions. In fact, Baron (writing in just 2009) predicts that tablet computers might finally 'solve this problem':

> Perhaps more promising in the technological convergence of longhand and digitization are developments such as the digital pen, which records hand

[12] http://www.time.com/time/magazine/article/0,9171,972695-1,00.html [Accessed 11th June 2012]

> movements for later downloading to a PC, and the new tablet computers. Like PDAs, tablet PCs still require users to learn a proprietary script, but unlike the PDA, writers generate streams of continuous prose, entire words and sentences, across the full, touch-sensitive computer screen, just as they would on paper, instead of tracing individual letters in the small window allotted to them on the Palm Pilot. (Baron, 2009: p.69)

Tablet computers are the latest in a series of objects that could be categorised as 'mobile productivity devices'. I use the word 'series' here to reflect the manner in which each of these devices is seen to offer an increasingly ideal solution to the 'problem' of combining work and home life in a productive fashion, rather than to reflect a natural progression or evolution of one single device. Having their origin in the enterprise culture of the 1980s, these devices promote the idea of the entrepreneur. Distinct from a businessman or professional – who works for a company – being an entrepreneur is a way of life. Where an office worker leaves their files on the office computer or on their desk, an entrepreneur needs them at hand 24 hours a day: a Filofax, PDA or tablet computer delivers this. The assumption built into mobile productivity devices that a person is only as productive as the data they command leads McMurdo to argue that the Filofax "may represent one milestone of an information society in which information work is a general, rather than a specialized activity" (McMurdo, 1989: p.362). Where professionals are productive at work, entrepreneurs *are productive*. Having information constantly to hand in a mobile productivity device is an example of the symbolic or ritualistic performance of being productive: whether the information is useful or not, having that information is the mark of a productive, i.e. successful, person (Liu, 2004: pp.153-154). The notion of 'personal productivity' is crucial in understanding how objects such as tablet computers mediate this conflation of work and home, and how this in turn means we must rethink concepts such as 'the workplace'.

Mobile productivity devices, which conflate work and non-work activities under one universal logic of productivity, lead to a way of life in which everything is undertaken in

what is effectively a *work* mode. As we saw with the tablet computer apps, this concept has been commodified under the title 'personal productivity'. The idea of personal productivity, sometimes called 'lifehacking' (Potts, 2010), is that productivity is not a feature of 'good working practices': it is a general characteristic of a successful individual. It implies that every activity in one's life, including non-work activities, should be undertaken in a productive manner. As a philosophy, personal productivity takes a commercially-situated principle and applies it in all-encompassing manner to a person's entire life. It is the root of the kind of comments overheard on a Monday morning at work: "I didn't do anything productive all weekend". Whether this is said with a tone of pride and satisfaction or guilt and anxiety matters not: either way, it indicates that productivity is being used as a valuative judgement for everyday life outside of work.

Filofaxes, PDAs and tablet computers embody the logic of personal productivity: they are designed to help you to *be productive*, rather than simply to complete work productively. These technologies not only contain business contact information and work schedules, but also shopping lists, personal addresses and phone numbers and so on. They remove the distinction between work and non-work, instead rationalising all everyday activities in terms of productivity. In other words, productivity becomes 'natural' – the accepted, expected way of doing things. These mobile devices are the locus of a productive lifestyle, in which one's entire life is undertaken productively: as though it were work. The normalisation of productivity means, however, that it becomes disassociated from work: it is just seen as normal. Of course, the representation of a way of operating as normal or natural is evidence that a particular discourse is in force (Lefebvre, 2004: p.38-9). Productivity as a desirable and marketable personal characteristic is a result of this discourse, where to be productive is a general cultural imperative, seen as an advantageous principle in everyday life. This is the basis upon which 'brain training' apps and games are promoted. Mobile brain training games allow the user to act productively at times and in spaces which would

otherwise be unproductive. Bassett argues that these games operate in an era in which identity is understood and constructed "in terms of a work on the self" (Bassett, 2009: p.58).

If personal productivity means that 'work' permeates everyday life, then this raises the question of how to define the workplace. The increasingly widespread use of technologies such as Filofaxes, PDAs and tablet computers forces us to reconceive of the workplace as both spatially and temporally unbound. As a point of comparison, we might consider the word 'workplace' itself. The spatial imagery of this word defines 'work' as not only an activity, but also the place in which that activity occurs. In this way, work is seen to 'belong' in certain spaces. In a Western industrial or post-industrial context, the idea of the workplace rests on the notion that work occurs in a physically distinct and separate place. Whether a factory or an office, the idea is that work is physically located in a demarcated space, and this space is defined by the work that goes on within. This can be observed in the way that 'the office' is used to label a room in the house where (paid) work is undertaken.

Mobile productive technologies, however, have a different effect on the way we think about the workspace. Their material properties in combination with the notion of productivity as a universal cultural imperative means that the workspace becomes much more fluid. Bassett (2009) identifies mobile gaming practices as reorderings of space as personal, noting the tensions that arise when gaming in spaces otherwise designated as public such as cafés or trains. Fuchs argues that both time and space are crucial for understanding labour, in his discussion understood in Marxist terms of value production (Fuchs, 2014: p.6). Rather than merely extend the space of work, these technologies completely eliminate traditional spatial and temporal definitions of work. Because their

material properties are such that they allow work to be done almost anywhere[13] (or at least this idea is part of the imaginary upon which they function), they can facilitate a kind of ubiquitous working. Where the industrial and post-industrial workplace used to be set within the limits of a physical space (or an extended or proxy-space such as a home office), and bound by the temporal convention of a nine-to-five routine, mobile technologies such as tablet computers have removed these restrictions. This is a characteristic of immaterial labour as defined by Lazzarato who notes that "with the economy of immaterial labour, 'leisure time' and 'work time' are increasingly fused, making life inseparable from work" (cited in Coté and Pybus, 2007: p.98). Gregg (2011: pp.7-9) notes that this sense of work being done 'outside' of the traditional workplace is not new: it is not caused by, or even necessarily simultaneous with, the rise of mobile technologies of productivity. The change that I wish to highlight here is the way in which this kind of work is understood. Specifically, I am interested in how discourses about mobile technologies might mean that this kind of work becomes normalised, expected, and devalued. Qiu *et al.* (2014: p.567) argue that the "impasse in attempts to theorize so-called 'immaterial' labour stems from a largely Western notion of separate public and private spheres for labour, which removed waged labour from the home, and feminized many aspects of reproductive and domestic labour in the process." The concern with personal productivity is not that it codifies new types of work as non-work, disenfranchising new groups in familiar ways, but that it removes this distinction altogether. If personal productivity means that the everyday activities are undertaken as though they were work, and mobile productive technologies mean that traditional work can be carried out anywhere, then it becomes increasingly difficult to define work or designate a specific workplace for activities completed using

[13] Although electronic tablets and other mobile communications technologies require a phone or wireless Internet signal to work, limiting their claims of working 'anywhere', the Filofax is an example of a mobile technology of personal productivity which could legitimately make such a claim.

tablet computers. These concerns are historically situated in a post-industrial revolution Western context. In contrast, the lack of distinction between home and work, or work and leisure, would not be analytically problematic in discussions of agrarian societies where people labour continuously and live on land which is their 'workplace'.

With a changed understanding of work comes an equivalent change in how we conceive of its opposite, whether that be home, time off, leisure, or free time etc. When using tablets and other mobile productive technologies, activities of both work and non-work are bound up within a productive mode of operating. When work emails and personal emails are all delivered to the same tablet computer, accessed anywhere, the distinction between work and non-work becomes harder to make. And if a person is used to checking their personal emails at home, then the logic of personal productivity would have it that it is quite reasonable to begin checking one's work emails at home too. The phenomenon is explored by Gregg in the pertinently titled *Work's Intimacy* (Gregg, 2011). Checking one's work email at home becomes standard, even expected, yet remains unremunerated because it is not seen as work. If evidently work-based activities cease to be seen as work, and are routinely carried out in one's free time, then this forces us to ask how we can usefully distinguish between work and free time.

Adorno condemned the division in late Capitalism between work and leisure (1991). He argued that free time had become a parody of itself, as it was not 'free' at all: it was used to regenerate the energy expended in labour so that workers would be refreshed and ready to work again (1991: pp.187-189). Adorno's critique of free time in late Capitalism relied on a distinction between work and non-work, with free time "shackled to its opposite" (Adorno, 1991: p.187). Still, in Adorno's critique, there *is* such a thing as free time. His argument operates on the basis of there being a space of freedom that is unfairly occupied by Capitalism. Examinations of technologies of personal productivity must address this issue. If everyday life is dictated by a productive imperative, then it is questionable whether

we can conceive of a space outside of work. If free time for Adorno represented a space that was theoretically external to – but unfairly co-opted by – Capitalism, then personal productivity represents a complete integration of work into free time. Where Adorno wrote that "unfreedom is gradually annexing 'free time', and the majority of unfree people are as unaware of this process as they are of the unfreedom itself" (1991: p.188), we are confronted today by a situation in which people are not just *aware* of the encroachment of work into leisure; they actively favour it. 'Being productive' is a positive phrase. In understanding the role of new technologies in everyday life, therefore, new forms of critique are required which are capable of dealing with this new understanding of the workplace.

It should be noted that Adorno writes of a genuine productivity – "the ability to bring forth something that was not already there" (1991: p.193). A similar distinction is made by Thomas Osborne who distinguishes between "contemporary 'creativity' and what he terms (following Deleuze) as 'inventiveness'" (cited in Bassett, 2009: p.50). It is clear that for Adorno this genuine productivity can only occur outside of, or beyond, Capitalism: "Productive free time is only possible for people who have outgrown their tutelage, not for those who under conditions of heteronomy, have become heteronomous for themselves" (1991: p.194). For Adorno, resistance to the dominant ideology of productivity is to be found in spaces that evade it; spaces that are not determined by Capitalism. One possible instance of this is given by Rancière, who argues that making use of the night is a form of resistance. He gives the example of nineteenth century worker-philosophers and "worker-poets [who] are *performing politics* by reusing the nights that are meant for proletarian sleep, by making themselves at home in a medium that is not theirs (poetry, philosophy), and dreaming of a life that they weren't born to" (Highmore, 2011: p.120, italics added). The extent to which tablets might offer a means of performing counter-hegemonic action will be addressed in later chapters.

Conclusion

In this chapter, I have given an exposition of the term 'the tablet computer', while at the same time arguing that any definition of a material object is always insufficient. The definition of an object is determined by the discourses that surround it: in fact, the definition is a site of contestation between those discourses. As such, it is impossible to say what a tablet computer *is* – or more accurately such a definition will never be neutral. It is perfectly possible, however, to define ways in which using a tablet computer *makes sense*. To say how an object makes sense has a critical agency: understanding how people use objects in their everyday life reveals the logics and cultural imperatives that make particular uses and meanings of an object 'natural'. As this chapter has shown, using an object in a way that makes sense involves social power relations that go far beyond the perceived limits of the context in which the object is used. The following chapter will give an overview of academic literature that has addressed similar issues, framing the work of this thesis within the disciplines of media and cultural studies and science and technology studies.

Chapter 2. Developing a conceptual framework to analyse the use of tablets in different contexts

> […] the constitutions of objects and subjects, risk and certainty, failure and success, and other aspects of object-centred sociality in contemporary sites of technoscientific practice is contingent, enacted within culturally and historically specific fields of persons and things. Within those fields, the multiplicity of objects affords ever ramifying, but always equivocal, opportunities for organizational, personal and technological reproduction and transformation (Suchman, 2005: p.395).

Introduction

This thesis examines the tablet computer within contemporary sites of technoscientific practice. I argue that a consideration of the way that material objects are defined in any given situation is an essential lens for research and analysis into technological practices. Jordan identifies the iPad as a "battleground": a place where "conflicts occur and the political stakes of information address our lives directly in moments of subjection and struggles for liberation" (2015: p.143). In this thesis I take the battle for definition of the tablet computer as a key focus. The way that the tablet is defined expresses a great deal about the desires for technology held by those doing the defining. It says a great deal about the definers and how they express their subject positions. It also says much about the situation in which they are using the tablet – in this thesis usually a research laboratory – and the power relations that operate therein.

My approach entails two concurrent contentions. The first is that this work of definition occurs through many different types of everyday practices. It can be explicit, observed in people's discussions about what the tablet is for, or in the declarations and pronouncements of those in defined positions of power who dictate what the tablet is to

be used for. It is often implicit, achieved in embodied actions that place the tablet at the centre or periphery of a particular situation, or in discussions of people's roles within a research project, which in turn imply a certain role for the tablet. This demanded an ethnographic approach where I as a researcher could observe scientists using tablets at close-quarters and for extended periods of time. It is only with this very close engagement with tablet users that the subtle, everyday practices that go into defining a new technological object can be observed. In each case, the specific, local conditions and context are fundamental to the analysis. At the same time, secondly, the work of this thesis can apply more broadly to understandings of how technoscientific objects factor in the production of scientific knowledge, in the creation and maintenance of social relations and in the way that people enact different subject positions. The everyday practices that I discuss are not unique to each ethnography; rather I argue that they can be read as situated instantiations of practices that are developed in response to a more general context.

This is different from saying that I can generalise based on my findings in each ethnography. Rather, the discursive work that goes into defining the tablet within specific contexts itself has implications and effects beyond those specific contexts. The specific and the general are two sides of the same coin. This thesis therefore requires a conceptual framework that can account for both the specific everyday practices that are the primary focus of the ethnographic research as well as the more general arguments that apply across the ethnographies to create a coherent and sustained argument about the role of tablets. In this chapter, I develop two key concepts that bring these two levels of analysis together. 'Affordance ambiguity' describes the material nature of the tablet and accounts for the way that it offers a range of uses that can only be enacted in specific instances of use. The 'tablet imaginary' describes the cultural values, meanings and understandings that are drawn on to define the tablet and are simultaneously constructed in that work of definition.

Methodology

This thesis is situated at the intersection of Media and Cultural Studies (MCS) and Science and Technology Studies (STS). Researching tablet computers in science labs, this seems a natural intellectual home for this work. But it was not obvious from the outset. Working at an intersection of two fields brings tremendous rewards: a wider range of theoretical tools to draw on, a diversity of perspectives that can be brought to bear on the research and the possibility of using conceptual framings that sometimes complement, sometimes critique one another in productive ways. Some of the links between MCS and STS have been made previously in academic literature. Others need to be outlined to show how and why particular connections can be made. Before outlining the two key concepts 'affordance ambiguity' and the 'tablet imaginary', I trace the intellectual path that my research has taken, highlighting key themes that I draw upon throughout the thesis.

The Ethnographic Method

Firstly, a key area of overlap between MCS and STS has been in methodological approach and perspective. My primary research methods in this thesis are participant observations and interviews, in the ethnographic tradition. Fundamental to the way that the research is presented throughout the thesis, is the idea of representation.

Latour and Woolgar's *Laboratory Life* (1979) is an influence on the current research as it is an early example of lab ethnography, where, as stated in the title of chapter two, 'an anthropologist enters the laboratory'. More than this, *Laboratory Life* discusses lab work as the construction of a scientific, positivistic account of reality. In their account, lab equipment "thoroughly constitutes" the substances studied, and the objects of study (chemicals, reactions, structures and so on) would not exist without the equipment creating them (Latour and Woolgar, 1979: pp.64-5). Often, the phenomena studied in the lab are *only* inscriptions: a graph representing a chemical reaction observed by a machine is

understood as a discrete, objective fact, but the reaction only occurred because it was set up to *produce the graph*. The book traces the construction of scientific facts in detail, critiquing the boundary between representation and reality. At the same time as offering this critique, the approach offers a problem for the ethnographic method. If the scientists are merely constructing representations, then what is the anthropologist doing? I will shortly return to this question in a discussion of academic literature that specifically addresses such problems in the ethnographic method.

The concept of representation, and critiques of the line between representation and reality, have also been fundamental to media studies. To take one example, Stuart Hall (2009b) argues that the representation is constitutive of social and political life:

> My own view is that events, relations, structures do have conditions of existence and real effects, outside the sphere of the discursive; but that only within the discursive, and subject to its specific conditions, limits and modalities, do they have or can they be constructed within meaning. Thus, while not wanting to expand the territorial claims of the discursive infinitely, how things are represented and the 'machineries' and regimes of representation in a culture do play a *constitutive*, and not merely a reflexive, after-the-event, role. This gives questions of culture and ideology, and the scenarios of representation – subjectivity, identity, politics – a formative, not merely an expressive, place in the constitution of social and political life" (2009b: p.271, emphasis in original)

The *construction* of particular representations should therefore be the site of media studies research. Hammersley (1992) addresses the question of realism in ethnography, arguing that ethnographers are committed in some sense to the idea of an external reality that they are examining, and at the same time to the idea that people (ethnographers included) construct the social world (Hammersley, 1992: Chapter three). Taking all of the above on board, my position in conducting the ethnographic research for this thesis follows the approach suggested by Hammersley, in line with the research traditions in both MCS and STS:

> The aim of social research is to represent reality, but this is not to say that its function is to *reproduce* it (that is, to represent it 'in its own terms'). Rather, representation must always be from some point of view which makes some features of the phenomena represented relevant and others irrelevant. Thus, there

> can be multiple, non-contradictory and valid descriptions and explanations of the same phenomenon. (Hammersley, 1992: p.51)

Similarly, Angela McRobbie "was keen to stress the 'partiality' of ethnographic writings, encouraging us to understand representations as interpretations rather than pure mirror images" (Moores, 1993: p.63). The positionality of the researcher is essential in understanding ethnographic research. Coffey (1999: p.5) emphasises how ethnographers help to construct the situations that become their data, and encourages reflexivity in methods and analysis to account for this. The influence of the ethnographer on the research and its presentation is vividly signified by Ben-Ari (1995) devoting an entire chapter to the study of the acknowledgements sections that precede publications.

In each chapter that presents ethnographic research, I give some details about the location, the participants and the context of that particular case study. In this introductory section, I will briefly give some more general points about my own position in relation to the research participants, my use of an authorial voice to construct an account of what took place at each research site, and the ethics and responsibilities of respecting and trying to remain faithful to all participants' accounts, while also aiming to offer my own interpretation of events.

I entered the laboratory sites as a non-scientist, and directly asked participants to explain their work and daily routines to me as somebody unfamiliar with them. In terms of the work being done at each site, this positioned me as an outsider and in some sense subordinate, as I was not part of the community of expert knowledge and practice. Conversely, participants often treated me as an expert in tablet computers, for example asking me for advice on what tablet to buy or what apps to download. I was honest about my level of knowledge of tablets, and the fact that I was interested in working practices, rather than necessarily in tablets themselves. Working with scientists in labs meant that the idea of conducting research was both an area of common ground and a point of difference.

I was sometimes asked, 'what do you want to find out', and participants seemed bemused that I could not give a clear, positivistic, response. In general, however, the fact that I was there 'to do research' was something that participants were satisfied with and took for granted.

The way that I report the findings of the ethnographic case studies focuses on key participants in each case. But there are other voices and influences that cannot be transcribed. The hegemony of an institution plays a role in the adoption of tablets, and this is not easily expressed through interview responses. The way that participants acted differently around certain colleagues, perhaps giving a more even-handed response to a question, choosing not to speak at all, is not easily reflected in direct reporting. I do my best to honestly and respectfully reflect the experience of key participants, while also trying to account for circumstantial explanations for the events I report.

In using an authorial voice that alternates between quoting comments and discussing actions of participants 'directly', and sometimes giving a somewhat detached or disembodied interpretation, I aim to reflect the complexity of the case studies. Where I give detached accounts of what has taken place, my aim is to highlight the interpretation of events that I judge to animate the case study most significantly. Similarly, there are moments where I essentially disagree with participants' accounts of what is taking place and why. This is the result of the temporalities of the research, where in some cases I visited labs every few weeks, over a period of many months. Different reasons or motivations for the same phenomenon are given at different times and in different circumstances. In my analysis, reflecting on the ethnography as a whole, I try to judge which reason is most significant, and most relevant to my research questions and interests.

Pseudonyms are always given, for names and places, in order to provide anonymity for participants. This was part of the standard practice and ethical considerations of the research. More than this, however, it reflects the sense in which this research is ultimately

my version of events, rather than that of the participants. To give one example, in one case, a participant requested to be named in any published research. Ellen (1984: p.151) points out that such requests can be read as demands for control over the veracity of the account. In my case, the participant reported that they were proud of their work and wanted their name to be included in public accounts of what took place in their laboratory over the time that I visited. Although I had to deny the participant's request on the grounds that it would compromise the anonymity of other participants, Ellen's point about ownership of the account also holds true. What follows is my "own construction of other people's constructions of what they and their compatriots are up to" (Geertz, 1973, p.9; cited in Moores, 1993: p.62). My account emphasises what I believe to be the most important questions about the way that tablets are defined, the implications of those definitions in terms of subjectivity and power, and the promise of technology.

Media and Communications, Science and Technology

In the broadest terms, this research is situated between or across two main bodies of literature: Science and Technology Studies and Media and Communications Studies. There is much overlap between these two fields and the great benefits of incorporating the two research traditions has been outlined by Gillespie and colleagues (Gillespie et al., 2014). In their words:

> "We believe a productive plateau has been reached, wherein distinct intellectual trajectories originating from disparate fields have gathered around a common purpose: to understand media technologies as complex, sociomaterial phenomena" (Gillespie *et al.*, 2014: p.1).

A key marker in this shared trajectory is Silverstone's work on media technologies and the idea of double articulation. Silverstone and Hirsch argue that media technologies are social as well as material objects, and that their social and material aspects are fundamentally linked and inseparable. They use the term double articulation

> "to refer to the ways in which information and communication technologies, uniquely, are the means (the media) whereby public and private meanings are mutually negotiated; as well as being the products themselves, through consumption, of such negotiations of meaning" (Silverstone *et al.*, 1992: p.28)

This double articulation makes media objects distinct amongst other domestic objects. In conjunction with the idea that media technologies are both social and material, Silverstone's writing on domestication gives an account of consumption that focuses on the ways that users/audiences make media technologies meaningful. And rather than focusing their analysis solely at the literal point of consumption, Silverstone and Hirsch argue that the study of consumption is something more. They treat consumption "as an extension and embodiment of the persisting need of modern society to sustain itself; and as structured by and through the abiding inequalities of class, status and power of that same society" (Silverstone *et al.*, 1992: p.5), thus politicising any analysis of consumption.

The double articulation of media technologies can be made clear in thinking about consumption. The materiality of media objects imposes itself on consumption through a device's design and engineering, which determines or encourages particular uses. This materiality is not simply given, however: "Technology is produced in environments and contexts, as a result of the actions and decisions, interests and visions, of men and women at work in organizations and institutions of complex and shifting politics and economics" (Silverstone *et al.*, 1992: p.3). The material form of a media technology emerges "as a result of complexes of actions and objects, politics and cultures" (*ibid.*). The material objects carry "both the mark of their social production and their capacity to reproduce the social and political values of the society that produced them" (*ibid.*). In this analysis, the material is social, and the social is material.

Silverstone's work has been influential and has found parallels in both media and cultural studies and science and technology studies traditions. Cockburn (1992) draws on Social Construction of Technology (SCOT) and Actor-Network Theory (ANT) traditions,

acknowledging the ways that each can be used within feminist critiques of technology. While SCOT and ANT each open up the social relations behind and prior to technology use, Cockburn also argues that these perspectives are aimed at explaining technological and social change, while for feminists it is more important to explain continuity (Cockburn, 1992: p.42) and the unchanging nature of gender and other social relations. I argue that this literature can be used to consider questions of technological and social fixity and stability (or appearances thereof), a point I take up in the course of chapter three.

One example of shared ground between media and cultural studies and science and technology studies is in the concept of interpretative flexibility. In Pinch and Bijker's empirical study (Pinch and Bijker, 1987), the development of a particular bicycle was characterised by rhetorical moves by different social groups, leading to a design which made sense to all those working on it. The fact that the design made sense was not due to there being one materially-determined correct design, rather the interpretative flexibility of both the material object and the design problem allowed members of the group to define the design problem and the desired material object in certain ways, for particular social reasons.

While the domain in question is very different, this shares many parallels with Silverstone's account of the domestication of technological objects. In the appropriation (Silverstone *et al.*, 1992: p.21) of an object, it leaves the world of the commodity and gains meanings within the household, in the process of consumption. For Silverstone, this is true of objects and texts (hence the double articulation), and, importantly, "the meanings ascribed to both objects and mediated texts and services within the household are not those necessarily ascribed to them in the public sphere" (Silverstone *et al.*, 1992: p.22). The idea of interpretative flexibility has parallels in other areas of media and cultural studies, especially in audience and reception theories. Hall's encoding/decoding model argues that media texts are polysemic, and that producers and consumers of text are engaged in

constant encoding and decoding of texts in order to generate meaning. Hall argues further that there are ideological forces that determine or constrain the range of available meanings in any given text:

> "Polysemy must not, however, be confused with pluralism. Connotative codes are not equal among themselves. Any society/culture tends, with varying degrees of closure, to impose its classifications of the social and cultural and political world" (Hall, 2009a: p.34)

As with the interpretative flexibility that was exploited by those working on the design of the bicycle for Pinch and Bijker, different social groups have different stakes, and different levels of influence, on the meaning of the text.

In a further argument for the social shaping of technology, Mackenzie and Wajcman argue that:

> A technological system like an electric light and power network is never merely technical; its real-world functioning has technical, economic, organizational, political, and even cultural aspects (1985: pp.17-18)

They argue (*ibid.*) that the economic aspect is most obviously important, and write that "Economic Shaping *is* Social Shaping" (1985: p.21, emphasis added), arguing that "Estimating costs and profits is part of what Law (1987) calls heterogeneous engineeering: engineering 'social' as well as 'technical' phenomena; constructing an environment in which favoured projects can be seen as viable." (*ibid.*)

Most interesting in terms of the current thesis is their account of how the materiality of an object like a tablet computer, as well as its history as a consumer device, impacts on the way that it is adopted and used. The heterogenous engineering of a tablet computer in this case might include shaping the consumer electronics economic environment, such that particular material characteristics of a touchscreen tablet are necessary component of a viable tablet product.

They write that the material objects that 'precede' (in popular accounts) a new technology, as well as the technology's "intrinsic properties" (Mackenzie and Wajcman,

1985: p.34), help to determine the way that the object is adopted. This is also shaped by the object's cultural and social history: in the case of tablet computers, a history in which tablets are positioned in a genealogy including clay tablets, Filofaxes, mobile phones and laptops (see Chapter One in this thesis). The (market or popular) success of a new technology is "not determined by their intrinsic characteristics alone, but also by their histories of adoption" (*ibid.*). The cultural history of an object shapes how its intrinsic material characteristics are understood.

Summing up the many factors which must be taken into consideration in their account, MacKenzie and Wajcman write that technologies "typically emerge, or fail to emerge, from processes in which no one set of human actors plays a dominant role, and in which the role of a recalcitrant material world cannot be ignored." (Mackenzie and Wajcman, 1985: p.28). As such, this thesis considers the materiality of tablets as being determined by the social context and situation in which the tablet is adopted and used, and the particular history given to an object by each user. This is a further justification for the ethnographic approach discussed above, in which the specificities of every case study are incredibly important in understanding how and why the tablet was adopted as it was in each case.

The importance of focusing on the context of adoption returns us to domestication. Given that Silverstone's work often focused on television and the domestic sphere as the key media forms of the time, Livingstone (Livingstone, 2007) discusses the status of Silverstone's work, especially the idea of double articulation, in more recent studies of new media. Treating media as both material objects and symbolic texts requires research that reflects this view, and Livingstone points out that "doubly articulated research has proved surprisingly difficult" (Livingstone, 2007: p.18). Livingstone argues that new media might offer more direct analysis, as users' interactions with media texts are overt, occurring "through selecting, clicking, scrolling and typing" and thus immediately available to the

researcher in ways that TV audience's interactions are not (Livingstone, 2007: p.20). Where Livingstone was cautiously optimistic, the idea of doubly articulated research has been approached more critically by the 'social life of methods' approach developed by Ruppert, Law Savage (Ruppert *et al.*, 2013), which takes a further turn by arguing that research into new media (which also occurs through selecting, clicking, scrolling and typing) constitutes a further layer of articulation that must be accounted for by researchers.

The history of the common ground between media and cultural studies and science and technology studies has manifested more recently in research that is sensitive to the material resistances of specific media technologies, while also asserting the agency of users. Hine's (Hine, 2008) ethnographic study of biologists using new ICTs argues that the database form has contributed to changes in the everyday practices of biological taxonomy, helping to spawn a new field, 'systematics'. Hine argues that "ICTs have an interpretative flexibility such that we can expect differences between disciplines in the way that ICTs are interpreted and the visions through which their possibilities are enacted" (Hine, 2008: p.256). While the use of databases has been central to changes in the daily practices and the status of biological sciences, Hine's ethnographic study demonstrates that these changes are always written through the context of the specific social setting in which the technology is used.

The use of tablets is studied in context, focusing on the *use* of tablets rather than exclusively on either the users or the object itself. This is more a conceptual focus than a methodological one; the use of tablets in context can only be achieved in practice by studying the users and the object. In this regard, I follow Livingstone's assertion that "the study of media, communication, and information technologies should always address the activities of users in context. Only then can we uncover the social shaping and social consequences of the digital" (Livingstone, 2014: p.241). This interest in users does not abandon a study of the material object, instead it defines the material as discursively

constructed. As Suchman (2005: p.381) writes, "if our project is to understand objects-in-action, the material resistances of objects are inseparable from the arrangements through which they materialize in practice." This argument can be taken slightly further, since the material is discursively constructed and understood. As Brunton and Coleman state:

> We assert the value of getting closer to the metal, and understanding in depth the technical architectures and processes that underlie online phenomena, but also assert that this dive into hardware is not a simple revelation of some true, foundational reality. When we peel back that deepest layer of materiality, we find people and practices underneath. (Brunton and Coleman, 2014: p.77)

The discursive construction of the material is in essence the underlying focus of the ethnographic research in this thesis: the discursive construction of the tablet computer in the science laboratory context. I maintain this focus on the present, emergent construction of the object. While studies that 'get closer to the metal' are important, they must be complemented by research that seeks to understand the material at the point of use (the point of use understood classically as consumption). The idea of consumption as a site at which technologies and users 'meet', thus recognising "consumers as agents in the shaping of technologies" (O'Riordan, 2010: p.13), has a long history in science and technology studies approaches to publics and cultural studies approaches to domestication (ibid.).

I understand tablets as complex sociomaterial phenomena, using ideas such as affordance ambiguity to consider their materiality, and at the same time emphasising the discursive construction of the material through the concept of the tablet imaginary. This approach rejects the idea of an explicit commitment to *either* technological determinism *or* social constructivism. As Sterne provocatively warns: "Even today, dissertations on communication technology still commonly take a moment to rehearse the terms of debate between determinism and constructivism as they were laid out in this period and before. It's a hard habit to break" (2014: p.123). Rather than 'rehearse the debate', I follow Sterne's terms, in an approach that:

> Methodologically presupposes the irreducibly political character of the constructive operation, [assumes] that power relations preexist the constructivist scenario, and [assumes] that any analysis is always situated and positioned (which is not to say that ideas are simply reducible to biography). [Such approaches] begin from the presumption that differential power relations animate any context before they arrive on the scene to analyze it, and they are motivated (often implicitly) by a normative framework that challenges those axes of difference at their very base (Sterne, 2014: p.125).

On this basis, drawing on previous research and methodologies from media and communication studies and science and technology studies, participants' uses of tablets are framed as active, productive processes whereby they create the object that they use. In certain respects this draws on SCOT tradition (Bijker *et al.*, 1987b) that extends the analysis of specific technologies beyond an examination of the technology itself and focuses instead on the wider social context. Key concepts from this tradition, in particular the ideas of 'closure' and 'interpretative flexibility', are discussed in the course of chapter three. The key difference in my approach is that I treat the production (or consumption – see below) of tablets as an on-going and open-ended process. Where SCOT research aims to demonstrate the messy social processes that lead to fixity and stabilisation of a technological object, I aim to show an inherent instability and ambiguity in the definition of tablets as they are used.

The Material Object

Understanding the materiality of the tablet object is a central concern of the thesis as a whole. The way that this materiality is constructed, the extent to which this enables, encourages or prevents particular uses and the effects that the understanding of its materiality have on power relations are key questions in this thesis. Suchman uses the term 'affiliative objects' to discuss "the ways in which objects are not innocent but fraught with significance for the relations that they materialize" (Suchman, 2005: p.379). I adopt this concept to understand how the connections enacted by associating oneself with a particular object, defined in a certain way, also generate relations beyond the user and object. This is

particularly relevant in chapter six when the tablet is a site of negotiation around expertise, with neuroscience researchers explicitly performing their non-affiliation with the tablet.

Knorr-Cetina (1997) argued for a more complex understanding of computing technologies, proposing that computers should be thought of as epistemic things rather than simple commodities:

> Computers and computer programs are typical examples; they appear on the market in continually changing 'updates' (progressively debugged issues of the same product) and 'versions' (items marked for their differences to earlier varieties). These objects are both present (ready-to-be-used) and absent (subject to further research), the 'same' and yet not the same. In sum, technologies of this kind must be included in the category of epistemic things. (1997: p.10)

This might suggest that tablets could be treated as epistemic things. But the casual implementation by participants in this research, along with the tablet's status as a consumer device, means that this is not a suitable category. Knorr-Cetina goes on to propose a new category of object, knowledge objects:

> The two major categories of objects familiar to social scientists and dominant in social life are those discussed before: commodities and instruments. The study of expertise in science and elsewhere brings into focus a third category, that of a knowledge object. The defining characteristic of this kind of object, from a theoretical point of view, is its changing, unfolding character - or its lack of 'objectivity' and completeness of being, and its non-identity with itself. The lack of completeness of being is crucial: objects of knowledge in many fields have material instantiations, but they must simultaneously be conceived of as unfolding structures of absences: as things that continually 'explode' and 'mutate' into something else, and that are as much defined by what they are not (but will, at some point, have become) than by what they are. They must also be conceived of as textual or signifying objects; most objects of knowledge produce, and are translated into, all manners of signs. Their special capacity as texts (and the problems of readability of the texts) raises questions I cannot go into here, but the phenomenon should be noted. Finally, knowledge objects exist simultaneously in a variety of forms, a point which becomes important in regard to their binding role for collectives. To foreground once more the temporal volatility and unfolding ontology of these objects, it is this which accommodates so well the structure of wanting, and binds experts to knowledge things. (1997: pp.14-15)

This quotation brings together many aspects of tablet computers and outlines the fluid ontology and emergent definition of the tablet as conceived in this thesis. The importance

of how the tablet is conceived and defined, as a material object and at the same time recognising that this materiality is not obvious and not stable, is key to my treatment of tablets. I draw on the ideas of knowledge objects and affiliative objects in the development of affordance ambiguity, one of two key conceptual framings that I use in this thesis.

Productive Consumption

Where SCOT analyses tend to focus on the development of technologies in the design phase, my focus is on consumption. The idea that users contribute to the innovation process is not new: von Hippel (1976) argued (in an article entitled *the dominance of users*) for 'recognition of the dominant role of users in the scientific instrument innovation process'. Yet my interest is not in users coming up with ideas for technologies that are subsequently designed on the basis of user ideas; 'turned into' scientific instruments. As I argue throughout, I focus on the consumption of tablets because I contend that the use of tablets is itself productive. In this regard, I owe much to cultural studies research that confers a great deal of agency onto the consumer or user, such as the idea of productive consumption. As de Certeau famously writes:

> To a rationalized, expansionist and at the same time centralized, clamorous, and spectacular production corresponds another production, called 'consumption'. The latter is devious, it is dispersed, but it insinuates itself everywhere, silently and almost invisibly, because it does not manifest itself through its own products, but rather through its ways of using the products imposed by a dominant economic order (de Certeau, 1988: pp.xii-xiii).

Users engage in the latter form of production (called 'consumption') and therefore play an active role in the construction of the tablet computer object. de Certeau's concern with the dominant economic order is taken up in the following discussion about my other key concept in this chapter, the 'tablet imaginary'.

In arguing for users' fundamental agency in this process, I depart slightly from the SCOT literature. Hughes, for example, argues that components of technological systems

are socially constructed because artefacts are made and designed by social groups: "Because they are invented and developed by systems builders and their associates" (Hughes, 1987: p.46). While I agree with this analysis, my emphasis is on the users of technologies rather than the systems builders or those who design and manufacture the tablet devices. In a more culturally-oriented study, Balsamo also focuses on designers, arguing that "Designers work the scene of technological emergence: they hack the present to create the conditions of the future" (Balsamo, 2011: p.6). Balsamo's understandably celebratory account of design is as follows: "Through the practices of designing, cultural beliefs are materially reproduced, identities are established, and social relations are codified. Culture is both a resource for, and an outcome of, the designing process" (Balsamo, 2011: p.11). Again, I agree with this analysis but would extend this to argue that culture, in Balsamo's conception (I will use the concept 'tablet imaginary' as roughly equivalent to 'culture' here) is also a resource for, and an outcome of, the consumption process. Indeed, thinking of 'productive consumption' is in some sense pre-empted by Balsamo's own rejection of the distinction between amateur and professional (Balsamo, 2011: p.3). In this case, 'professional' tablet and app designers are engaged in the same articulatory work as 'amateur' tablet users.

There are significant overlaps in this respect of work at the intersection of STS and media studies. As Lievrouw points out, in both STS and media and communications studies frameworks, "the stabilization or standardization of material objects [is used] as a key mechanism for explaining their influence" (Lievrouw, 2014: p.32): to focus on design or consumption reflects the choice of case study and emphasis rather than a distinct methodological or conceptual commitment.

The Specific and Generic Technological Split

The focus on use, the idea of productive consumption and the insistence on a finely-grained ethnographic approach do not preclude analysis at larger scale. The tablet

computer is a specific technology that expresses a more general technological logic. The characteristics of this general logic can be inferred from specific instances of technology use. I argue that technology is inherently split into specific and generic forms. Specific technologies are actual devices that we use, they have certain capabilities, they carry particular cultural meanings, they have advantages and they have flaws. The generic side of the split is the abstract idea of technology. Without a context of use, technology can be seen as perfect; having the transformative potential to improve our lives in countless ways. Generic technology, considered in the abstract, appears to be neutral, devoid of the politics and meanings that are often evident in embodied, situated uses. Of course, this appearance of neutrality is itself an ideological construction.

This split is inherent in a technological rationality that guides our understanding not only of technological objects but of technology's role in society in general. The notion of a split between generic and specific has been elaborated elsewhere, although not in these terms. In Ellul (1964) the specific machines and in particular the specific methods that we adopt in society add up to a general technique. Postman (1993) proposes three taxonomies, in each of which the use of specific technologies are treated as manifestations of the general technological order: tool-bearing, technocracy and technopoly. Marcuse (1982) distinguishes between "technics proper (that is, the technical apparatus of industry, transportation, communication)", in my terms ' specifics', and "Technology, as a mode of production, as the totality of instruments, devices and contrivances which characterize the machine age [which] is thus at the same time a mode of organizing and perpetuating (or changing) social relationships, a manifestation of prevalent thought and behavior patterns, an instrument for control and domination" (Marcuse, 1982: p.138), or technology in general. Borgmann (1987) argues that "Technology becomes most concrete and evident in (technological) devices, in objects such as television sets, central heating plants, automobiles, and the like. Devices therefore represent clear and accessible cases of the

pattern or paradigm of modern technology" (1987: p.3). Although each of these authors makes their own particular arguments about technology, they share a theoretical conceptualisation that incorporates a split between generic technology as a more or less overarching social structure and specific technologies as instances of that structure.

On a scale more comparable to the current examination of tablet computers, Silverstone, Hirsch and Morley express this idea in terms of multiple biographies of objects: "the individual object (my computer), the product (the Olivetti M24), the generic technology (computers)" (1992: p.18). Bell and Dourish (2007) give this split a teleological inflection in their idea of a 'proximate future', which can be read as an idea of a reachable perfection in computing design (general) that is aimed towards in the material design of current technologies (specific). Dourish and Bell (2011: chapter two) argue that Mark Weiser's (1991) article "*The Computer for the 21st Century*" set a rhetorical tone of progress in ubiquitous computing "toward a proximate (and inevitable) technological future" (2011: p.23). The idea of a 'proximate future' incorporates a split between generic and specific that operates in terms of a well-defined conception of perfection: where specific technologies are fallible and generic technology (in a proximate future that may or may not be achievable) is perfect. Tablet computers are particularly instructive in thinking about this split, as the relationship between the material device (generic) and its apps (specific) can recursively manifest the split at the level of a single device. I will discuss this in more detail in chapter four when discussing perfection in the ethnographic case study of the Lab.

Expertise

A key way in which the definition of tablets operates is in the expression of users' and others' subjectivities. Discussions of tablets, what they were for, why certain people could or should use them, were often used to comment on the nature of scientific expertise. Users' definitions of the tablet helped to construct the object (and therefore the user) as an object of scientific expertise in chapter five and as merely technical expertise in chapter six.

Expertise features in the thesis as a part of users' subjectivities expressed in embodied practices involving tablet computers. Academic literature on expertise often treats it as an issue of public policy. A typical framing of this debate is found in the introduction to *Exploring Expertise*:

> We live in an age where the number and range of specialist fields of knowledge is burgeoning, and where 'experts' from these fields are called on to solve problems and advise in ever more areas of social and economic life. (Faulkner *et al.*, 1998: p.1)

Turner uses a rhetorical question to frame the debate, asking "Why would patrons, especially democratic governments, pay for something, namely science, that they didn't understand and could not easily assess the value of?" (Turner, 2014: p.1). Expertise does not factor in this thesis at the level of public policy; instead I analyse the role of expertise in the practice of science based on ethnographic study, following Lynch's (2007) suggestion that expertise should be studied in practice rather than in the abstract. In the case described in chapter five, for example, the scientists' use of tablets expressed their expertise in using – specifically in *testing* – technoscientific objects. My aim in this chapter is not to understand expertise in an abstract sense. Nor is it to give an account of expertise in the specific case in question. Rather, by giving an account of expertise as it was defined and deployed as related to tablet computers in particular cases, I examine the way that tablets are understood as expert or non-expert objects, arguing that the materiality of the tablet offers both possibilities simultaneously.

In the ethnography presented in chapter six, the tablet functioned as a shibboleth representing the difference between scientific expertise and non-scientific expertise. I draw on recent and on-going debates within STS on the nature of expertise. Expertise sometimes looms large and generates focused debates such as that initiated by Collins and Evans (2002) that was used as a way to map the territory of STS. Such moments of intense academic debate are situated within broader considerations of expertise. After discussing

Collins and Evans' (2002) proposed 'third wave' and how they used expertise as their own shibboleth in defining the future shape and limits of STS, I will turn to a broader consideration of expertise, particularly as it has been theorised within feminism.

Collins and Evans' proposed 'third wave' of science studies (Collins and Evans, 2002) aims to better define expertise in order to solve 'the problem of extension' or the idea that STS has demystified scientific knowledge to such an extent that we can no longer take the expert status of scientists for granted. Since the publication of that article in 2002 there has been much debate and discussion about Collins and Evans' programmatic history and prescribed future for science studies. The sometimes circular and self-referential nature of this debate is reflected in the fact that the articles that I cite in this discussion are all taken from *Social Studies of Science*, which published the original article and has become the location of subsequent debate. While the history of this debate is important, recent commentary (Coopmans and Button, 2014, Lynch, 2014) offers an opportunity to cut through the discussion. Before doing so, I will address some of the criticisms of Collins and Evans' (2002) article.

Jasanoff (2003) observes that their reading of the relevant science studies literature forms a "misleading characterization" (p.391) of the field, which she argues is more diverse than they suggest and features work that seems already to fulfil their requirements for a new 'Third Wave' approach. Rip (2003) argues that the key question in this area should ask how the framing of public debates about science and technology reinforces definitions of established and acknowledged scientific experts, rather than the inclusion of other types of expertise in these already framed debates. Wynne questions the efficacy of Collins and Evans' approach in terms of its ability to affect public science policy in real-world cases, saying that the legitimacy problem that Collins and Evans identify is caused by "the undemocratic imposition of assumed meanings on the issue, and on the public, through the institutional scientific culture" (Wynne, 2003: p.412). All these authors (Jasanoff, Rip,

Wynne) object to Collins and Evans' attempts to set the academic trajectory for science studies and all note the irony in the fact that their critical responses perpetuate this. Certain terms from Collins and Evans have nevertheless remained instructive in STS, notably their distinction between contributory and interactional expertise. I use these terms as the basis of a critical framework in which to analyse the interdisciplinary expertise in the case study. I move away from these two terms but find them a useful base from which to develop my arguments about the performativity of expertise.

More recently, Coopmans and Button (2014) have criticised Collins and Evans' use of analysts' categories based on an abstract model of expertise, arguing for a more grounded approach that uses actors' categories taken from empirical research of scientific practices as the basis for developing a normative theory of expertise. Collins and Evans (2014) rebut this criticism, arguing that the distinction between actors' and analysts' categories cannot be maintained. Treading a line between the two perspectives, the distinction is useful as it encourages the researcher to consider their own role in the construction of a case study. The arguments that I make about expertise are made on the basis of ethnographic research, but the categories such as 'tablet expert' and 'scientific expert' that I discuss only exist as categories within the context of my work. For the scientists involved, they were never categories in the sense of being consciously constructed and recognised as ways to differentiate between things. As an analyst (to use the terms from Coopmans and Button), I inferred these categories from the actions and practices of the actors. These categories are derived from observations of practice and useful for the analyst, without claiming them to be representative of the actors' own experiences.

More pertinently in terms of the approach that I take in this thesis, Coopmans and Button also argue that, in setting the terms of the debate as they have done, Collins and Evans:

> present a stark choice between 'relational' approaches to expertise, which they say help pinpoint how expert status is negotiated but not what substantive expertise consists of, and their own 'realist/substantive' sociology of expertise built around a theoretically derived classification scheme that defines, at different levels, the various knowledges and abilities people draw on when they make judgements (Coopmans and Button, 2014: p.767).

Coopmans and Button reject this 'stark choice' by arguing that it is in the everyday practices of actors, "that expertise is claimed and demonstrated, and made relevant as a description of some human activities, and consequently, it is at this level of consideration that the substantiation or the refutation of expertise resides" (Coopmans and Button, 2014: p.767).

Making a parallel point, Lynch suggests that "proponents and critics alike frequently misunderstand attribution theories as arguments against the reality of the phenomena in question" (Lynch, 2014: p.795). In a subtle redefinition of the 'reality' of expertise, the definition of which is of course the centre of the whole debate, Lynch argues that "we can observe that attributions or denials of expertise have real consequences, regardless of how they are made or justified" (Lynch, 2014: p.768). This point opens the debate out and sets it within a wider literature on expertise, particularly within feminism. Using the terminology of 'skilling' and 'deskilling', Karpf (1987: p.163) argues that "there is nothing intrinsic about skill: it is a category to be contested and negotiated". The designation of a given type of work as skilled is often constituted along the lines of gender. McNeil argues that women's skills tend to be 'naturalized' and thus excluded from the realm of expertise (McNeil, 1998). Professions, institutions and various types of discipline all play key roles in the ideological policing of what counts as expertise (McNeil, 1998).

Liff (1987) points out that while gender is a defining factor in the designation of types of work as skilled, expert or not, the problem of expertise is "not just a women's problem" (McNeil, 1987b). Insights from feminist critiques of work, skill and expertise have shown broadly that expertise is not inherent, not neutral: it is ideological. And this is the most

important critique of the abstract types of analysis of expertise exemplified by Collins and Evans. Fleck suggests that expertise be thought of as "a 'trialectic' with three elements in continual tension: namely, knowledge, the substantive content of expertise; tradeability, its economic value and social utility; and power, which has an overall legitimating and defining role" (Fleck, 1998: p.168). Abstract accounts of expertise may present useful ways to think about the substantive content of expertise, but are not well-suited to capturing the power relationships that define and are defined by categories such as 'expertise' and 'scientist'. Lynch argues that "For all their pleasures and advantages, scholarly analyses, and even reflexive inventories of 'ordinary' usage, are likely to miss the surprising moves generated in lively occasions of interaction" (2007: p.161). Feminist critiques have shown that imbalances of social power that lead to exclusion from categories like 'expert' are necessarily opaque if not invisible, themselves bound up in the ways that terms like 'expert' are used. I pursue an analysis of expertise that focuses on the ways in which the definition and designation of expertise has real consequences for scientists' understandings of their own expertise, the expertise of a tablet computer programmer, and the status, role and definition of the tablet as an object.

Neutrality

The idea that tablets were neutral was expressed by many different participants throughout all of the ethnographies. I critique this perception of neutrality in each chapter, not only highlighting ways in which the tablet is not neutral, but also discussing the effects that thinking of the tablet as neutral has on the construction of the object. It is not unexpected that many participants thought of the app as a neutral technology. As Feenberg argues, the instrumental view of technology is the most widely accepted:

> It is based on the commonsense idea that technologies are 'tools' standing ready to serve the purposes of their users. Technology is deemed 'neutral', without valuative content of its own (Feenberg, 2002: p.5).

Considering this perception of neutrality using the more specific example of software, as opposed to technology in general, Fuller argues that software "is seen as a tool, something that you do something with. It is neutral, grey, or optimistically blue" (Fuller, 2008b: p.3). Fuller also goes on to say that software studies demands inventive engagement rather than distant critique. This perceived neutrality is contested by writing in software studies. Following Chun (2008), Bassett warns against the abstraction of both code and software becoming a fetish "beguilingly implying a return to essential building blocks, to things unfreighted by ideology" (Bassett, 2013: p.208), arguing that gender politics can be abstracted away from view by this fetishisation. Fuller argues that "[software's] ostensive neutrality can be taken as its ideological layer, as deserving of critique as any such myth" (Fuller, 2008b: p.3). Indeed, in direct contradiction and critique of this perceived neutrality, it is not difficult to find academic work that describes and discusses the cultural values bound up in software. Fuller's edited collection abounds with illustrations of this point. Montfort uses the example of a software practice called 'naming obfuscation' to argue that "everything about a programmer's task is not automatic, value-neutral, and disconnected from the meanings of words in the world" (Montfort, 2008). While it is relatively easy to demonstrate the non-neutrality of technologies, the important work comes in understanding how neutrality operates, how it is used to justify certain practices and exclude others. I address this issue in each chapter, with particular focus in chapters four and six.

Affordance Ambiguity

A key concept that has informed research into human and technology interaction in many academic fields is the idea of 'affordances' (Gibson, 1986: chapter 8). Of particular interest is the way that affordances have been used as a materialist corrective to the social constructivist approaches in STS in general and SCOT in particular (see: Lievrouw, 2014

pp.48-51). While Hutchby (2001) argues that the concept of affordances provides a middle ground between determinism and constructivism, my take on affordances is different.

The idea of affordances has been used to understand the relationship between users and objects. We might say that a fire affords warmth, a chair affords sitting, a television affords watching programmes. The term appears frequently in tech journalism. A *techradar.com* review of the Samsung Galaxy Tab 8.9[14] stated that "it affords just a bit more mobility and just the right screen size for books." A *Wired.co.uk* review of the iPad Mini[15] claimed "The extra inch the iPad Mini affords its user [is] really taken advantage of, and it makes a big difference." There are countless examples of the concept of affordances being used as an equivalent to advantages. It rarely gets used to describe something negative. When the same *techradar.com* review went on to state that the tablet's screen was poor – "But the movie Captain America proved to be a stumbling point for the 8.9-inch tab. The intro segment was washed out and gray" – it did not say that the tablet afforded unsatisfactory watching of films. Yet the concept of affordances as developed by Gibson (1986) accounts for any property of an object that emerges in the interaction with a particular user. A chair affords sitting; it also affords stubbing your toe.

The way that affordances has been adopted to mean a useful function or property of a device can be traced to the concept's development in terms of design and human-computer interaction, especially by Donald Norman. In *The Design of Everyday Things*, Norman encourages designers to make the 'actual' affordances of an object match the 'perceived' affordances: "With doors that push, the designer must provide signals that naturally indicate where to push" (Norman, 2002: p.4). If a door that needs to be pulled looks like it should be pushed, then Norman argues that this is badly designed: he writes that "the user

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[14] http://www.techradar.com/reviews/pc-mac/tablets/samsung-galaxy-tab-8-9-1037035/review/9 [Accessed 4th February 2015].
[15] http://www.wired.co.uk/reviews/tablets/2012-11/ipad-mini-review [Accessed 4th February 2015].

needs help" (Norman, 2002: p.8). It is clear to see how this understanding of affordances emphasises the advantageous properties of an object. The idea is that successfully designing affordances into objects will encourage or allow users to use the object correctly. The idea of a correct use of an object, however, is evidently not neutral. Bloomfield and colleagues point out that research in disability studies highlights how the '"affordances' of, say, a chair, a post-box or a cigarette are not reducible to their material constitution but are inextricably bound with specific, historically variable, ways of life" (Bloomfield *et al.*, 2010: p.428). Norman's phrase 'the user needs help' assumes a particular user, with particular knowledge and ability.

Norman's use of affordances undoubtedly helps to improve the design of everyday things. But this understanding of affordances loses something significant that was present in Gibson's original conception of the term. For Gibson, affordances emerge in specific instances of use and are relative to the object and the user. This emergence, this relativity, is essential. To illustrate why this is so, I would like to use the example of the *Myth of the Paperless Office* (Sellen and Harper, 2002), a book that I actually think provides an excellent account of the pitfalls of adopting new technologies. Sellen and Harper's book examines adoption of paper replacement technologies and assesses the problems that are encountered in this process. They summarise their use of affordances as follows: "The physical properties of paper make many actions not possible and many activities not achievable. We can then compare and contrast these affordances of paper with those of existing digital devices" (2002, p.18). Physical properties and affordances are taken to be one and the same thing. This understanding of affordances gives focused research and analysis that is very clear, very useful, but also totally instrumental. Sellen and Harper write that:

> […] organizations need to change their thinking in order to move effectively toward the future. Rather than pursuing the ideal of the paperless office, they should work toward a future in which paper and electronic document tools work

> in concert and in which organizational processes make the most of both worlds. (2002, p.22)

This perspective, based on affordances, gives an insightful and useful account of paper and digital technologies. But it is also a totally instrumental account. The benefits of knowledge work and capitalism are assumed and unstated. 'Moving effectively toward the future' is stated as though it were a clear, neutral, common sense idea. The best affordances of paper can be combined with the best affordances of tablets or other technologies to give an unbeatable office of the future. Their book could work as a guidebook for the successful adoption of paper replacement technologies in offices – it is undeniably useful for this aim. This approach to affordances gives clarity for design. But it also depoliticises. Rather than using affordances to try to capture the 'best' use of a device, we might think about what 'best' is, who decides, who is enabled and who is prevented from using the device in this 'best' way and why. I use affordance ambiguity as a way to open up these questions.

Returning to Gibson's initial emphasis on the relationship between user and object (in his terms, animal and environment), the strength of the concept lies in its insistence on emergent meaning. Gibson's affordances take shape in an entangled relationship between user and object: the term affordance "Implies the complementarity of the animal and the environment" (Gibson, 1986: p.127). Rather than using the concept to analyse ways in which technologies are useful (or not) in given situations, I turn the lens around and analyse the subject positions assumed or constructed by understandings of affordances. The entangled relationship between user and object means that "built into every affordance is a particular sort of user" (Bruni *et al.*, 2013: p.60). As Suchman argued in her discussion of improvements to the Xerox 8200 photocopier: "All of these enhancements implied as well a greatly elaborated 'user interface', including not only aspects of industrial design, the lay-out of the machine's control panel and its instructions for use, but the actions required of the user herself" (Suchman, 2005: p.384). Defining the affordances of an object entails

defining its user, their role and their capabilities. This evidently involves certain normative assumptions about what might be thought of as normal uses of any given object.

This thesis is concerned not in the technology of tablets and their objective usefulness in a given situation (even if there can be such an objective judgement). My interest is in the way that users conceive of affordances and the subject position that they correspondingly construct. For example when two participants in chapter five discussed the tablet as an inventory management tool, this perceived affordance casted them as *scientists who engage in inventory management*. This subject position has particular implications in the laboratory context, where inventory management may be thought of as a task appropriate to a technician rather than a researcher – a distinction that has ramifications in terms of cultural and economic capital, as a researcher is likely to garner more respect within the laboratory (from other researchers at least!) and almost certain to receive higher remuneration than a technician. Reading affordances 'backwards' to get to the subject is part of the method of analysing the management of failure (a concept that I discuss shortly).

An affordance for Gibson is something that (imposing my own terms now) a particular object offers to a particular user: a *relative* characteristic rather than an abstract physical property (Gibson, 1986: p.127). An affordance is fundamentally a material property that emerges in the relationship between user and object, specific to that relationship. Yet despite its relativistic nature, the affordance is also clear-cut and reliable. A horizontal, flat, extended and rigid surface will *always* afford sitting to animals that sit. Although the affordance only 'appears' in an encounter between animal and environment, the same affordance is reliably repeatable in subsequent encounters. Gibson's argument that "Terrestrial surfaces, of course, are also climb-on-able or fall-off-able or get-underneath-able or bump-into-able relative to the animal" (1986: p.128) allows for objects to be used in different ways. While a single object offers different affordances to different users, to a single user the affordance does not change: "An affordance is an invariant

combination of variables [i.e. properties or qualities]" (Gibson, 1986: p.134) – this is essential to our learning about the environment and the reason that we recognise a chair when we see one. This is the limitation of the concept of affordances when applied to technological objects such as tablets and their users. The tablet computer has no such invariant qualities.

A tablet computer is a phenomenally blank object. It does not offer an obvious tactile encounter, it has no handles or buttons that suggest and afford a clear, unambiguous interaction. The tablet is not evidently a screen and therefore does not obviously afford viewing. The blankness of the object is part of the aesthetic that characterises Apple products. Yet even in adverts and other representations of tablets, this blankness is interrupted slightly by a line superimposed across the middle of the screen, suggesting that on its own the object is somehow too blank. This blankness is the basis of the joke in the chopping board sketch, discussed in chapter one. The affordances of the tablet as a computing device are so obscure that the grandfather only perceives the tablet as a flat, rigid surface, that he then – quite reasonably – uses to chop onions. As such, the tablet computer is characterised by 'affordance ambiguity'. Each distinct use of the same tablet computer can be entirely different for the same user. The concept of affordance ambiguity is key to understanding the emergent definition of tablets as material objects. Affordances of tablet computers and other app-based new media devices are never simply given by the material characteristics of the object but are always emergent. This emergence is distinct from the sense of emergence that Gibson uses, which relates to his claim that *qualities* of objects are not abstract physical properties, rather they emerge in the process of human perception of the environment. Emergence refers to the on-going work that users undertake to understand the function of the tablet. It is this process that allows 'radically situated and correspondingly multiple' (Suchman, 2005: p.394) objects to be experienced as simple *commodities* (Borgmann, 1987).

The ambiguous affordances of the tablet can allow users to adopt an inquisitive approach to the object. Rather than find out what the tablet is for, users can be encouraged to always find out *what else* it is for. Certain types of users may experiment indefinitely, installing new apps on a daily basis to instigate new affordances in the device. These users treat their use of the object as a kind of 'permanent beta' in which they perpetually test the device. Beta testing is used extensively in software, essentially as a form of quality control. Before full public release, a version of the software is made available to a (usually limited) public audience who use it as though it were the finished product. Any bugs or faults that are found are reported and repaired and the final product is then released. A consumer commodity such as a tablet computer is typically expected to be free of bugs – to work properly. The perpetual redefinition of the tablet computer by users is much more evocative of a form of testing than of simple consumption.

The level of experimentation depends on the individual user, which brings the question of subjectivity into play once more. Ongoing experimentation with the affordances of the tablet constructs the user as a capable tester of the device. Using only the pre-installed apps on the tablet constructs the user as a disinterested, incapable or otherwise unwilling tester of the technology: a position developed alongside intersecting subject positions such as technophobe, anti-Apple, naysayer and so on. Thinking about the use of tablet as a 'permanent beta' complements the earlier argument for treating consumption as a type of production. Treating tablet users as beta testers casts them as involved in both design and consumption. Affordance ambiguity can be used as a lens for the researcher to identify ways in which the subjectivity of a user is expressed in the degree to which they test or experiment with the tablet.

To understand this, it is necessary to address the context in which tablets are used. I will therefore now change the focus from the object and its materiality to the discursive construction and definition of the object. I propose the concept of the 'tablet imaginary' to

account for the way that the material device is conceived and 'held together' as a unified object in any given case.

Tablet Imaginary

The phrase the 'tablet imaginary' accounts for ideas and meanings related to the tablet that participants draw on and develop. This tablet imaginary is the discursive world in which the tablet is defined. It includes media treatments of tablets, marketing discourses, colleagues' understandings and comments and cues taken from the tablet itself such as recommendations of useful apps.

Taken as a whole, this tablet imaginary acts as a repository of ideas about the tablet that users draw from and contribute to. The tablet imaginary accounts for the ways in which meanings are created in the use of new technologies. I identify these meanings in different ways according to the specifics of each ethnographic case. The definition of successful or failed use of tablets is one common way in which the imaginary is expressed. The tablet imaginary accounts for the meaning of the device in a given case study and also connects these otherwise distinct meanings.

The idea that the material object is discursively constructed is central to the tablet imaginary. The term 'imaginary' intentionally highlights the constructed nature of the object. Rather than a material object with objectively identifiable material features, the tablet is regarded as an object *in use* that is emergently defined and understood. The tablet imaginary is a set of ideas and meanings about tablet computers that is formative of particular uses of tablets and is at the same time formed by such uses.

Instead of considering the tablet in terms of affordances granted by its materiality, I seek to understand the materiality of tablets through the discursive construction of its affordances. In other words, the tablet is a material object that is understood through the lens of the tablet imaginary: a culturally-derived set of meanings that constrains but does

not determine the user's understanding of the object. The tablet imaginary is by definition fluid and emergent. It is the discursive world in which the tablet computer is used and made to make sense.

Part of the work of each chapter is to trace the tablet imaginary as it operates for the ethnographic participants. It is necessarily informed ideas about tablet computers that I bring to bear on the research (for instance in the form of the genealogy that makes up the first chapter) and that I exchanged, shared and developed with users during the research process.

Although any discursive world is inexhaustible, my aim is to outline its key aspects in each case study. In theory it would be possible to map the entire tablet imaginary for a single case. In practice, this is impossible for two reasons: firstly because elements of the imaginary may never be expressed by participants or identified by the researcher; secondly because a map is a static object and the imaginary is emergent. The attempt to map the tablet imaginary in a given case can be thought of as a 'conjunctural analysis' (Hall and Massey, 2010, Balsamo, 2011) – an assessment of the meaning of a technological object at a particular point in time. The imaginary traced in the following chapters may well have significant overlaps with other cases of people using tablets. It may indeed have significant overlaps with imaginaries relating to smartphones or other new media devices. The more similar the case, the more likely there will be significant overlaps. As I hope to show by using the concept of the tablet imaginary, there are many culturally-derived shared meanings that inform individual understandings of tablets, but these understandings are always expressed in particular uses. It is reasonable to expect that generalisations about uses of tablets would be broadly applicable, with the caveat that this is only demonstrable with further ethnographic research. The concept is therefore at the same time rather limiting, referring only to the case study in question, and vastly expansive, referring to attitudes to technology in general.

The tablet imaginary may best be understood as the set of meanings, ideas and practices that contribute to the definition of the object by a user in a given context. A user's definition of the tablet at any given time is informed by expectations of the object's role and function and at the same time by their actual uses. The crucial point is that the tablet is defined *in use*. In each use, at each moment, the object is therefore defined *differently*. This emergent definition links to the concept of the permanent beta and affordance ambiguity.

The tablet imaginary provides a framework for understanding what 'working properly' means for any user. Yet I argue that tablets have an ontological indeterminacy that means there is no straightforward sense of what it means for a tablet to work properly. The tablet has no predictable affordances that identify it as working or not. The assemblage of operating system, app, user and context is so radically flexible and unpredictable that the tablet develops a fluid ontology. Partly these characteristics might be indicative of the form of contemporary technoscientific objects, perhaps challenging more broadly the concept of what an object *is*.

While this is grounded theory in the sense that its definition and content is dependent on empirical research, I draw from previous work that has discussed and analysed the role of imaginaries in various ways. Michael discusses discourses such as 'surveillance society' or 'virtual society' and argues that "As accounts of (near-)future society, they 'perform' in various ways" (2006: p.102). These ideas are not mere predictions or aspirations about the future; they impact upon current understandings and practices related to technologies. Woolgar (2002) argues that we must take such discourses into account if we are to understand the adoption of any given technology. Indeed, he does not separate the technology from the discourse, saying of these discourses that "Their constitutive function makes them part of the phenomenon to be understood" (2002: p.8). Following this, I endeavour to outline participants' use of tablets by analysing not only their expectations

and actual uses, but how these expectations and uses relate to wider social discourses. The idea that users make sense of technologies based on an idea of the future is expressed by Bell and Dourish in terms of the 'proximate future', an analytical concept that they use to account for the development of framing narratives in ubiquitous computing or 'ubicomp'. They give three 'framing points' that summarise the idea of proximate future:

> First, the centrality of ubicomp's proximate future continually places its achievements out of reach, while at the same time blinding us to current practice […] Second, the framing of ubicomp as something yet to be achieved allows researchers and technologists to absolve themselves of responsibilities for the present" […] Third, the seamlessly interconnected world of future scenarios is at best a misleading vision and at worst a downright dangerous one. (2011: p.22)

Of most importance to the current discussion is their first point; the idea that current practice is 'bound to' a projected future that is perpetually out of reach. In a similar vein, Marcus argues that "[people] are constantly trying to understand the present by borrowing from a cautiously imagined emergent future, filled with volatility, and uncertainty, but in which faith in practices of technoscience become even more complexly and interestingly constructed in new locations of doing science" (1995: p.4).

The importance of *faith* in the practices of technoscience is evident in each ethnography, where participants regularly disavow the idea of tablets not being useful by engaging with their affordance ambiguity, the fluid definition always offering an escape route from failure. The idea of failure, and how this is managed, is expressed differently in each chapter. In chapter four, failure is denied; in chapter five it is suspended and in chapter six it is deferred. Managing failure is one way in which faith in technoscientific objects is expressed. The faith that users thereby demonstrate is directly related to the tablet imaginary and the interesting temporality that it exhibits. As an idea of the future constructed in the present, the tablet imaginary allows users to suspend judgement over their technological devices: never 'it does not work', but always 'it does not work *yet*'. The analysis of failure is fundamental to the Social Construction of Technology tradition:

"failures should, Pinch and Bijker believe, be of as much interest to historians and sociologists of technology as the success stories" (Bijker *et al.*, 1987a: p.14). More recently, Anne Balsamo (2011), in her discussion of the process of technological design, gives special attention to the tenth of her 'ten lessons of technocultural innovation', which states that 'failure is productive'. She explains her perspective as follows: "I regard this insight from the vantage point of someone who still believes that everyday culture is a zone of struggle and contestation, where failure is but one name for the texture of that struggle" (Balsamo, 2011: p.25). Failure and success are two paradigms that connect in the tablet imaginary. Relating this to the earlier discussion of affordance ambiguity, the perceived success or failure of the tablet in a given instance is an expression of the 'best' way to use the tablet. Every success story masks an alternative interpretation. Success and failure are not neutral concepts: whether the tablet fails or succeeds we can ask on whose terms and to what ends this evaluation is made.

When a given use of the tablet – as a scientific instrument, a paper replacement, a piece of unremarkable background tech – succeeds or fails, this understanding draws on particular elements of the tablet imaginary. The work that users perform in defining the tablet is part of a struggle to establish their preferred understandings of the tablet – for example as efficient – as normal, unquestioned, accepted. At the same time as it draws on the tablet imaginary, by the same process this work contributes to the imaginary by embodying and substantiating it.

Conclusion

Affordance ambiguity and the tablet imaginary are concepts that I use to bring together technological practices within and beyond the laboratory. The local, contextual practices discussed in this thesis are at the same time part of a more general picture. This is not to say that these observations can be directly *generalised*. But neither is it to say that each

case is unique and has no bearing on any other. Suchman, citing Mol and Law (2002), puts it like this:

> This is a radically contextual view, in which objects and their positions are inseparable, subjects are always located, and subjects and objects mutually implicate each other. […]Methodologically, it means that the value of a case such as that offered here lies not in its instantiation of a general theory but in its suggestions for further—comparative and contrastive—investigation. Cases, like objects, are multiple, affiliative and subject to mutual interferences as well as partial connections. (Suchman 2005, pp.394-395)

I aim in this thesis to show how affordance ambiguity and the tablet imaginary can work as concepts to make connections *between* local, contextual practices that occur separately. This chapter has given an abstract outline of the two concepts, showing their intellectual foundations and how they connect to a wider literature. While this is essential, the concepts – and this thesis – rely on a commitment to analysing the actual practices of tablet users. The following ethnographic chapters should therefore give the clearest picture of how these concepts can be used in the analysis of the everyday use of technoscientific objects.

Chapter 3. Tablets as Scientific Instruments

"Capture Data Your Way!" (Website slogan for *Irisnote* laboratory management app)

Introduction

In this chapter I examine the role of laboratory objects and argue that tablets have specific characteristics that differentiate them from other lab objects. I draw on historical accounts of scientific instruments (Van Helden, 1983, Galison, 1997, Golinski, 1998) to argue that the use of tablets brings particular meanings to the laboratory context. Focusing on laboratory management applications (lab management apps, or LMAs), I argue that tablets affect *how* scientific phenomena are produced, and discuss the consequences of this for everyday lab practices. Developing Latour and Woolgar's (1979) analysis of laboratory objects, I propose that we should consider tablet computers as objects of 'reified practice'.

Thinking about the materiality of tablets as digital objects raises further questions when considering tablets as instruments in the lab context. To underpin this discussion, I draw on a range of literature that examines digital objects in various ways: I outline the key approaches here. 'The social life of methods', developed by Ruppert *et al.* (2013), is concerned with the implications of digital technologies being used in social science research and asks how methods can become objects of inquiry (Savage, 2013). They extend the concept of 'methods' beyond academia and treat everyday processes as methods. Their insight can be applied to the 'method' of using LMAs. I examine the social and cultural structures – and the social relations – that are constructed by LMA methods. Langlois and Elmer (2013), while mainly discussing corporate social media, offer some insights about digital objects more generally. They give three aspects that describe the multifaceted nature

of digital objects: semantic, networked and phatic. The Facebook 'like' button, for example, is a textual multimedia element on a user interface and also a software element that functions as part of ranking algorithms (Langlois and Elmer, 2013). Their concern is with the ways that digital objects both construct and are constructed by social processes. This is useful as a way to think about 'what is available to the researcher' (Langlois and Elmer, 2013: p.11) and how digital objects such as LMAs can be approached.

The main body of this thesis is built around four research-based chapters, three of which are based on ethnographic research in science laboratories. The current chapter, which precedes the ethnographies, asks whether the tablet computer can be considered a scientific instrument and examines the implications of this question. This is not based on ethnographic research but instead draws on an analysis of advertising and marketing material for laboratory-specific apps. Although I am committed to the ethnographic approach that seeks rich understandings of situated practices, I also agree with Galison that the "meaning of instruments should include not only what we say about them but the often unspoken patterns of their functional location with respect to other machines, patterns of exchange, use, and coordination" (1997: p.51). Some of these aspects can be examined outside of the laboratory context. The current chapter therefore looks at how tablets are discussed as belonging in labs, the role that they are assigned and the construction of their relationship to other laboratory objects.

The theoretical framework that underpins this thesis is based on an understanding of material objects as situated in specific contexts of use. I focus on the meanings that emerge in uses of material objects, insisting on this emergent notion of meaning. As such, I would like to make two points about my approach in this chapter which takes an abstract examination of tablets as scientific instruments. Firstly, I examine the construction of scientific instruments as being neutral objects in order to critique that understanding. To ask whether tablets are (or can be) scientific instruments demands an analysis of what

scientific instruments are, what they represent in the lab and what assumptions are made in naming an object an instrument. I follow the construction of neutrality in the marketing of LMAs to open up these questions.

Secondly, the aim of this approach is not to argue strongly either way, for example that tablets indeed *are* scientific instruments. The aim is to examine the conditions in which a tablet is treated as such. This chapter analyses what tablet and app makers *say* a tablet will bring to a laboratory. This is done with open eyes and a healthy disregard for advertisers' accounts of what their product will do. While tablets may indeed bring efficiency to the lab, this aspect of tablets can only be manifested by users in practice. Whether advertising or any other discourse influences such efficient uses of tablets can only be judged in ethnographies in specific labs. As Galison comments on instruments, these "knowledge-producing machines acquire meaning through their use within the physical laboratory" (1997: p.51). In the conclusion of this chapter, I draw on Barad (2003) to insist on performativity and the emergent nature of relationships between users and objects. The authors discussed above all share a concern with digital objects, and Barad's account shows us that these concerns only count when the objects are being used by people in specific situations. This is best illustrated in the subsequent chapters based on ethnographic research. The juxtaposition of this chapter before the ethnographic chapters is intended to highlight the distance between the promise of technology and the reality of its implication, to show how the construction of a material object is emergent and can only be read in the context of its use.

Tablets as scientific instruments. A genealogical approach.

Laboratory science is characterised by the use of a wide variety of scientific instruments:

> Since the seventeenth century, when natural knowledge was first systematically pursued through experiments, scientific research has been conducted in a

> purpose-built world of specially manufactured instruments. By instruments are meant the material tools the human investigator uses to disclose, probe, isolate, measure, represent, or otherwise bring to attention the objects of investigation. (Golinski, 1998: p.133)

Tablet computers are not purpose-built for use in the sciences. By Golinksi's definition, then, tablets are not scientific instruments. Van Helden gives a wider-ranging definition by detailing a set of assumptions with which we associate scientific instruments:

> [By] *scientific instrument*, we mean a device used by scientists to investigate nature qualitatively or quantitatively. We tacitly assume that: (1) there is a proper, even essential, place for such devices in the study of nature since the human senses alone are too limited for most scientific investigations; (2) the results or readings obtained with them are usually beyond question; (3) scientific instruments are based on undisputed scientific principles, such as the law of the lever; (4) newer instruments are more accurate, powerful, or convenient than older ones, the limiting factor usually being the state of the art in contemporary technology. (Van Helden, 1983: p.49)

Even according to Van Helden's more accommodating definition, tablets are not scientific instruments. Lab management apps do not collect data (point 2 in Van Helden quotation above) and are not based on scientific principles (point 3 in Van Helden quotation above). Yet Van Helden's historical study of scientific instruments allows us to use a less static definition and allow for tablets to be considered *potential* instruments. By taking a genealogical perspective, we can observe changes and trends in what is considered a scientific instrument at any given historical moment. Every familiar laboratory instrument such as the microscope had to fight to be considered a legitimate tool for the production of scientific knowledge. Instruments do not enter the laboratory already accepted. The laboratory is, initially at least, a proving ground for instruments.

Van Helden's argument concerns the way that we classify instruments. His historically-situated definition lists four assumptions that characterise instruments today. He adds that these modern assumptions were not always applied to instruments, only becoming accepted as the use of certain instruments became commonplace (Van Helden, 1983: p.49). It is important to clarify here that Van Helden's list of assumptions is

retrospective: it is created in response to a given set of accepted objects such as microscopes, thermometers and so on. The assumptions describe a set of objects that we now call 'scientific instruments'. Because it is retrospective, it is inflexible and does not cater for new objects. The point of making this clarification is to argue that instruments define their category, not the other way around. Specifically, if any object becomes accepted as an instrument, then the category 'scientific instrument' and its implicit assumptions will be altered to include its particular characteristics. Against this apparent inflexibility, then, we can use the logic of an historical classification of instruments to argue that tablet computers, although not considered instruments today, may be considered instruments in future. If this were to happen, then a future scholar outlining accepted assumptions about instruments would include assumptions that incorporated the characteristics of tablet computers. This is all a more detailed way to argue that judging tablet computers against a set of classifications derived from observing current lab objects is not a useful approach. But this does not mean that we must postpone an analysis of tablets as instruments indefinitely. Instead, it points the way to a more useful approach to answering this question. If tablet computers are not scientific instruments (as currently considered), then what function do they have in the lab? If they are not instruments, what are they?

Latour and Woolgar's landmark study *Laboratory Life* (1979) discussed the laboratory as a "material setting" containing a series of material objects that constitute the kinds of facts that the lab can produce (1979: p.66). They argue (1979: pp.64-66) that a laboratory is a place that contains a specific set of objects. The collection of objects in this laboratory for example (Figure 1) could only exist in a laboratory that analyses macromolecules such as DNA. The gel electrophoresis apparatus defines this space as a genetics laboratory. The objects assembled in that lab space combine to produce phenomena that are pertinent to genetics research. In other words, the space is only called a genetics laboratory because of

Figure 1 – Gel electrophoresis apparatus. Photo by the author.

the set of objects that exist therein. And the set of objects defines the science that can be done in the lab:

> The central importance of the material arrangement is that none of the phenomena 'about which' participants talk could exist without it. […]It is not simply that phenomena *depend on* certain material instrumentation; rather, the phenomena are *thoroughly constituted by* the material setting of the laboratory (Latour and Woolgar, 1979: p.64, emphasis in original)

There are similarities here with Van Helden's classification of scientific instruments. The material objects are taken to be the fundamental defining factors. If in future, phenomena accepted as pertinent to bioscience research could be produced by tablet computers (or any other given object), then the presence or absence of tablet computers in a lab would contribute to the lab being considered a bioscience lab or not.

For Latour and Woolgar (1979), the laboratory is defined by the collection of objects that it contains. And this does not only include the objects that we would call 'scientific instruments'; the whole material setting of the lab contributes to the production of scientific phenomena. This conception inevitably runs into a logical problem when it comes to attributing influence to different objects. If the whole material setting of the lab contributes to the production of scientific phenomena, then how is it possible to differentiate between different lab objects? A problem that is absolutely relevant to the current question of tablets being regarded as scientific instruments. Latour and Woolgar deal with this problem with a memorable quote:

> "Obviously, however, not all pieces of equipment condition the existence of phenomena and the production of papers in the same way. Taking away the trash can, for example, would be unlikely to harm the main research process; similarly, withdrawal of the automatic pipette would not prevent pipetting by hand, even though this takes longer. By contrast, if the gamma counter breaks down, it is difficult to measure amounts of radioactivity by mere sight! (1979: p.64)

The quote makes it clear that while all lab objects are equal, some are more equal than others. To differentiate between lab objects such as the gamma counter, that affect the production of phenomena, from those that merely facilitate it, such as the trash can, Latour and Woolgar use Bachelard's concept 'reified theory'. This concept refers to the fact that instruments are built upon scientific principles that were once novel, that went through a rigorous testing process involving both theoretical debates and experimental demonstrations, and finally were accepted as factual by the scientific community. Theory that has been accepted is then used to build new instruments, in other words the theory is reified, and used in the production of further scientific facts. This phrase conveys the idea that instruments embody previously debated scientific theory. It is a sign of acceptance by the scientific community for a theory to be used in the development of new scientific phenomena, in the process of establishing new theories. It can be seen as a mark of total acceptance of a theory when instruments based on it are commonplace in laboratories.

Theories developed in very specific domains of an individual discipline come to be deployed as instruments in a variety of ostensibly unrelated fields: "Every move in the laboratory thus relies in some way on other scientific fields" (Latour and Woolgar, 1979: p.66). Theories of refraction, diffraction and reflection of light, for example, can be said to be accepted as factual by the scientific community because they are the theories upon which microscopes are based. Those theories, reified in optical microscopes used in all kinds of scientific laboratories, are part of 'normal science' (Kuhn, 1996): used to create new phenomena with the aim of developing new theories, which may eventually be reified in new instruments (Latour and Woolgar, 1979: p.66).

In order to avoid their 'material setting' account of lab objects ascribing equal influence to both trash cans and gamma counters, Latour and Woolgar differentiate between two types of laboratory objects: those water and gas pipes that are a general condition for producing scientific phenomena (1979: p.64), and those objects that affect the precise type of scientific phenomena that can be produced, in other words instruments. This distinction is a useful starting point for the analysis of tablets as instruments, but it requires some additional theorisation. Maintaining this distinction for the time being, I will develop this analysis by making an argument about those laboratory objects that reify theory, the scientific instruments, emphasising an idea that is in some ways implicit in Latour and Woolgar's argument. Latour and Woolgar use the idea of reified theory to account for the fact that a wide variety of instruments, with origins in many different scientific fields, are all found together in one laboratory and combine to produce phenomena totally specific to one particular field. They point out that "The inscription devices, skills, and machines which are now current have often featured in the past literature of *another field*" (1979: p.66). The strength of 'reified theory' as a concept is that it demonstrates how scientific practice is *limited* by instruments. The fact that instruments reify theory, that they embody theory established in other disciplines and eventually

accepted elsewhere, means that phenomena produced in the lab can be accepted. It is this positive sense of 'limitation' that needs emphasis: using instruments limits scientists to producing only those phenomena that will be accepted by the wider scientific community. Galison discusses this using the term 'constraints': "theoretical (and experimental) constraints play a constructive role as well as a restrictive role. Because constraints restrict moves, they shape the theorist's positive research program - giving a problem-domain form, structure, and direction" (1997: pp.16-17). A result produced using new, untested or untrusted equipment will be treated correspondingly as untrustworthy: a concept that will be relevant throughout the discussion of LMAs. A result produced using an instrument that reifies universally accepted theories will be accepted as factual.

Latour and Woolgar describe two types of laboratory object: instruments that affect the types of phenomena that the lab produces, and other objects that merely facilitate but do not affect the scientific process. By this definition, tablet computers would fit into the latter category of objects, alongside the trash can and so on. They do not embody any established theory or produce phenomena that can be accepted as factual results. However, a recent type of laboratory-specific tablet app unsettles this dichotomy and requires a more complex account of the material setting of the laboratory.

The promise of efficiency. Improving practices without changing them

Laboratory management apps (LMAs) such as *LabGuru*, *colwiz* and *Quartzy* promise to improve laboratory efficiency by offering a digital workflow and data management system so that a lab's entire working process is conducted within the digital space of the lab management app. Electronic Lab Notebook (ELN) apps such as *eCat*, *LabArchives* and *Irisnote* promise to digitise and automate laboratory data recording methods so that each lab member can instantly access any other lab member's results. I have chosen to treat ELNs and lab management apps as one group of digital objects that I will refer to as LMAs.

Although comprising two categories and dozens of different products, the common feature that used to define them as a single group is that they incorporate digital spaces in which data is shared between lab members. As a point of comparison, the Enterprise Resource Planning (ERP) systems fulfil a similar role and promise in commercial enterprises:

> ERP systems are (mostly off the shelf) software packages designed to integrate physical production systems with all major business functions. An ERP system consists of a number of different modules that mediate the performance and documentation of various business functions (such as finance, sales, inventory management, or human resource management). (Knox *et al.*, 2007: p.26)

LMAs are similar to enterprise resource planning systems insofar as they are 'off the shelf' products that can be integrated to working practices as they are, or customised to suit the specific needs of a given lab. These products are promoted on the basis of an assumption that instant access to a colleague's data means instant understanding of that data. They therefore require all users to follow a standardised (or standardising) format when recording experimental data. As an indication of the type of service that these products offer, lab management app *LabGuru*'s website states:

> INTEGRATE YOUR DATA WITH LABGURU
>
> Your experiments generate vast amounts of data in various formats - from gel images to graphs. Your research relies on publications and protocols, materials and results. Labguru puts it all together.
>
> - Define research goals and monitor progress, anytime, anywhere
> - Never again lose data or knowledge
> - Enhance collaboration in your lab – Mentor your team, share ideas, and publish faster
> - Push your grant funds further[16]

Lab management apps are a new kind of laboratory object that do not fit into Latour and Woolgar's dichotomy that distinguishes simply between scientific instruments and everything else. As outlined above, they argue that the material setting of the lab

[16] http://www.labguru.com/ [Accessed 7th August 2013].

'thoroughly constitutes' the phenomena being studied (1979: p.64). A lab's results can be trusted because they have been produced by a material setting that combines two different types of laboratory object. Firstly, objects such as water pipes that are neutral and have no valuative content; secondly, scientific instruments that consist of well-defined, recognised and accepted content as they reify established scientific theory. The trustworthiness of the results is thus built on a combination of two opposite understandings of objects. Results produced in the material setting that includes water pipes, trash cans and automatic pipettes can be trusted because these objects have no influence on the phenomena. Results produced in the material setting that includes gamma ray counters and microscopes can be trusted because they have a specific and well-defined influence on the phenomena.

Lab management apps are a new type of laboratory object because they promise to exhibit both characteristics. They promise to be neutral, or transparent, that is to have no impact upon the results or phenomena produced. Yet they also promise to improve the research process, indicating that they do affect the production of phenomena in the lab. The table below (Table 1) shows some ways in which to differentiate between these three types of laboratory object. I have placed LMAs between the two categories of objects defined by Latour and Woolgar, not to suggest that this forms a rigid tripartite system of classification, but to allow clearer comparison.

The table below (Table 1) shows a number of ways in which tablets and lab management apps differ from both facilitating objects and scientific instruments. I would like to focus on points four and five in Table 1: the idea that tablets are theory-neutral just like water pipes, but are able to affect the production of specific phenomena. LMAs feature characteristics of both facilitating objects and scientific instruments. Apps perform discrete, specific tasks. Lab management apps are no different: they are designed to improve specific laboratory functions, most commonly the recording of experimental data. The commercial success of these apps is built upon a paradoxical promise that I outline in more detail in the

following chapter as the myth that 'digital technology can replace tools without changing processes'.

Table 1. Types of Lab Object

Objects that facilitate	**Lab management apps**	**Scientific Instruments**
Requires no special expertise to use	Requires computing expertise to use	Requires scientific expertise to use
Institution pays for, maintains and controls	Individual may pay for, maintain and control. Lab head may do so. Maybe a combination	Lab Head pays for from research budget
Fixed location in the lab	Portable: can be moved throughout the lab and also removed each day by the individual	Often fixed location in the lab, but can be moved
Not based on any theory that is involved in the production of phenomena – has no impact on results	Not based on scientific theory. But promises to have impact on results i.e. improve the process of creating phenomena	Reifies scientific theory to produce new phenomena – determines results
Trustworthy because based on engineering or other technical skills (today not regarded as scientific)	Trustworthy because theory-neutral	Trustworthy because based on established scientific principles
Allow any phenomena to be produced	Allow any phenomena to be produced. But improves production of specific phenomena	Determine the types of phenomena that can be produced

Lab management apps promise to improve research processes without changing them. The paradoxical claim to improve processes *without changing them* is crucial when we consider the role of different laboratory objects. The defining characteristic of a scientific instrument is that it affects the kind of phenomena that can be produced, because it reifies established scientific theory. As described above, this affects the research process by limiting experimental results to only those that will be accepted by the scientific community. Imagine for a moment that a laboratory management app claimed to improve research *by fundamentally changing the research process*. In such a circumstance, the apps would not be

trustworthy. Their trustworthiness comes from being (or claiming to be) value-neutral. In the case of LMAs, they are trusted because they do not affect research processes; they merely improve them by making them more efficient. As such, they *must* claim only to facilitate the research process. Claiming to do any more than that would make them untrustworthy and would destroy the scientific validity of the research. The reason for this again concerns the limiting function of instruments described above. LMAs reify new modes of working – rather than scientific theory – and are therefore linked to productivity.

Latour and Woolgar argue that because scientific instruments reify established theory, it is practically impossible to challenge scientific results (Latour and Woolgar, 1979: pp.242-243). Challenging an instrumental result equates to challenging the theory that the instrument reifies. But the time, cost and effort of disputing theories that are so well-established that they have been reified in instruments means that there is a point at which they become unchallengeable. It would mean challenging the validity not only of the result at stake, but every single other result that has been produced using the same instrument as well as the entire historical literature that led to the underlying theory being accepted. Referring to facts as 'stable inscriptions', Ruppert *et al.* sum this idea up:

> […] if some of those inscriptions have become more or less stable, difficult to undo or immutable, then this is because of the scale of investment (literal and metaphorical) that has gone into making them up. It has become too 'expensive' to undo them (Ruppert *et al.*, 2013: p.31).

This lends scientific phenomena the solid and immovable status of 'factual' and means that using instruments limits the lab to producing only acceptable types of phenomena. A result produced using any non-instrument object that affected the research process, on the other hand, would not have this weight of historical science to support it and would therefore be extremely fragile. This is not an abstract situation. In 2006 a protein crystallographer Geoffrey Chang had to retract five papers due to a mathematical error in some software code used in the production of his results, with Chang commenting, "I've

been devastated" (Miller, 2006). This shows the extent to which non-instrument objects involved in the production of phenomena cause those phenomena to be fragile, thus the requirement for any non-instrument lab objects to depict itself as neutral. This all goes to explain why lab management apps claim to improve research processes *without changing them.*

It is for this reason that I argue that lab management apps are theory-neutral. To put it very simply: scientists will not use untested tools in place of instruments. Whether a lab management app or a revolutionary type of apparatus, no laboratory object that determines the types of lab phenomena that can be produced will be adopted by scientists without it being subjected to the rigour of scientific testing. No results produced using any such new tool would be publishable (or if published would be 'weak' like Geoffrey Chang's), so no experiments using such techniques would be pursued. While there is room of course for new techniques to be introduced to scientific practice – particularly in the course of 'revolutions' as outlined by Kuhn (1996) – in general the material setting of the laboratory demands that objects either be theory-neutral like water pipes, or entirely theory-laden like instruments.

Lab management apps introduce something different to the material setting of the lab. These apps are theory-neutral, but value-laden. I propose that these lab objects should be categorised as 'reified *practice'*, as their specific materiality limits scientific practices by encouraging users to conduct their work according to cultural values. These cultural values do not affect the type of phenomena that are produced, but they can affect *how* phenomena are produced in the lab. The values that these laboratory apps imbue vary slightly from product to product, but a common feature is an emphasis on efficiency and data management. A critical analysis of these products reveals how they associate 'good research' with 'efficient data management'. At this juncture, we can begin to make links between the specific characteristics of lab data management apps and digital culture more

broadly. By analysing the promises and logics of these apps, we can make visible the promises and logics of digital technology more generally.

Dealing firstly with the idea of efficiency, in one sense, the promise of increased efficiency or productivity simply represents the limit of what these products are logically able to offer. As outlined above, they cannot offer to change processes, only to improve them: increased efficiency is therefore all they can provide.

Table 2. Promise of Efficiency

Product	**Promise of efficiency**[17]
LabGuru	Enhance collaboration in your lab – Mentor your team, share ideas, and publish faster
ColWiz	Sign up to simplify and speed up your research process
eCat	How does the eCat electronic lab notebook help your lab become **more productive**?
iPad ELN	[In list of reasons to use iPad ELN:] 4. I think that scientific information in general is not sufficiently well-organized and that this greatly interferes with the progress of science.
Sciency ELN	Enhance workflow productivity
Irisnote	Obviate the inefficient, unregulated and potentially insecure use of external thumb-drives, email, drop-box or other methods of sharing files between and communicating among colleagues or collaborators.

While the table above (Table 2) shows a general trend in which these apps promise to make lab research processes more efficient, analysing the detail of these claims reveals something more interesting. Almost exclusively, the claim that an app will increase efficiency in the lab is based solely on the fact that the app is digital. Rather than explaining why or how a digital system is more efficient than a paper-based system, the superior

[17] Taken from product websites accessed 8th August 2013 (emphasis in originals).

efficiency of digital systems is assumed. This is most clearly visible in product descriptions that simply mention the 'digitalness' of the system, as though this on its own confers efficiency on a process. The table below (Table 3) shows a few examples where the idea that the digital is inherently more efficient is more clearly – though still implicitly – stated.

Table 3. Explanation of Efficiency

Product	**Explanation of efficiency**[18]
LabGuru	**Streamline Paper Writing**: Rather than searching through spreadsheets, piles of papers images and data on multiple machines, Labguru lets you keep all aspects of your research organized in 1-place, making it easier to gather and understand your data when it comes time to writing papers.
Scilligence ELN	All experimental records are captured electronically and searchable by chemical structures and keywords.
Irisnote	**Capture data your way!** Text, handwriting recognition, voice dictation, drag-n-drop, email directly into irisnote, digital pen (4Q13)
LabandMe	You can take full advantage of the mobility afforded by an iPad to eliminate paper based workflows between the lab bench and your office, saving you documentation time and lets you capture results with increased accuracy.
iPad ELN	**5. I am used to working with a paper notebook and I am not attracted by the prospect of using a software system instead.** First, you don't need to give up your paper notebook completely – it can still be useful for quick recordings at the bench or it may be required for protecting your documentation. Second, science is a serious business with important consequences – get your priorities straight.

Of particular note in the above table (Table 3) are *Irisnote*, which stresses the superiority of digital inputs even in terms of pens and handwriting, and *iPad ELN*, which

[18] Taken from product websites accessed 8th August 2013 (emphasis in originals).

accuses scientists who do not want to give up paper for software of being wilfully difficult and holding back science: "science is a serious business with important consequences – get your priorities straight".

These examples show that, despite these products being theory-neutral, they embody a particular view of scientific research that values efficiency. And a very particular kind of efficiency. Efficiency here is related strongly to productivity, evidenced by research output, measured by the speed with which a research paper is published. These products are value-laden because they assume that the most efficient lab processes are necessarily the most desirable. This view may well correspond to many researchers and lab heads, who agree that they want to "push their grant funds further" (LabGuru website 2013). But the idea that the digitalness of LMAs will create efficiency is only implied, never explained. Sutherland associates networked digital media with a more general "culture that fetishizes efficiency, flexibility, and, above all, speed, driven by the unchallenged assumption that a continuous increase in the productive capacity of labour is not only synonymous with progress, but is also necessary for continued prosperity" (2013: p.7). The idea of efficiency is presented as common sense and embodied in the practices encouraged by LMAs. Whether or not efficiency (defined by rate of publication) is a universally desirable characteristic, lab management apps assume that it is, in turn encouraging those using it to adopt working practices based on that assumption. It is in this sense that lab management apps are reified practice. Reified practice entails the ideological prioritisation of a cultural value, in this case efficiency, into scientific research practices. The non-neutrality of instruments that I imply here intersects with the ideology of software as neutral, examined in Fuller (2008b) and in more detail in the discussion of the London Group in chapter six of this thesis.

Instruments limit scientific practice by reifying previous scientific knowledge and therefore only allowing phenomena that will be accepted by the wider scientific community

to be produced. Lab management apps have an equivalent but distinct limiting effect based on cultural values rather than scientific theory. Lab management apps limit scientific practices by encouraging efficient processes and discouraging processes that take a long time to complete or are perceived as wasteful of the lab's resources including time, money and equipment. This limiting effect does not alter the nature of phenomena produced. As explained previously, these apps *cannot* intervene in the production of phenomena because they do not reify theory, so can only produce 'weak' knowledge that does not have the support of previously debated scientific theory. The limiting effect does alter the everyday lab experience by encouraging efficient processes in preference to inefficient processes (or tablet-based methods as opposed to paper-based methods, with an assumption that this will entail increased efficiency), and by changing the way that lab members share data.

In the final sections of this chapter, I examine the 'merely' *technical* aspects of apps, outlining how this has an instrumental effect on their everyday use. My approach is to examine the logic of the system as expressed in the user interface. This position aims to bridge the gap between the explicit and implicit; the visible and invisible values of lab management apps. Rather than analysing the underlying code, I analyse the material instantiation of code as it is enacted by the user. As Parikka argues (2013: p.6), users experience digital objects by developing an understanding of how to interact with the code and algorithms of those objects, regardless of the fact that most users have no interest in or knowledge of digital algorithmic techniques. It is in the logic of the system at user-interface level that the implicit values of the digital object are substantiated.

Cultural values are embedded within digital objects in ways that are not visible to the user. Langlois and Elmer argue that because such aspects of digital objects are "only partially visible at user-interface level, it is important to maintain the long-standing critical position whereby the analysis is not only about what is visible, but also about what remains invisible – and thus unquestioned and accepted as the norm" (Langlois and Elmer, 2013:

p.13). Savage (2013: p.17) notes that implicit values embedded in objects can have as much of an instrumental effect as explicit values and that a critical analysis can displace but never remove the implicit. In the case of LMAs, it is in the normalisation of efficiency as a desirable characteristic of research practices – in the way that lab management apps stabilise and fix the value of efficiency – that ideology can be seen to be at work. In this context, a critical analysis would ask whose interests are constructed as normal? Is (this particular form of) efficiency a desirable adjunct to existing values of scientific practice? Or, what happens to scientific practice when non-scientific objects (or non-instrument objects) like tablet computers introduce cultural values like efficiency into the lab? I take up these questions in response to ethnographic material in the following three research chapters. For now, I will look at the logic of LMAs and the implication of their promise of efficiency for lab community practices.

It is only when we consider the primary way in which lab management apps promise to increase efficiency, through data-sharing, that the real impact of the way that these apps reify practice becomes clear. Cultural values "are tied up with the processing and organization of flows of digital data and things" (Savage, 2013: 10) and that specific types of social relationships are produced in the creation, transfer and organisation of digital data. The value of efficiency affects the way in which social relations in the lab are formed based on an idea of community established through data-sharing processes.

Communities of Data

Laboratory management apps promise to increase efficiency by streamlining, digitising and simplifying data recording processes. The app serves as a centralised data management service, so that all data is recorded within the app. One promised advantage of this is that data can be shared infinitely with other lab members and members of labs in other institutions not geographically connected. In a paper-based lab, each lab member has a

laboratory notebook or 'lab book'. As is discussed in more detail in chapter four about 'the Lab', a lab book is used in academia and industry to keep a precise record of the activities taking place in the lab on a daily basis. This record serves two functions: scientifically, it acts as a record of past experiments that can be referenced in future; bureaucratically, it acts as a record of lab activities including what was done and who did it, so that responsibility and intellectual property rights can be assigned. In principle, any lab member could read another's lab book to find out what they had been working on, how they had gained their results, what processes and instruments they had been using. Data recorded in the lab book should therefore be easily understandable by anybody with the relevant scientific expertise. This has practical advantages: for instance if a lab member permanently leaves the lab, then their replacement can continue their work by referring to the departed lab member's lab book. In the course of routine everyday lab work, a lab member may read another's lab book while the latter is at lunch, for example, rather than waiting for them to return to ask which protocol they used in a given experiment.

Lab management apps create a digital space in which all lab members' data are recorded together. Although data continue to be linked to the individual user who recorded them, the aim of this centralised approach is to have a shared pool of data that is accessible by everybody in the same way. Each lab user would access their own data in the exact same way that they would access another lab member's data: through the lab management app. At the same time, the apps encourage or require standardised ways of recording lab data. As outlined above, a lab book should record data in a universally understandable manner, which in practice varies from lab to lab and is often dictated by each lab head's personal preferences. The lab management app places new and greater significance on standardisation of data recording, however, because external lab members can also have access to the data. In addition to each lab group having its own standard recording method, a lab management app calls for standardisation across labs and between institutions.

Idiosyncrasies of data recording that were useful in paper lab books become problematic in lab management apps.

In this situation, the common feature around which standards can be agreed is the lab management app itself. Rather than being determined by a researcher, the lab management app's default settings could become an objective benchmark against which standards are defined. Knox *et al.* (2007) discuss exactly this problem using the comparable example, mentioned earlier, of Enterprise Resource Planning systems. ERPs are based on templates that claim to represent industry best practice, and Knox *et al.* found that commercial enterprises therefore consider it "difficult, risky and expensive" to customise ERPs, with the consequence that "organisations are therefore required to reengineer their business processes in order to conform to those presupposed by this template" (Knox *et al.*, 2007: p.26). Cramer and Fuller make the more general point that interfaces, "like any language or instrument still impose and enhance particular workflows, thought modes, and modes of interaction upon or in combination with human users" (Cramer and Fuller, 2008: p.151). The ideological implication of this point is emphasised by Gillespie who points out that, by using algorithm and computational processes to standardise processes, "the perceptual or interpretative habits of some users are taken to be universal, contemporary habits are imagined to be timeless, particular computational goals are assumed to be self-evident" (Gillespie, 2014: p.174) . The design logic of LMAs demands that users across different labs and institutions undertake their research in a standardised manner. This constrains the ways in which work is likely to be carried out, as certain uses are constructed as normal and others as deviating from the standard.

Laboratory management apps frame this standardisation in terms of efficiency. No longer will lab heads waste time searching through junior lab members' lab books to work out just how they came up with a result. No longer will collaborating scientists within or between labs have to discuss the processes involved in gaining a result or share the

technical knowledge learned when no results were produced. All this information will be present within the lab management app, with no differentiation between one's own data and any other lab member's data. With these elements of human interaction made redundant, there will be more time to spend doing the research. The lab will be more efficient because more research time means that more papers can be published more quickly. A critical analysis of the logic of LMA systems demonstrates that the pursuit of efficiency, in other words, is manifested in an attempt to eradicate human interaction.

Each lab member accesses the data they need via the app, adds new data to the data pool via the app and uses the app's own system of hierarchies or metadata-tagging to inscribe relationships between data. The only structure or systemic logic that differentiates data is that of the lab management app itself. The result is that each individual lab member interacts only with the lab management app (Figure 2).

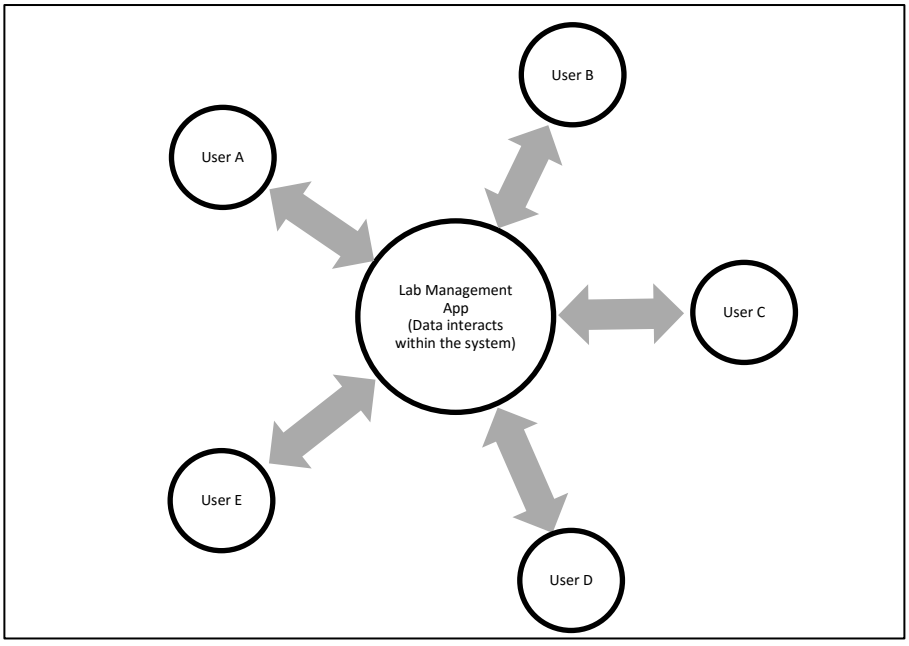

Figure 2 - Depiction of flows of information between users and the LMA

The logic of the lab management app, structured around the value of efficiency, treats human interaction as unnecessary, even harmful, for a lab's research output. The resulting

system creates what I call 'communities of data', in which users interact only insofar as they add data to the app for others to use and in turn use data from the app that others have added. This specific way that data are shared has specific consequences for the way that users are constructed as related to each other, the research project and the institution(s) involved.

Ruppert *et al.* (2013) develop Foucault's concept of the *dispositif* to account for the various aspects of digital devices more generally: material, institutional and behavioural elements that are all simultaneously in play when digital objects are used (2013: p.30). They add that "such cascades are simultaneously embedded in and shaped by social worlds, and can in turn become agents that act in and shape those worlds" (Ruppert *et al.*, 2013: p.30). Their concern with the social life of methods – which I extend to include LMA methods – is that they are not neutral 'data-gathering' processes, but agents that shape the social world that, for sociology, is the object of study. 'Communities of data' refers to the specific ways that LMAs construct social relations.

The community of data consists of exchanges of information 'between' individuals *without human interaction*. Data are only exchanged between an individual and the lab management app. One reason that I call this a 'community' is because this is the language and imagery used by the products. In contradiction to the logic that demonises human interaction, these apps are sold on the basis of improving the research community within the lab, as shown in Table 4.

Table 4. Promise of Community

Product	**Claim to improve lab community**[19]
LabGuru	Enhance Collaboration In Your Lab – Mentor Your Team and Share Ideas. Meaningfully communicate with your team - even when not in the same room - regarding

[19] Taken from product websites accessed 8th August 2013.

	specific plans, projects, and results.
Irisnote	Optimize collaboration within your team, and with others! Create dynamic groups so members can share their research work
Sciency	Improved Communications: Cross-team collaboration, discussions, and data sharing
colwiz	Connect & Build Your Network. Connect with other researchers with similar interests. Work with Others. Use secure spaces for your collaboration projects, discussions & shared materials. Organise Events. Schedule group meetings & research trips in a click of a mouse.

Laboratories consist of a number of lab members who work under an overarching research aim or narrative defined by the lab head. Each member's work is a discrete contribution to the overall research. In practice, lab members may indeed experience the app in terms of community. The use of the app within the lab may map onto the existing lab community, the practices of data recording made to fit alongside existing verbal, non-verbal, digital and analogue communications practices in the lab. Yet in terms of actual exchange of information, the only interaction is between a user and the app. The word 'community' is also used in this phrase because it encompasses the idea that interaction does take place in a certain sense. Exchange of data between users does occur, but only in a way that is totally mediated by the app, with interaction between users' data rather than between users.

In a simple example, user A (see Figure 2) might enter data referring to a negative experimental result which means that user D's experiments are questioned. Other data, perhaps from an unrelated experiment, entered by user D based on the questionable result would also be questioned. In addition this would affect user D's immediate research trajectory as they may have to repeat previous work or conduct a new range of experiments. User A's research trajectory may be affected in turn, as may those of users B, C and E. This process clearly resembles interaction between the users. In terms of everyday

experience within the lab, it will most likely be experienced as interaction between the two lab members: user A's data has affected user D's work. Yet the only interaction that actually occurs is between an individual user and the app. This idea could be clarified when we consider a system in which there is only one user. The single user's experience is exactly the same as if there were other collaborators as described above. The individual user adds data to the app, takes data from the app, and adjusts their experiments in response to this. As far as the user is concerned, the other lab members need not exist. As Ruppert *et al.* state about digital transactions more generally – they give the example of the movement of items through logistics networks – "transactional 'doers' may be people, but in and of itself this has no special significance" (Ruppert *et al.*, 2013: p.36). Once inscribed within the app, the data's origin ceases to have relevance. Its origin is obscured by the standardisation of recording. Once data has been entered, there is no difference between a user's 'own data' and data entered by anybody else. This is the basis of LabGuru's promise to "ensure knowledge continuity"[20] and prevent data being lost and research efforts wasted when a lab member leaves. Communities of data formed by LMAs are a perfect example of the fact that "data generated by digital devices allow non-individualist and non-humanist accounts of the social, where the play of fluid and dynamic transactions is the focus of attention" (Ruppert *et al.*, 2013: p.35).

The significance of the digital object is only revealed when an analysis of the cultural values imbued in lab management apps is considered in conjunction with an analysis of their technical structure. Where a cultural analysis of the discourses and values associated with the object can reveal something about ideologies that are brought into play in the use of the object, a technical analysis of the digital object's structure reveals how those values are manifested. Combining these two forms of analysis reveals a fuller and more useful

[20] LabGuru website http://www.labguru.com/features/product-overview [Accessed 3rd September 2013].

picture of the impact of specific objects on practices. The obscure and counterintuitive materiality of digital objects can discourage analysis of their structure: the user can forget that their structure affects practices as much as the values they carry. A combined analysis of the technical and cultural specificity of the lab management app as a digital object reveals that the app encourages 'efficient' everyday laboratory practices (efficiency measured by rate of publication), manifested in a substantial devaluation of human interaction. The specific impact of lab management apps is due equally to the cultural influence of the value of efficiency and to the logical or systemic influence of the technical structure of the digital object.

This analysis explains why lab management apps are different from the two categories identified by Latour and Woolgar: objects that facilitate (such as water pipes) and instruments. Where those two types of objects are differentiated by the way that they affect the production of phenomena (facilitating objects do not affect the types of phenomena produced; instruments do), lab management apps affect *how* the phenomena are produced and affect relationships between lab members. They are value-laden but theory-neutral; an altogether different type of laboratory object that does not fit within Latour and Woolgar's system of differentiation. They affect how phenomena are produced by encouraging practices that are deemed efficient, in other words practices that produce publishable results as quickly and cheaply as possible. They affect relationships within the lab by casting human interaction as inefficient and thus contrary to scientific progress. In order to capture their specific effect on lab practices, I describe LMAs as objects of 'reified practice'.

These objects are not unique in bringing cultural values to the lab. Cultural values will always exist in the lab as in any other given context. Every lab member has their own idea of what types of processes are normal, preferred or unwanted in the lab. The types of values that are most respected in any given lab are related to social hierarchies, with the most senior lab members such as lab heads having the greatest influence on this. A lab

head who believes that daily lab meetings where all members discuss on-going research are of utmost importance will confer these values onto everyday lab processes. A lab head who believes that maximising the reach of the research budget is important will confer these values onto everyday lab processes. Each lab member will respond to this environment in their own way, negotiating the requirement to fit into the research culture of the lab with their own beliefs and ability to exercise those beliefs. A new undergraduate project student present in the lab for a few weeks may be more likely to adopt the practices of the lab without question than a new postdoc who has worked in labs for several years and has the knowledge and confidence to impose their preferred values on lab practice. In this regard, lab management apps are not doing anything novel by introducing cultural values to the lab. What *is* novel, though, is the way that they fix, normalise and obscure those values. A lab member can question how and why the lab head focuses on efficiency in the lab. It is much more difficult to question how and why an app does so.

Tablets running lab management apps are not scientific instruments. But neither are they background objects that merely facilitate research. They affect scientific practice by affecting *how* phenomena are produced, though not *what types* of phenomena are produced. By manifesting cultural values in the lab, they limit scientific practice in a way that is equivalent but distinct from the limiting effect of scientific instruments. This limitation may either benefit or detract from scientific research, but its impact is obscured by the technology of lab management apps that embed cultural values within scientific processes. This effect of lab management apps is only revealed in a combined analysis of the cultural and technical aspects of the technology. The way that the cultural value of efficiency is invisibly manifested in these apps can inform our understanding of how cultural values are embodied by other digital objects in other contexts.

Conclusion. The importance of context

Tablets and apps are objects with particular material properties that constrain certain uses and encourage others. I have examined the discursive construction of tablets as laboratory objects that 'bring' efficiency to the lab, and challenged the portrayal of efficiency as a neutral value. In adopting the language of the marketing discourse as a means of critiquing that discourse, tablets have been treated in a technologically determinist way, for example in the idea that they *are* efficient. While I do believe that tablets can be involved in efficient lab practices (as will be discussed in chapter five), I do not assign agency to tablets. Following Barad, and in line with Galison's claim, stated earlier, that instruments "acquire meaning through their use within the physical laboratory" (1997: p.51), I argue that it is only in use that any cultural value such as efficiency can be manifested.

Tablets have no agency of their own. Barad's agential realism defines agency as something that emerges in intra-actions between users and objects (though her relational ontology also makes it difficult to use such terms as user and object), rather than something that is a property of a person or thing – a humanistic position that she rejects. The terms user and object are useful because these or equivalent terms are used in marketing material and by participants in the ethnographies discussed in later chapters. While these terms allow for simplicity of expression, my focus remains relational. In thinking about tablets in laboratories, I am interested in how uses of tablets at the same time implicitly draw on cultural values (in this chapter, efficiency is a particular focus), and performatively construct certain types of social relations and values. There is an ethical aspect to this approach that demands that we acknowledge and remain "accountable for the role 'we' play in the intertwined practices of knowing and becoming" (2003: p.812). To say that tablets *are* efficient is to ignore the active processes by which tablets are constructed as efficient and efficiency is constructed as neutral or obviously beneficial. Against the

abstract understanding of instruments or apparatuses as neutral devices, Barad offers this definition:

> Apparatuses are not inscription devices, scientific instruments set in place before the action happens, or machines that mediate the dialectic of resistance and accommodation. They are neither neutral probes of the natural world nor structures that deterministically impose some particular outcome. […] apparatuses are not mere static arrangements in the world, but rather apparatuses are dynamic (re)configurings of the world, specific agential practices/intra-actions/performances through which specific exclusionary boundaries are enacted. (Barad, 2003: p.816)

I began this chapter by asking whether tablets can be considered scientific instruments. Taking performativity of scientific practices seriously, the simplest answer to this is 'yes, if they are treated as such'. Of course, this answer then opens up further questions about the implications of treating tablets in this way; for example, what exclusionary boundaries are enacted in the processes of using tablets as instruments or other types of object in the lab? The following three chapters respond to these further questions by examining ethnographic research into tablets being used in labs. Each chapter examines the way that the tablet is constructed as a particular type of object – whether designated an instrument or something else – and, most importantly, the role that this construction plays in the development of scientific (and other) subjectivities within and beyond the laboratory.

Chapter 4. Perfection: The adoption of tablet computers in a large science laboratory

"You don't have to load paper before you can write on it" (Tammy, research participant)

Description of Fieldwork

The content of this chapter is drawn from fieldwork carried out between November 2011 and August 2012. Using a combination of interviews and non-participant observations, I studied the planning and implementation stages of a project that saw a large University science laboratory 'go paperless' and adopt tablet computers[21]. The project had been first mooted in Summer 2010, and was given the green light in June 2011. The paperless lab opened in September 2012, just after I finished my fieldwork.

The resulting chapter analyses the planning and implementation stages of the paperless project, answering the key research question, "why are tablet computers adopted as a paper replacement technology?" The purpose of this chapter is to examine the actual processes that take place in an organisation when a new digital technology is adopted. As I argued in the previous chapter, the definition of an object is determined by the discourses that surround it. The way that the new technology is understood by various parties within the organisation can show us what there is to be lost or gained with the change from paper to tablet computers; who will suffer or benefit from the change; and whose opinion counts.

[21] For the sake of anonymity of the participants, the University has not been named. All names of people and buildings have been changed. Job roles have also been changed to an equivalent that describes the role and level of seniority.

A possible second phase of research had been planned that would analyse the actual outcome of the project: its success or failure in practice. Unforeseen circumstances dictated that this phase could not be carried out. This second phase might have added to the rapidly-increasing body of academic research into the impact of tablet computers in higher education (Lim, 2011, McCabe, 2011, Kukulska-Hulme, 2012, Morris *et al.*, 2012, Sung and Mayer, 2012, Uluyol and Agca, 2012). As my primary concern in this thesis, however, is to understand the factors that dictate how technologies are understood, the fact that this second phase was not completed does not affect the arguments made here. What remains is a complete analysis of the planning stages of the project: the rhetoric, logic and discourses that together resulted in the decision to use tablet computers to replace paper.

The chapter traces how the affordance ambiguity of the tablet computer allowed for the object to be defined in a way that suited the preferences of members of the institution in recognised roles of power. In short, the fluid ontology of the tablet meant that it could be discursively constructed as a legitimate and suitable paper replacement. In fact, the affordance ambiguity of the tablet allowed for it to be defined as *perfect*. The way that this definition was constructed and became accepted is the focus of this chapter.

The fundamental argument here is that the way that the tablet computer is made to make sense reveals an *overarching myth of technology*. This overarching myth functions as an ordering narrative which affects how people think about the technology at hand. For Barthes, "myth is a type of speech" (Barthes and Lavers, 1993: p.109): it orders our thoughts about ideas, objects, people and so on. In this case, the myths of technology define the way that the tablet computer is understood in the Lab. In this case, the myths work to limit the ways in which tablet computers make sense: in other words, the myths work to define what a tablet computer *is*. Discussing language in semiological terms, Barthes argues that "it is very rare that it imposes at the outset a full meaning which it is impossible to distort" (Barthes and Lavers, 1993: p.132). At the outset of my fieldwork in

the Lab, the concept of 'tablet computers' was far from well-defined, making it a particularly susceptible target for myth.

By using the word 'myth', I also intend to incorporate the idea that stories can be used to mediate power in organisations (Gabriel, 2000). This is similar to the way that Bell and Dourish discuss myths as "stories that motivate and celebrate the development of the Ubicomp agenda" (Dourish and Bell, 2011: p.4): The way that tablet computers are spoken about in the Lab, the stories that circulate involving these devices, can indicate which definitions have currency, whose version of events is most prominently circulated, and how tablet computers are understood by the broader community.

The overarching myth involves a contradiction between the ideas of actual and potential in relation to technology. Specifically, the myth is that technology's inherent *potential* means that it will eventually, but inevitably, improve a situation in which technology is employed. Note 'will improve', not 'could improve'; the notion that technology will improve the situation was found repeatedly in the Lab, most often in the persistent discussion of tablet computers' potential. Tablet computers, and I will argue technology more generally, were justified in terms of what they could potentially do, rather than what they would actually do. This myth can be traced in this case study in the way that the tablet computer was defined. As a way of capturing the definition that users gave the tablets, I outline the requirements that the tablet was intended to fulfil.

In my conceptual framework myth sits underneath the broader concept of the tablet imaginary. Myth is identified in this chapter as a way to trace the tablet imaginary. Similarly, I discuss the management of failure in the following chapter as a way to develop the idea of the tablet imaginary. The tablet imaginary is constructed in the use of tablets and consists of a range of meanings, only some of which will apply in any given context. Myth as I use it here is an idea that draws on and contributes to the tablet imaginary; a specific manifestation or enactment of an idea for a situated political purpose.

Setting the Context: the reason for going paperless

The case study in this chapter is a UK University undergraduate sciences teaching lab that made a decision to 'go paperless', and began using tablet computers to replace paper in all of its teaching and learning activities. In one sense, the decision to go paperless was a simple response to a health and safety requirement. But the way in which this decision was reached, and the subsequent decision to use tablet computers, reveals much about how new digital technologies are regarded.

The Lab

This case study features the chemistry and biology undergraduate teaching laboratories of a UK University, which in 2012 moved from their existing location in one campus building where each discipline had its own dedicated lab, into a newly-renovated building in which all disciplines would work together in one large lab. As explained by Technical Manager Elsie and IT Solution Manager Ben[22], the move was made possible because an existing campus building was unexpectedly vacated by an external party, leaving a free building with the potential to develop. Although in perfect working order, the existing labs were fairly old, and Elsie explained that it was agreed from the very initial planning stages that, "over the next five years maybe something would have to be looked at" in terms of renovation of the existing labs, "and then that opportunity came on board, so it sort of sorted itself out really". So instead of renovating the existing labs in the near future, the decision was taken to move into the empty building and renovate it for the purpose of housing the labs. Rather than the existing series of separate labs which could hold around 40 students at one time, the large new lab – referred to hereafter as 'the Lab' – would house up to 200 students at once, and be 'paperless'. Before explaining a little more about the tablet computers and paperless initiative in the case study, I will describe the Lab itself.

[22] Names used throughout the chapter are pseudonyms.

Located within a large building on the university campus, the Lab is a large open-plan space containing lab benches in rows in the middle, and fume cupboards and other workspaces around the edges. Approximately 35m long by 30m wide (within a building that is a further 15m long and 5m wide in total), with high ceilings containing metallic air vents and strip lighting, the space has not quite shaken off the feeling of being like a factory floor: before its conversion to house the science laboratory, the building had in fact been operated by a car manufacturer. Adjacent to the Lab is a preparation area, containing chemical stores and space for the technicians to prepare materials for lab classes. The rest of the ground floor consists of two smaller self-contained lab spaces, a plant room, several locker areas, and a social space with tables and chairs and two vending machines. The upper level contains two more small self-contained labs, an office space for the administrative and technical staff, and various storage areas. Although only taking up roughly a quarter of the total floor space of the new building, the importance of the Lab as its primary function meant that during my time on site, the whole building was always referred to as the Lab. In this chapter, I will use 'the Lab' to refer to the laboratory itself, and 'the Lab Building' to refer to the building as a whole.

Why paperless?

Moving from existing laboratories into this newly converted building involved bringing together various disciplines that had previously been housed in individual labs, including biochemistry, chemistry and microbiology. All laboratories are subject to biocontainment precautions, designed to protect workers and the environment from potential harm arising from working with biological agents. This is controlled in the European Union by an EU directive[23], and by similar legal directives in other territories. It

[23] Council Directive (EEC) 1990/679/EEC of 26 November 1990 *on the protection of workers from risks related to exposure to biological agents and work (seventh individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC).* OJ L374, 31.12.1990, pp.1–12.

is commonly referred to as the 'biosafety level' or 'containment level' of a lab, and ranges from 1 to 4 depending on the materials being used in the lab, with 1 being the least and 4 being the most potentially hazardous.

In the case study, the microbiology lab used materials that meant it was containment level 2. None of the other labs were subject to this containment level. One requirement of containment level 2 labs is that no organic material can be allowed to leave the lab space without being treated This requirement can be met in various ways, primarily by 'autoclaving' – a process in which a range of lab materials including glassware and instruments are sterilised with steam heated to over 100°C – and by controlling the movement of materials into and out of the lab.

Previously, when each discipline was located in its own lab, this meant in practice that staff and students working in the microbiology lab were required to complete extra health and safety training, and access to the lab was limited. This was quite simple to control, as microbiology was housed in its own bespoke lab. In the Lab, however, the open-plan layout meant that the containment level 2 requirement of microbiology had to be extended to the whole shared lab space, including all the disciplines. One material requiring management is paper: its physical characteristics of being porous and light, along with its ubiquity in most people's daily lives, mean that its movement in and out of containment level 2 or above labs must be regulated. This is the rationale behind the decision for the Lab to be paperless: it is a way to meet the containment level 2 requirement. The paperless policy extends to all parts and all members of the Lab: lecturers, students, technicians and administrative staff are all required to work entirely without paper inside the lab space.

This brief outline of the Lab gives a sense of how the project originated and developed. The developments that led from 'this lab must be paperless' to 'this lab uses tablet computers' are the particular focus in this chapter. The question that runs through this analysis is, 'how is the tablet computer made to make sense in this context?' The

definition of what a tablet computer is and does in this context reveals much about our relationship to technology. Because although the tablet computer's 'official role' in the Lab is to replace paper, the way that it is spoken about by interviewees and fieldwork participants reveals that they conceive of it as much more than a paper replacement tool. It is seen as environmentally-friendly, as a marker of progress, a tool of surveillance, a storage medium, a security threat, a radically new technology, a familiar object, a comfort, a risk, and a panacea for the problems encountered in teaching in a large open plan space.

Requirements of the paper replacement technology in the Lab

The previous section explained the rationale as to why the Lab had to be paperless. Using fieldnotes and interview responses, this section gives an account of why tablet computers were chosen to replace paper in the Lab, instead of other possible paper replacement systems or technologies. The simple answer to this is that tablet computers were regarded as being the best way to replace paper. But of course this is anything but simple: the phrase 'best way to replace paper' is incredibly complex. The choice of tablet computers as a paper replacement was not simply based on tablets' usefulness as writing tools. In fact, tablets were found to be quite poor writing tools. Their presence in the Lab was based on their ability to fulfil other roles: as evidence of expense spent by the University, as symbols of 'cutting edge' research, and many other things beside. The 'best way to replace paper' in this context had little to do with the micro-level activity of reading and writing, and much to do with the macro-level activity of running, organising and marketing an academic institution.

The fundamental reason for adopting tablet computers in the Lab was to replace paper. Sellen and Harper (2002) note that organisations wishing to 'go paperless' often do not fully appreciate what function paper actually fulfils in the workplace. This ties into a more general sense in which "users are often [at] fault for expecting 'magic bullets' –

technical systems that will solve social or organizational problems" (Star and Ruhleder, 1994: p.263). Sellen and Harper argue that paper typically represents one of three different kinds of problem that organisations wishing to go paperless perceive (2002: p.25). Firstly, a symbolic problem that using paper marks you out as old-fashioned. Secondly, a cost problem particularly related to the long-term physical storage of paper records. Thirdly, an interactional problem relating to the fact that paper requires people to be present; both with the paper itself, and with anyone else working on the same thing (2002: pp.23-33). Sellen and Harper argue that the complex role of paper means that "new technologies need considerable forethought before being introduced into working life" (2002: p.19).

The gap between the representation of paper as a background tool and the reality of its complex role has a parallel in the idea of visible and invisible work (Suchman, 1995). Suchman argues that representations of work are "interpretations in the service of particular interests and purposes" (Suchman, 1995: p.58). The effect of treating paper as a simple tool – as a mediator of invisible work – may well be to devalue types of work achieved in this manner. The person who can define the work as such is in a position of power (Star and Strauss, 1999: pp.13-14). Star and Strauss give the example of "Feminist movements like the British 'Wages for Housework' [which] began a public campaign to define those activities as work – work with real economic value" (1999: p.10): a clear response to the vulnerability that can arise from having one's work badly-defined or invisible. Yet this does not mean that invisibility is necessarily an entirely vulnerable position. Invisibility can allow the person to engage in the type of unseen practices that de Certeau calls *tactics* "[which] do not obey the law of the place, for they are not defined or identified by it" (de Certeau, 1988: p.29). Suchman's 'Equivocal Reflection on Making Work Visible' (Suchman, 1995: p.60) recognises the tension between the benefits of having one's work recognised as such and the risk that opening up and defining previously

invisible work can leave the person and their work exposed to increased rationalisation and control.

In the Lab, the 'definer' was Ben, the IT solution manager and head of the paperless Lab project as a whole. Ben summarised the function that the paper replacement would fulfil as follows: "anything that students do requires a method of writing what the lecturer says, recording what they have written, and being able to access it later". This recalls Freud's Mystic Writing Pad (Freud, 1925), mentioned in the previous chapter: a medium that can repeatedly record and store information. The requirement of the paper replacement technology is to allow for writing, and storage and retrieval of that writing. This can be stated as the first requirement that the tablets must fulfil in the Lab (Table 5).

Table 5. Requirements

Requirements
Must replace paper's functions as a means of recording, storing and retrieving writing

So why were tablet computers specifically chosen to fill this role? The interviewees most often explained the role of the tablets as providing a paper replacement due to the Lab being containment level 2:

> the lab itself is a biochemistry lab so we didn't want to take porous material in there as it could get contaminated and it can't be taken out. The idea with the tablets is that they would sit in the lab at all times (Susan, IT Trainer);

> one of the aspects that has determined what we do is the health and safety aspect. And this need for the Lab to be containment level 2, and what the implications were for how we worked in there. And so in those meetings last summer, we were discussing various options […] And as part of those discussions, the use of tablet PCs was first mooted (Edward, Senior Lecturer);

> microbiology has a containment level issue which is where the tablets came in (Ben);

> So from the containment level, obviously that's where the tablet came about (Elsie).

It is clear, then, that the idea to use tablet computers was a response to a simple health and safety requirement. But the containment requirement explains why paper could not be used, not why tablet computers should be used: tablet computers were not the only paper replacement technology available. Ben the IT Solution Manager explained to me that they trialled various paper replacement options including continuing to use paper but scanning everything, using desktop PCs, using 'thin client' Citrix systems (where the internal workings of the computer are run on servers located away from the computer terminal, allowing the user to work with a physically small computer interface), and using tablet computers. Although I will return to this idea towards the end of the chapter, I would like to highlight here that these alternative solutions all involve computing technology of some kind: none are 'low tech'.

One way to get a better sense of why tablet computers were chosen is to examine the reasons these possible alternatives were rejected. This in turn reveals what the people involved in the project understood the tablet computer to *be*. Statements of other technologies' failures are a way of defining the tablet[24].

Ben summarised the scanning solution as follows:

> Put some big screens up to be able to display the content that we want to show, do everything on paper, scan it and destroy it. It would work, it's not a very good option, definitely not environmentally friendly, but it would work. So we quickly moved away from that…

Another consideration of the scanning solution was the time it would take to scan everybody's work:

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[24] In later chapters, I develop 'analysis of the management of failure' as a key method in understanding what tablets represent to users. As my time researching the Lab included the planning stages but not the implementation, I could not apply this analysis of failure to tablets in this case.

> if there were 180 students and 6 scanners dotted around the place, then at the end of the lesson, even if it only took one minute per student, that would be [half an hour]: that would simply have taken too long (Ben);
>
> there were clearly logistical difficulties – if you've got 180 students all wanting to scan, do they scan themselves, do they, do we get the technical staff to scan them? (Ben).

Thus, the paper replacement solution needed to be environmentally friendly, and not to take up too much time.

The relative environmental friendliness of paper compared to tablet computers is debatable: the problems of definition and logistics involved in comparing the whole environmental impact of the paper industry to that of the computer industry make it virtually impossible to generate any conclusive result. Jordan argues that the rapid and widespread adoption of industrially produced tablets means that the "success of the iPad *necessitates* environmental exploitation" (2015: p.149, emphasis added). On the connection between paperless technologies and increased carbon consumption, a Greenpeace report published in 2010 argues that as "cloud computing becomes more common and demands on the internet grow, major companies hosting online services are using more and more energy for their data centers" (Greenpeace, 2010). The report makes a specific connection between tablet computers, the cloud metaphor and increased energy consumption. The 'truth' of the relative level of energy consumption between paper and tablets is not a problem here, however, because in this case 'environmentally friendly' functions simply as a symbolic phrase. Throughout the fieldwork in the Lab, the only mentions of environmental issues centred around an assumption that 'going paperless' was a carbon-saving initiative. Ben had this to say:

> there's also the further impact of looking at the carbon initiative. At the moment there's a lot of focus on carbon use, carbon buildings, carbon efficiency *et cetera* and we are looking at a regeneration of this campus. So as part of that, going on this route was a good staging post.

When asked directly what was the primary motivation for losing paper, Ben had no hesitation in answering, "The university's is carbon. Saving on carbon, saving on paper", clearly equating the two. While there is no reason to doubt the University's intentions to reduce carbon, I found no evidence that the University had any plans, proofs or forecasts regarding the impact that replacing paper with tablet computers would have on carbon. Furthermore, while making an argument about the relative monetary costs of tablets and paper, Edward, a Senior Lecturer, also revealed that no study was ever undertaken, no report produced, which determined how much paper is actually used 'per student' in the University's labs.

This is why I argue that the carbon-saving properties of tablets in the context of the Lab are symbolic. Rather than actually reducing carbon, the University wished *to be seen to value carbon reduction*. This is summed up by Ben's rejection of the scanning option:

> There is also a carbon issue, as any notes would have to be recorded in the lab, then scanned, then destroyed, then probably printed off at home. That was something that we didn't really want to sell!

Note, it is not something that the University did not want to *do*: it was something the University did not want to be *seen to be doing*. Given this, the requirement needs to be changed subtly to read 'must symbolise environmental friendliness'.

Interestingly, Ben noted that "lecturers would prefer scanning, as this would not require any change in their working practices", but that it was nevertheless quickly decided that this solution was unsuitable, because it would take too long. I was surprised that Ben was effectively saying that changing lecturers' fundamental working practices was acceptable; taking too much time was not. From the scanning solution, we can infer some requirements of the paper replacement technology, and some things that it is not required to do.

Table 6 Requirements

Requirements
Must replace paper's functions as a means of recording, storing and retrieving writing
Must not take up too much time
Must symbolise environmental friendliness

Another option was to use Citrix PCs. We might note here that Ben's description of a Citrix PC solution demonstrates that he disregards or underestimates the complexity of replacing paper that Sellen and Harper identify, as outlined above (Sellen and Harper, 2002):

> So if you're using Citrix PC, as your input device, it's not that much of a change. You just remove pen and paper, and you just type everything up. Everyone's all really comfortable with that. (Ben)

The Citrix or thin client terminals were rejected on the basis of being unable to broadcast video satisfactorily. Ben said that "the Citrix system … *could* do broadcast. But it would be at its limit. And we didn't want something that was working at its maximum capacity, we wanted something that could handle what we asked of it". We can therefore add to our table:

Table 7. Requirements

Requirements
Must replace paper's functions as a means of recording, storing and retrieving writing
Must not take up too much time
Must symbolise environmental friendliness
Must be able to broadcast video without working at full capacity

Desktop computers were also considered as a paper replacement technology, but were rejected for two reasons. Firstly, another issue relating to the health and safety requirements of the lab, and secondly a consideration of the aesthetics of the lab space:

> the fans in PCs can suck in all sorts of bacteria and so on, [so with] PCs there might be containment issues. And if anything was to go wrong, we couldn't send the PCs off to be fixed because they would be contaminated (Ben)

> Also, the other part of the remit they wanted us to avoid was turning the lab space, as it is determined, into an IT facility. That was one of the big ones: it can't be an IT space (Ben)

Table 8. Requirements

Requirements
Must replace paper's functions as a means of recording, storing and retrieving writing and a means of drawing
Must not take up too much time in each lesson
Must symbolise environmental friendliness
Must be able to broadcast video without working at full capacity
Must not turn the Lab into an IT space
Must have a screen per student
Must use cloud-based storage ("Which is the direction of the future")
Must be able to fulfil the function of a lab book, which records daily activity in the lab

As 'conforming to containment level 2' was a requirement of any technology in the Lab, it has not been added to the list of requirements of paper replacement technology specifically. The necessity not to look like an IT space, however, was another requirement. Seemingly out of step with the search for a technological solution to paperlessness, this

requirement refers to a fairly subjective impression of how the technology would make the space *feel*. Adding this requirement, and others mentioned by participants, results in the Table 8.

Suitability of tablet computers

Taking each requirement of the project individually, we can see how well tablet computers fulfil these, categorising them as *suitable*, *questionable*, or *unsuitable* in each case. Doing so will allow us to judge the overall suitability of the tablet computers as paper replacement technology in the Lab. The judgement of tablets as suitable or not is based on the relative success of the tablet computers at fulfilling the requirements of this particular case study.

Firstly, '*must replace paper's functions as a means of recording, storing and retrieving writing and a means of drawing*'. The ease with which the touchscreen tablets can be used for typing is doubtless subjective, but several different people raised concerns about this. Fiona, a Senior Technician, complained that "writing on them with a stylus, I can't get on with that", and "the time it took me to write a chemical formula, switching between letters and numbers – I just gave up". Two Technicians had the following conversation showing doubt about tablets' ability to support typing:

> Yeah you can't type on them can you? (Owen)
>
> Yeah that would be my main thing on them, I'd need to be able to type. (Tammy)

It could be argued that some of these reservations result from the unfamiliarity with the technology. Tammy admits that she got used to using her mobile phone's touchscreen: "typing text messages with a touchscreen, getting more used to that maybe in the long term with iPads it might, I might get used to using touchscreens for typing more lengthy documents". It was unfeasible in the fieldwork to conduct a study into the ease of touchscreen typing and how this changed over time with increased familiarity with the

technology. Accuracy and speed of typing have been shown to be higher on physical keyboards as opposed to various types of touchscreens (Hoggan *et al.*, 2008). The size of the touchscreen keyboard has an effect on the rate of typing (Sears *et al.*, 1993). Different keyboard configurations have been suggested as ways to improve comfort or accuracy of touchscreen typing (Trudeau *et al.*, 2013). Regardless of research into the efficacy and speed of touchscreen typing, the fact remained that, anecdotally, members of the Lab had serious doubts whether touchscreen typing could ever be a satisfactory method of data entry.

The issue of drawing using tablets was also raised, with Neil, a Laboratory Demonstrator, telling me during an observation that using tablets "ruins students' futures". His concern was that he already comes across students who can only draw graphs using computer software, not by hand. And it was not only graphs: Neil said that many final year undergraduates "can't use pipettes", implying that these students are wrongly being taught more advanced techniques without being competent doing 'the basics'.

During a lab test of the tablets in the 'old labs', one student complained that reading the protocol on the tablets was fine, but that she likes to tick things off once they're done. On a paper protocol this is simple, but on the tablets it is tricky. Although the student had tried typing 'done' on the document in lieu of a tick, this altered the layout of the protocol and made it difficult to read. This seemingly simple stage in the student's preferred lab practices may be surprisingly important for her learning. Hoffmann (2013: p.299) argues that writing "may not be reduced to its archival function alone": writing can be a procedure for thinking and can function in science as a 'non-material research device'. The inability to tick off parts of the protocol is one instance of tablet computers failing to replace the full functionality of paper.

All in all, tablet computers are an *unsuitable* paper replacement in this regard. Although they could replicate paper's functions, this could only be done by radically changing the process. While providing a means of recording, storing and retrieving writing, the tablets

required users to learn completely new processes. This was not a way of 'writing' or 'reading' that anybody would recognise as such.

Despite tablets' unsuitability for this task, there was little concern amongst participants that tablets could replace paper. The difficulties experienced in the lab tests were put down to the fact that these were trials: it was simply a question of finding the right app to replicate the process of writing with pen and paper. Members of the Lab showed an endless faith in the *potential* of the technology. With the requirement of replacing paper's function of writing, storing and retrieving data, the tablets were always seen as capable: the problem was working out how to make use of this capability. How did tablets remain a going concern despite all the evidence that their use would require changes in the processes of reading and writing? The answer lies in the bureaucratic process involved in the running of the Lab. Tablets were initially signed off as a paper replacement:

> using the tablet as a book was the first one. So purely as a notebook. You can either get content and read stuff on it, or you can write. Very plain and simple. We decided yes it would do that. So when it was originally signed off to go the tablet route, it was signed off on that premise (Ben)

This rationale had clearly been accepted by the members of the Lab that I spoke to. When asked what tablets were for, participants always gave simple answers:

> when it was first signed off it was signed off as a notebook realistically, nothing more (Ben);
>
> the tablet PCs are primarily a paper replacement (Edward);
>
> the tablet is the solution to the paper-free problem of the Lab (Owen).

Once the idea that tablet computers will replace paper has been fixed in the bureaucratic process, their suitability for this task ceases to be questioned. In fact, it ceases to be questionable.

If we analyse Ben's account of the 'signing off' process more closely, the hierarchy of power in the university as an institution comes into play. The interplay of authority and expertise was interesting in this instance. Ben and the IT Solution team decided that the tablets could replace paper, with Ben freely admitting that this was his personal preference. Given this assurance, the academic staff agreed to the use of tablet computers. On this basis, the administrative hierarchy signed off the tablets as a paper replacement technology. In this process, Ben's original decision is ratified by the academic community, who defer to his expertise. Yet it is not Ben's decision to make, so it is upon the academic staff's authority that the University 'sign off' the tablets. The academics defer to Ben's expertise, thinking it must be a good solution if the IT manager recommends it. The University defer to the academics' expertise, thinking it must be a good solution if the academic staff support it. And everybody involved defers to the University's authority, thinking it must be a good solution if it has gone through due process and been signed off. There is a triple system of justification to which every party has given their authority on the basis of somebody else's expertise. The whole process makes the concept of tablets as a good paper replacement unquestionable. The myth that tablets can replace paper without changing the processes of reading and writing – that must at least require some justification – goes unexamined.

The second requirement identified was that the paper replacement '*must not take up too much time*'. As a paper replacement, the tablet computers would work in the following way[25]. The lab protocol (the instructions from the lecturer to the students on how to complete that session's lab work or experiment) is uploaded onto the Virtual Learning Environment (VLE) by the lecturer 24 hours before the lab session. The students enter the Lab, find a free bench space, turn on the tablet and download the protocol from the VLE. During the

[25] This is taken from a teaching delivery flow chart produced by Ben. I was free to view and discuss the flow chart but not to reproduce it.

lab session, the students use the touchscreen keyboard on the tablets to make notes in Evernote, a commercial note-taking software that records and stores notes using cloud storage. At the end of the lab session, if students' notes are to be marked, then they upload their notes to the VLE. Compared to the paper system in place in the old labs, this takes more time. Simply having to turn on, log in and download the protocol introduces at least a minute or two extra compared to paper: as one technician Tammy put it, "there's no loading of the paper before you can write on it". In one of the lab testing sessions when students were given tablets to use in the 'old' laboratory (i.e. before moving to the Lab), several students were observed to complain that they don't have time to email work to themselves during a class.

Tablets are *unsuitable* for the requirement of 'not taking up too much time in each lesson'. In which case, why were tablet computers chosen as a paper replacement tool? The answer is that the Lab was always envisaged as a high-tech space, and the management were happy to go through a difficult teething stage in order to accommodate the technology. Elsie, the Technical Staff Manager, was keen to stress that the Lab would be high-tech: in an interview she interjected to add the phrases "pushing boundaries" and "at the forefront", and described the Lab as cutting edge and progressive.

There was a necessary adjunct to phrases such as 'cutting edge' and 'at the forefront'. It would be no good introducing radical new technologies that nobody could use. The idea that people would 'get used to the technology' was a very common theme amongst those involved in the Lab:

> "I like to tick things off once they're done … but I suppose it's just getting used to it. (Undergraduate student, comment during lab test);
>
> other staff involved, the demonstrators and stuff, they didn't appear to find any problems once they'd got used to it (Edward);
>
> "I think it's just a matter of time getting used to them (Sam, Lecturer);

> It's an extra strain on students to get used to using it. (John, Support Librarian).

The adoption of new technologies relies on the idea that people 'will get used to it'. This allows the transfer from existing to new technology to go ahead smoothly. Anybody who objects to the new technology can be dismissed with the phrase 'you just need to get used to it'. And more than this, the difficulties associated with getting used to the technology can be offset by the promise of the technology's extra potential. The implication here is that getting used to technology is not a matter of training or practice. It occurs simply by exposure, by owning or using the technology. In the Lab, this was manifested in the fact that all members of staff were offered a tablet to 'just have a play with', as the phrase went.

> And as regards to myself, because I'd had one to play with both last year for a while and then again from December I've had this one – so I've got more familiar with them (Edward).

Playing with the tablets was seen to be a way to get used to them. Why play? There are two primary reasons, both related to the infantile connotations of the word. Firstly, the idea that you can get used to a technology just by playing with it undermines anybody who claims they find it difficult to use the technology. It's child's play. Secondly, calling it 'play' encourages an informal self-training that comes at zero cost to the University. Telling staff to 'just have a play with it' gives the impression that it's something of a treat, an enjoyable task. Using Android devices, the participants would have been able to find and purchase 'productivity' apps on the Play store, Google's online app shop. The rise of 'playbour' practices (Kücklich, 2005, Goggin, 2011) contributes to the conflation of work and leisure, expressed in a form of consumption in which skills useful for work are 'gamified' and consumed as leisure activities. Whether or not the person does find this playbour enjoyable, from the University's perspective this involves huge savings in staff training.

Another requirement of the paper replacement technology was that it should symbolise the University's commitment to be environmentally friendly. In the promotional material for the Lab (which I cannot cite directly here due to anonymity), the idea of paperlessness and carbon saving have equal billing with the idea of the Lab being a high-tech learning environment. The use of paperless technology is described as part of a carbon reduction policy. While the University does have a flagship carbon initiative, Ben revealed that "[Our carbon initiative] was launched after the Lab came about, but before we started considering these solutions". So although any carbon savings in the Lab could be usefully promoted under a grander carbon initiative, they could not be said to be a planned intention of such an initiative: remember that the Lab was necessarily going to be paperless, regardless of carbon considerations. Although it could be accused of being disingenuous to do so, the University can certainly point to its paperless Lab as evidence of its commitment to carbon reduction. As a result, I would argue that the tablet computers succeed in giving the impression of environmental awareness, and are therefore *suitable*.

Citrix terminals were rejected because they were unable to fulfil the requirement of broadcasting video *without working at full capacity*. The task of using tablet computers to broadcast video was the biggest technical problem faced by Ben the IT Solution Manager. The tablets proved to be unsuitable for this. But an interesting issue is raised when we examine the reasons that the tablets were unsuitable: *the reliance on external factors*. The tablet computers themselves are able to broadcast and stream (i.e. send and receive) live video via the Internet. This is perfectly within their capabilities, and indeed Internet video streaming apps such as iPlayer and YouTube are often featured in advertisements for tablet computers. Yet when it came to implementing this in the Lab, several problems were encountered. Ben explained that their experiments with online video broadcasting services failed because of audio and video synchronisation issues: "the quality was full. […] There

was, however, approximately a two- to four-second delay if you pumped all your audio out at the same time through the same stream".

Ben described this tablet-to-tablet video broadcasting system "a good concept but bad solution". He explained that they then spoke to a number of suppliers, including Cisco, HP, Apple, and Samsung to try to get technical support for a tablet-to-tablet video broadcasting system:

> We went to people like Cisco, who couldn't underwrite us on the tablet solution, because it's never been done in the world. It's a world-first, so they wouldn't underwrite us as a teaching method. […]Because the big thing everyone was worried about was the quantity of devices. You can happily stream, and stream reliably, to 10 devices. To 20 devices. Even 30 most probably. The problem is, up to 200 at the same time, all in sync, with an audio solution, gets a bit more complicated.

Although there is nothing about the tablets themselves that makes them incapable of this kind of video streaming, the problem comes in the amount of third-party support that is required. Firstly, as with any IT service, this would require reliable and high-quality IT infrastructure within the University if it were to run successfully (Alsabawy *et al.*, 2013). This particular service would also need to be supported by a reliable external company who would provide the software and, crucially, take responsibility if it failed. This third-party support, necessary for the video broadcasting function, was never found. Although one tablet could broadcast video without working at full capacity, 200 tablets could not. As this was the actual requirement, tablets were *unsuitable* for this.

The next requirement that the tablets had to fulfil as a paper replacement technology was not to turn the Lab into an IT space. This is important when considering the influence that the setting has on teaching and learning. Roth and Hsu (2014) argue that science laboratories should be designed as "smart spaces" which enable participation. Blatt comments "the setting [of science learning] itself can be viewed as *active*, an active participant, in fact, in contributing to the action that occurs in that setting" (Blatt, 2014:

p.124). Keeping a 'scientific' aesthetic would therefore be beneficial to the teaching and learning planned for the Lab. According to Ben:

> The other part of the remit they wanted us to avoid was turning the lab space, as it is determined, into an IT facility. That was one of the big ones: it can't be an IT space – that was one of the big things [another University] did badly. […] they've got beautiful benches, but then they've got half the benches taken up with a PC cluster, where you've got full PCs, full mice, full keyboards, nice big monitors on there. Really good if it was an IT suite, but as a lab it's awful, because the actual amount of space you've got to do the lab work is very small.

Partly this relates to a practical concern about how much space the technology would take up on the bench. This concern was expressed by researchers in a case study from 1994:

> When asked whether, in a future system, it would be desirable to replace lab notebooks with small palmtops or digitized pads, most researchers were dubious. Respondents at one cramped lab in an urban high-rise, simply noted that there was no place to put another computer — they did not even have space for all the necessary lab equipment. (Star and Ruhleder, 1994: p.256)

But more than a practical consideration, Ben's concern also relates to the 'feel' of the Lab. There is an interesting juxtaposition of requirements here, with technology regarded as the best means of achieving paperlessness, but also being seen as undesirable aesthetically. Even though it is evidently a science laboratory, the idea that the technology could take away from the 'sciencey' feel of the Lab was clearly a concern for Ben, who mentioned some of the technology installation:

> it's not what we'd class as the right kind of cable management for the visually [sic] aesthetics. Because it's obviously going to be a very clean lab, we want it to look the part. So if that means tidying away cables into white sleeves or whatever, fine, we'll pay the bit extra to have that done to give the right impression to fall alongside with the lab environment

Although to some extent this is a subjective matter, I consider the tablets to be successful in this regard. The fact that they are mobile, battery-operated, wireless devices means that there are no wires or cables on the lab benches, nothing is plugged in, and there

are no monitors, keyboards or mice on the benches. In addition, the fact that the tablets are handed out and taken back in at the start and end of each lab session has the symbolic effect of making the technology feel subordinate to the lab space itself. The feeling is that the Lab is first and foremost a science lab, with the technology being a useful but not essential add-on.

Although I consider the tablets to be *suitable* in terms of not making the Lab feel like an IT space, there was another technology introduced in the Lab, which did make it feel unlike a science space. Due to the size of the room, the fact that the technicians would be in a separate room, the number of students in the room, and the fact that there may be several different classes running at once, it was decided that for both practical and health and safety reasons, everybody in the Lab would use an audio headset to communicate. Lecturers and demonstrators have microphones and earpieces to broadcast and receive audio; students only have earpieces so they can hear instructions but not communicate back. Against the potential for interactivity offered by computing technologies, the tablets in this instance seem to resurrect the rote learning practices associated with nineteenth century writing slates. Whilst not necessarily like an IT suite, the presence of headsets means the Lab does feel different from other lab spaces: one lecturer worried that it would feel like a call centre. My own interpretation is that the headsets are in fact far more intrusive than a computer monitor on a lab bench would be, and the AV system does make the lab feel more like an IT space than it would otherwise.

The next two requirements were that the paper replacement technology in the Lab needed to provide one screen per student, and needed to use cloud-based storage. Evidently, the tablets are *suitable* in both cases. The idea of providing 'one screen per student' also raised an interesting question on the simultaneously personal and impersonal nature of the tablets.

On one hand, tablets are impersonal devices: they were handed to students at random at the start of each class and did not belong to any individual. On the other hand, students were required to sign in and work with their personal data. This leads to a rather self-evident summary: every device is impersonal except the one you are using at the time. In terms of the Lab*,* this allows the users to work with a handheld, portable, personal device *all the time they are signed in*, and allows any sense of that person to be erased from the device as soon as they sign out. The tablets are therefore at once personal and impersonal. It might be added here that this has a significant financial advantage, as the University only have to purchase the 200 tablets for one full class, rather than the 1000 it might take to provide every student in every cohort with one.

The final requirement that the tablet computers had to fulfil if they were to successfully replace paper was the ability to replicate the function of a lab book. A lab book is essentially a daily diary used to record the work in the lab. The lab book is used as standard across scientific disciplines in both academia and industry to keep a precise record of the activities taking place in the lab on a daily basis. This record serves two functions: scientifically, it acts as a record of past experiments which can be referenced in future; bureaucratically, it acts as a record of lab activities including what was done and who did it, so that responsibility can be apportioned if litigation, health and safety or any other such problems arise. The importance of the lab book depends on the institution, for instance in industry it functions more often as a legal record of scientific work that is used to defend intellectual property, whereas in academia it might be more commonly used to record and recall previous work. Some academic publications have started to include scanned copies of the paper lab book as supplementary information, (for example Lang and Botstein, 2011). In the Lab, keeping a good lab book is treated as an essential part of learning to be a good scientist. Partly this is regarded as "best practice" (Ben), and partly it is a skill that students

will realistically go on to use if they enter industry (Edward). All in all, the ability to keep a lab book is crucial to the running of the Lab.

To what extent can a tablet computer be a lab book? For the purposes of this discussion, I will disregard the questions raised earlier about the convenience of writing using tablets, and focus on the ability of tablets to fulfil the function of a lab book. Edward raised some immediate concerns regarding the difference between paper and tablets:

> [A paper lab book] kind of self-organises because you start on page one, and then page two and page three, page four. With electronic information like this, there is a potential for having a whole set of bits which are not necessarily in the right order

As well as representing an organisational problem, the difference between an electronic form of note storage and a paper-based form has significant implications for the validity of the data. As Edward continues:

> The one advantage of the lab book as a piece of paper, paper-based, is that I as a member of staff can go back if need be and look through what they've done. Electronic has the potential for – I'm trying to think of the best way of putting this – manipulation. I mean obviously with paper, people can rip pages out, but then you can see that they've ripped a page out

One means by which the physical properties of paper are incorporated in the use of lab books is that nothing is allowed to be erased. As Ben explained: "If you cross something out, you put a cross through it, clearly, sign it and say why you crossed it out". Lecturers would therefore be required to check the electronic lab books for alterations. This requirement of surveillance did not apply to paper lab books, where checking for alterations was an inherent part of reading the student's work: part of the normal process of teaching.

Overall, the tablet computer is an *unsuitable* means of replicating the function of the lab book. The paper system forces a particular order upon the lab book, which follows the passage of time and ensures that the entries in the lab book imitate the chronology of the

lab work itself. This is not present in the tablet computer, which *allows* sorting by time and date, but also allows several other means of sorting. More importantly, the tablet computer affects the lecturer's role and demands an active process of surveillance.

Table 9. Requirements and Suitability

Requirements	**Suitability of tablet computers**
Must replace paper's functions as a means of recording, storing and retrieving writing	Unsuitable
Must not take up too much time in each lesson	Questionable
Must symbolise environmental friendliness	Suitable
Must be able to broadcast video without working at full capacity	Unsuitable
Must not turn the Lab into an IT space	Suitable
Must have a screen per student	Suitable
Must use cloud-based storage	Suitable
Must fulfil the function of a lab book, which records daily activity in the lab	Unsuitable

Why were tablets adopted if they were unsuitable?

The table (Table 9) that results from this discussion of requirements demands some further analysis. How and why were tablet computers adopted in the Lab when as a paper replacement technology they are suitable only for four of eight tasks, and in fact unsuitable for three tasks? Considering the extent to which tablets are flawed as a paper replacement, how are they justified? How can it make sense for the University to purchase around 250 tablet computers, the same number of AV headsets, several projectors, screens and high-definition visualisers, and myriad supporting technologies such as Wi-Fi, which ultimately combine into a distinctly imperfect replacement for paper?

Why did the Lab adopt tablets even though they were unsuitable? The answer is twofold. Firstly, a combination of the institutional politics of the University and people's personal and professional investment in the Lab meant that there was really no choice but to make the tablets make sense. Secondly, the way that this was achieved involved an overarching myth concerning tablets and digital technology more generally: Digital technology can be justified by its potential. Taken to its logical extreme, this myth helps to construct a technoscientific imaginary in which tablets are treated as perfect. In the remainder of this chapter I will analyse these two aspects that explain how and why tablet computers were made to make sense as a paper replacement technology.

Institutional Politics

Most institutions are organised around a hierarchical structure of roles and offices (Grint, 1998), as is the case for academic and industrial science laboratories. The organisational structure of the University in this case meant that the final say on matters pertaining to the Lab fell to the Campus Regeneration Board, headed by the Dean of the School of Science and Technology. While the requirements of the project from the point of view of those who would be working in the Lab have been discussed at length, it must be recognised that the requirements of the project from the perspective of the Campus Regeneration Board may be different. It is important to look to functions other than 'a paper replacement technology' that tablet computers fulfil in the Lab.

The Lab was conceived of as part of a larger campus redevelopment programme that was already taking place when an external party, a car manufacturer, left the original building. Importantly, it was decided that the space would become the Lab before it was even decided what such a lab would really be. Although reluctant to be drawn on the details, it is clear from interviews with Ben and Elsie that the idea for the building to become the Lab was chosen amongst competition from other schools and departments of

the University, each vying for the prestige of having a bespoke building dedicated to their work and research. From Ben's account, it was the science aspect that won out:

> From that it opened a new opportunity of what to do with the building – do we invite someone else on? Do we do something else with it? Sciences in general are a developing area of academic interest, so it's a good area for use to invest resources and money into.

The following quote from technician Owen reveals both the perceived status gained by moving to the Lab and the somewhat controversial debate surrounding the decision to turn the building into a biosciences laboratory rather than put it to another use (note that sports sciences had labs alongside biosciences in the old building but did not move to the Lab):

> I know the sports technician, he said it would have been better to move just sport over to the Lab. Because it's a large area and the way that sport teaches, they just need large areas with things like running machines and different large equipment that they could house in there, so they said it would be better suited to them. It would be cheaper to fit out. But you don't know if that's a bit of sour grapes that they're not getting [it] […] maybe this building is not as pretty as the [new] building that we're going to. So I think maybe sport are a bit sour about not going.

Although the sports science technician's envy of the 'pretty' new building seems rather superficial, it was in fact hugely important to the University that the Lab should be aesthetically impressive. Specifically, the building's appearance in terms of both its architecture and its internal fittings had to function as a marker of expense spent:

> obviously it's nice for the students to see the University's putting into its infrastructure (Elsie);

> I guess it's being built because the Vice Chancellor had a great vision of an amazing new Lab full of happy students all paying thirty thousand pounds a year or whatever it is [note: heavily sarcastic] (Owen);

> last Summer we were discussing what we could provide for the students to offset for the fact that they're going to be paying large fees from this coming October (Edward).

As an institution, perhaps the University required the Lab project as a whole to represent investment in infrastructure and resources which would justify the increase in fees from £3465 per year for full-time UK or EU students to £8500. Support Librarian John offered this opinion on the purpose of the tablet computers in the Lab (taken from my interview notes):

> The university wants to please the students so they fill in the Student Survey; it is for the perceived wants of the students, not for any actual 'good reason'.

This differs from, and in a sense shortcuts and simplifies, Veblen's (1994) notion of conspicuous consumption. The obvious spending on technology and architecture in the Lab, rather than a display of power or status, may be read simply as a display of expense spent. What for Veblen was a spectacular display of the exotic and unknowable wealth of the *nouveau riche*, in the Lab is a more or less literal translation of the students' own fees into tangible objects, with the increased impressiveness of the Lab acting as an analogue for the increased fees charged.

There are clear parallels here too with Adorno and Horkheimer's argument that, for products of the culture industry: "The universal criterion of merit is the amount of 'conspicuous production' of blatant cash investment. The varying budgets in the culture industry do not bear the slightest relation to factual values, to the meaning of the products themselves" (Adorno and Horkheimer, 1999: p.34). Their pejorative sense would be shared by John the Support Librarian but presumably not by Edward, who simply thought it 'nice' that students could see this direct investment.

This goes some way to explaining the justification of tablet computers as a paper replacement in the Lab, and answers an earlier question about the absence of any 'low-tech' solutions. The containment issue could have been solved, for example, with this low-tech solution: use paper lab books that are kept in the Lab at all times. Remember, the containment requirement is exactly that: it is in place to keep potentially harmful

substances *contained* within a laboratory. The existing microbiology labs worked in this way. While this would have solved the containment issue, this would not have been suitable for the institutional politics which required, bluntly, an *expensive* paper replacement.

The operation of institutional politics partly explains how and why tablets made sense as paper replacements despite being unsuitable or questionable in various ways. Yet institutional politics affect decisions in any large building project. The importance of displaying expenditure to justify an increase in tuition fees is admittedly particular to the Lab because of its place within a University. The premise that tablets are a suitable paper replacement was provided by key members of the University hierarchy and then enacted as seemingly common sense notion by other members. This partly explains why participants were motivated to justify the tablets in this way, rather than rejecting them or the project of the Lab as a whole. This case clearly contradicts the microphysics laboratory context discussed by Galison (1997), who argues that "broader institutions do not determine the bench-top environment of physicists' laboratory life" (p.3). In the Lab, the broader university institution did directly affect the material culture of the lab.

But the influence of institutional politics is not enough alone to explain how and why tablets were justified as a paper replacement in the Lab. In addition to the institutional politics, participants were engaging with a technoscientific imaginary that focused on the *potential* of tablets rather than their *actual* suitability.

Digital Technology as Justifiable by its Potential

Throughout this case study, tablets were not being judged by what they did but by what they could potentially do. Taking this more broadly, I call the idea that "digital technology is justifiable by its potential" an *overarching myth of technology*. This overarching myth explains why, in the face of a set of requirements for which tablet computers are significantly ill-suited, they can be regarded as perfectly suitable. The 'trick' to making tablet

computers make sense in the Lab was to judge them not by what they can do, but what they could do.

One example of the promise of potential being used to justify the tablet computers relates to their ability to use a split display, or have two apps running side-by-side. In a planning meeting with Kevin the Head of IT Services and eleven members of technical and academic staff from the various disciplines that would be moving to the Lab, the idea of tablets being able to display two apps side-by-side was discussed. At this stage, it had been decided that tablets would be used, but the choice of brand had not been finalised: a choice between the Apple iPad or the Samsung Galaxy Tablet.

Lecturers discussing the requirements of the tablets and the perceived relative advantages of each brand focused on the ability to have more than one app displayed on the screen at the same time. This would typically be one app used to display the lab's protocol and a separate app to take and record notes. This function is not supported by either the Samsung or Apple tablet computer, but the lecturers and technicians clearly expected it to be so. One lecturer said in a meeting that he assumed Ben the IT Solution Manager was 'on his way to resolving the two screen problem'. The tablets' inability to have two apps open was clearly stated by Ben in a telephone interview one month before this meeting, when he told me, 'what neither [Apple's nor Samsung's operating system] can do is open two apps side-by-side on the screen'. Yet the frequency with which I encountered the idea that the tablets could *potentially* run two apps side-by-side throughout my fieldwork at the Lab made it clear that this idea was being circulated somehow. I strongly believe that Ben (whom I described earlier as 'the definer') was the source of this idea: firstly because his position as IT Solution Manager made him the 'expert' in terms of what the tablets could do, and thus more able than anybody else to influence the definition of a tablet computer that would circulate in the Lab; and secondly because he mentioned it to me more than once. In an observation of a laboratory trial of the tablets just one week

before the meeting mentioned above, Ben told me that a developer version of the Android operating system (used on the Samsung tablets) was available that could split the screen and thereby display two apps side-by-side. A developer version is a version not for general public release, which is shared amongst members of online communities with the tacit expectation that they can use the new operating system if they also reprogram any bugs that they find. In other words, it is in development, and as Ben pointed out 'not 100% stable'.

Although the idea that the tablets could show apps side-by-side never materialised and thus eventually ceased to inform the definition of a tablet computer in the Lab, this idea still had agency during the period in which the academic staff were discussing the changes in their working practices that would be required when moving to the Lab. I am not arguing that Ben or anybody else was being deceitful or consciously misleading in suggesting that the tablets had this potential. In fact, Ben is careful at various points to make a clear distinction between what tablets could potentially do in the Lab, and their actual function:

> So yes we've got potential to long-term develop onto stuff like [new apps] , but we shouldn't… Well… I believe we shouldn't be looking at that from the beginning. Because in the beginning, we're looking to replace pen and paper.

My fundamental argument in this chapter is that this *overarching myth of technology* affects how digital technologies are understood and defined. There is a slippage in the definition such that the potential of the technology informs how we understand the reality. In other words, it is not 'mistaken' or 'misleading' to include some idea of what a digital technology potentially could do in how we understand what it actually does. Quite simply, the potential of the device, whether realisable or not, informs how we understand the device.

This is not a particular quirk of how tablets were treated in the Lab: this slippage between potential and actual pertains to a technoscientific imaginary that is more generally

widespread. I discussed this in chapter two, drawing on Ellul (1964), Marcuse (1982) and others to argue that this split follows a split inherent to our understanding of technology as having both a general and a specific sense. Specific technologies (or uses of technologies) express a general technological rationality. The slippage occurs between an imagined potential world of technological perfection and the actual devices that represent this imaginary: in this case, tablet computers. While the actual tablets were unsuitable paper replacements, the tablets *fulfilling their imagined potential* were perfectly suitable.

The *overarching myth* was first identified in an early laboratory observation, around 3 months into the 11 month fieldwork time frame. A demonstrator asked Ben how data can be uploaded to the tablets if they do not have a USB socket. The tone of Ben's reply, that an adaptor can be purchased that will allow you to connect USB devices, implied a distinct sense of triumph: that the USB question was solved. Yet Ben's very next sentence was, 'Now, we haven't looked at that for the Lab, because obviously if you take the USB stick, you can't take it out'. So although it is possible in theory to use a USB adaptor, in practice in the Lab this would be impossible or at the very least hugely impractical. My fieldnotes at the time include the comment:

> I think Ben's discourse implies that the tabs are a fix-all solution. But he is careful to note that what he is actually doing right now is replacing pen and paper. I think this division between expectations of the University and what Ben is providing is being driven by the misleading way in which Ben mixes 'potential' of the tablets with what he can actually provide in the lab. (Fieldnotes)

The reader may object that this fieldwork covers the planning stage of the Lab and therefore we should expect the potential of the tablets to be tested against real world conditions. But it is crucial to note that what I describe as the slippage between potential and actual in the way that the tablets are understood is not a stage in a process in which we go from an uninformed 'potential' understanding to an informed 'actual' understanding. The slippage is permanent. This is demonstrated in another example of the technology

being justified by its potential: the video streaming requirement discussed earlier. The idea that the tablets could be used to stream video was an essential requirement in the Lab. In an interview one month before the Lab was due to open, I asked Ben whether it was still on the cards to use the tablets to broadcast and receive audio and video:

> Still is. It still is. But no network provider in the world would underwrite it. Because we'd be the first in the world. So we're now testing it. Actually as of yesterday, we were doing a YouTube test yesterday. Which failed. But we think that's a limitation of YouTube. […] But because nobody would underwrite it, we needed a fall-back. So the fall-back is: everything will be produced in advance and be uploaded onto [our] virtual learning environment.

Despite the continued currency of the idea that the tablets could potentially broadcast and stream live video, the actual solution had no live video element at all. In this case, Ben has not accepted that this potential is unachievable in practice. The tablet is still defined here as a device that *could* broadcast and stream live video. Its potential continues to inform its actuality.

In the case of the Lab overall, I would argue that the slippage between potential and actual in the definition of digital technologies explains the choice of tablet computers as paper replacements. Tablets were suitable for the potential applications that Ben envisaged, but not suitable for the actual function they were originally intended to support. Although there were several instances of tablets having potential that differed in practice from what they could actually deliver, Ben describes one quite broad application that sums up the way in which digital technologies can be justified by their potential:

> The thing in the back of my mind was always the potential for you to be able to collaborate over distance with different institutions or different individuals. My theory came about because, [we previously] ran a system using Live Meeting which is a video conferencing tool. And we did a flexi Masters programme with a number of people out in the NHS. All over the country. […] we used Live Meeting to broadcast out to them and have discussion with them, for them to do presentations to us, and to manage that relationship. Following on from that, if you put that into the lab context that we're now in, if you think a bit bigger on that, you can be teaching 200 people in this lab, and if everything was cloud-based, you could then be teaching another 10,000 people if you really wanted to,

> at remote locations or remote institutions. All at the same time. You can hear your instructions. If they have the appropriate instrumentation and stuff, which they would have if they were at a different university, or if they were a medical establishment – if they were at home, they might have to get all the stuff themselves, but I'm sure they can do that for the majority of stuff. But the audio can be piped out over the Net, content's on-demand. It is possible.

I can only speculate on the extent to which Ben's vision influenced the University's decision to use tablet computers in the Lab, but the idea of using digital technologies to provide virtual courses is appealing to any education institution that wishes to reduce costs. In a damning account of 'educational corporatism', Spring argues that the savings achieved by delivering online courses are counterbalanced by a reduction in the quality of instruction (Spring, 2012: p.2). While this argument must be judged on a case-by-case basis, Spring associates online courses with a broader trend of educational profiteering, citing examples of 'branch campuses': for-profit franchises of public Universities set up overseas (Spring, 2012: chapter two). The attraction of this educational corporatism is undeniable in the context of the Lab*,* when the state of the national economy means the University is facing huge budget cuts and simultaneous uncertainty about student intake after a 150% increase in tuition fees. If tablet computers, and the move towards online teaching methods that they represent, have the potential to usher in profitable teaching services like the one outlined by Ben, then the importance of their ability to work as an actual paper replacement may be diminished in the eyes of the University's.

A final illustration of this myth comes from a comment in which Ben relates the adoption of technology with a broadly defined sense of progress:

> Speaking to a lot of the people in industry […] they've been saying that our students when they come will be able to help them as an industry move forward and adopt these practices which should have been adopted already, which haven't been because the people they have are extremely good at their discipline, but aren't really good at embracing new technology and change. So this will bring about that ability to adapt correctly.

Ben's curious phrase 'adapt correctly' is an example of what Feenberg describes as the "dominant view of modernization [which] is based on the deterministic assumption that technology has its own autonomous logic of development. According to this view, technology is an invariant element that, once introduced, bends the recipient social system to its imperatives" (2002: p.138).

This teleological understanding of technological development requires a concomitant understanding of technology as 'potentialful'. This rather ugly neologism is an attempt to capture the sense that the potential that is attributed to digital technology is not regarded as possible, but as inevitable. That the physical devices of digital technology somehow hold, contain or imbue a potentiality that, when the devices are used, will automatically spring forth and become actual. This understanding is summed up by Ben's answer to the question, 'what is your primary motivation for losing paper?': "Mine is adapting technology. The more people that use it, the more technology will move forward". This potentiality of technology is a fundamental characteristic of what we understand technology *to be*.

We can now return to the *overarching myth of technology*, which stated that "digital technology can be justified by its potential". For this myth to operate, there are two simultaneous requirements that must be fulfilled: firstly, the general and commonplace understanding of technology as 'potentialful'; secondly, a local and context-specific will or desire to focus on the potentiality of a particular technology. In the Lab, the former is a commonplace understanding of technological development (Feenberg's 'dominant view'); the latter was manifested as an acceptance of the necessity to go through a difficult 'teething stage' (i.e. the technology's *actual*) in order to reach a hoped-for advanced stage (i.e. the technology's *potential*).

At this stage we can finally return to the definition of myth:

> Myth does not deny things, on the contrary, its function is to talk about them; simply, it purifies them, it makes them innocent, it gives them a natural and

> eternal justification, it gives them a clarity which is not that of an explanation but that of a statement of fact. (Barthes and Lavers, 1993: p.143)

In the Lab, tablet computers are a paper replacement technology. That is a statement of fact. The myth of technology works to remove the ambiguity, the problems, the questions and the debate from the way that tablet computers are understood. Ultimately, the myth helps users to clearly define exactly what a tablet computer *is*.

Chapter 5. Management of Failure: Getting tablets to work in a chemistry department

"I've already got a real inkling that this is going to be… The way forward" (Nathan, research participant)

Description of Fieldwork

Between August 2013 and February 2014, I conducted ethnographic research in a lab with two members of the chemistry department at a university in the South of England. Tom is a Teaching Fellow and Nathan is a technician. The research involved regular visits to the lab for observations and informal discussions, seven extended interviews and the exchange of around 50 emails. Tom, Nathan and the technical services manager Ursula, Nathan's line manager, each responded individually to an email I had sent to all science departments at the university to find participants who used tablets or apps in the laboratory. They each emailed me to say that Tom and Nathan were intending to begin using tablets in the laboratory but had not yet bought any. I met Tom and Nathan two weeks after this initial email exchange, by which time they had bought a 16GB Wi-Fi iPad Mini each.

In this chapter, I consider how Tom and Nathan engage with and make use of the affordance ambiguity of the tablet. Reflecting on the ethnography, a key theme that emerged was the idea that Tom and Nathan were managing the tablet's failure. I use the management of failure as a paradigm with which to analyse the way that Tom and Nathan deal with affordance ambiguity. Their use of affordance ambiguity was most clearly expressed at moments that I observed to be failures but that Tom and Nathan never treated as such. Over the six month period of investigation, Tom and Nathan searched for

and tested various different apps and tried to adopt tablets in various ways in the lab. Throughout these six months, Tom and Nathan's aim was to find ways to use tablets in the lab. At the outset, they did not have a clear or specific idea of what they wanted to use tablets for. They simply had a strong desire to use tablets in the lab somehow. At the time of our final meeting, Tom and Nathan had not found a way to implement tablets in the lab. As an observer, I would have considered their attempts to have failed (although I will expand on my use of this word shortly), but Tom and Nathan's attitude was unchanged. Throughout, they remained keen and enthusiastic to find ways to use tablets in the lab, despite never in six months finding any application that they found to be definitively useful.

Tom and Nathan *suspend* failure: I trace their attempts to use tablets over the course of six months, showing that whenever the tablets do not fulfil a desired or expected function, Tom and Nathan simply 'move on'. The failure of the tablets is never conceived as such because the definition of the tablet – what it is *for* – is fluid. This differs from my analysis of perfection in the previous chapter regarding *the Lab*. In that case, the tactical redrawing of the boundaries of the object allowed users to construct the tablet as a perfect, infallible object. In the case of Tom and Nathan, the management of failure took a different form. Failure was never accounted for, it was simply avoided. When the tablets did not work in the way Tom and Nathan had expected, they did not discuss or explain it because they had already moved on to try using tablets in another way. Failure was neither denied nor accepted, it was suspended. The constant redefinition of the object meant that success and failure, understood as static or stable judgements about the object, did not apply. This was the clearest way in which affordance ambiguity was manifested in Tom and Nathan's use of the tablet.

Tom and Nathan's changing definitions of the tablet are presented by tracing their ideas and expectations about what the tablet could or should do. Although at any given

time, Tom and Nathan discussed the tablet as having a singular function, taken over six months the tablet was seen as an object with many possible uses. I account for this complexity by presenting a series of vignettes representing key themes of the definition of tablets expressed by Tom and Nathan. Tom and Nathan made use of the affordance ambiguity of tablets by cycling through several definitions. By engaging in an excessive, slipping definition of the tablet, they expressed their subjectivities as good scientists with a 'researcher attitude' and capable, expert testers of technoscientific objects. The tablets acted as affiliative objects (Suchman, 2005), with the definition of the tablet entailing a definition of a given group of users. Tom and Nathan's use of tablets did not only express their own subjectivities as scientists, it invoked their colleagues as a potential network of users who would all benefit if everybody adopted tablets.

The methodological approach in this chapter entails analysing the participants' management of failure. The management of failure consists of the participants' efforts to make the technological object work. When the object is not used in the way that participants have stated they wish it to, I consider this to be a failure. Failure may well not be recognised as such by the participant at the time. To give a concrete example; Tom and Nathan began intending to use the tablet as an inventory management tool, but its perceived role changed several times. Tom and Nathan never felt they had *failed* to use the tablet as an inventory management tool, nor that the tablet had failed. As a researcher observing their practices and conducting interviews, however, I identified this changing definition of the tablet as a failure. The term is not pejorative and is intended only to reflect the fact that the idea of the tablet *changes over time*. This approach runs the risk of framing the participants as dupes and the researcher as an objective expert. This is not the intention. Analysing the management of failure over time takes the analysis away from stable definitions and fixed assessments of the use of the technology, towards an understanding of the emergent, active definition of the material object. This is the type of

understanding discussed with reference to Barad (Barad, 2003) in chapter three on scientific instruments. The aim of tracing the management of failure is to trace the user's active construction of the object. The focus on failure is beneficial because it allows analysis of emergent uses of tablets without falling into a discussion of single emergent uses of tablets as instantaneous, novel, and ephemeral. Linked to the conjunctural analysis approach, analysing the management of failure is a way of examining specific emergent uses of tablets whilst maintaining connections between different uses over time. I also consider how this analysis links with the concept of closure (Bijker *et al.*, 1987b, Wynne, 1988).

In a final section, I use the material presented in this chapter to develop and clarify the concept of the tablet imaginary. My account of Tom and Nathan's adoption of tablets in the lab aims to demonstrate their reliance on an imagined future in which tablets are useful in given ways. The practices that they adopt based on their faith in this imagined future in some sense *create* the future that they envisage. This is the essence of the tablet imaginary – a set of ideas that is formative of and formed by specific uses of tablets in context. By using the concept of the tablet imaginary, I aim to account not only for the meanings and ideas associated with tablets 'imposed' on Tom and Nathan by the economic order, popular culture and other factors (including my own presence and involvement in their project), but also for the meanings and ideas that they contribute and develop through their uses and experience of tablets.

I argue firstly that Tom and Nathan's use of tablets engages with a pre-conceived idea of an imminent technological future, and secondly that the use of tablets then actualises certain aspects of this imagined future. The phrase 'tablet imaginary' is used to capture both the usage of tablets in the present and the technological culture that this present usage develops. The tablet imaginary is both the idea of an imminent technological future that led Tom and Nathan to start using tablets, and the outcome of using tablets in this way.

Emergent Definitions of the Tablet

I always met Tom and Nathan together: they were working as a pair, having both bought tablets together at the same time. Tom and Nathan had a close working relationship and clearly got on well with each other, sharing jokes and asking about each other's personal life at various times during interviews. They had set out to trial tablets together in the lab and they clearly felt that it was a joint endeavour. On occasions when one had to cancel or rearrange a meeting, the other always postponed too; they evidently wanted to meet me together as they felt that they were engaged in a joint project.

They shared an idea that using the tablet computer would change their laboratory practices and be beneficial in a mostly unspecified way. Throughout the interviews, the tablet imaginary can be traced through their references to capabilities or potential uses of tablets. It was striking that they did not have a clear idea of what tablets would specifically do. They did not have a specific task or function in mind that they envisaged tablets fulfilling. Their decision to buy tablets was based on a desire simply to use tablets. Not to use tablets *for* something in particular. Their motivation for using tablets was based on a set of ideas about what effect using tablets might have; the tablet imaginary. The tablet imaginary was never stated explicitly or succinctly by Tom and Nathan, instead it was something identified in their responses throughout the six months of interviews and email exchanges. The first part of this chapter presents their responses and builds up a picture of the tablet imaginary expressed by Tom and Nathan. To flesh out the concept of the tablet imaginary, I present comments from Tom and Nathan that refer to the intended, hoped or imagined idea of what using tablets would or could bring about in the lab. The main elements of the tablet imaginary for Tom and Nathan are that tablets: will save money; allow for more efficient and productive working practices; are a gateway to a mass of free material and apps; will change other people's practices; succeed best when used by everybody; are inevitably soon to become extremely important in laboratories and

universities generally; should be easy to use with little barriers to adoption; are futuristic; and become indispensable once adopted. Each theme is addressed individually, using the management of failure paradigm to build up a picture of the fluid definition of the tablet. I consider this through two key framing concepts: the affordance ambiguity of the material object, and the subject position of Tom and Nathan as scientists and therefore expert users of technoscientific objects. Taken together, the vignettes presented here also illustrate the tablet imaginary as it operated for Tom and Nathan. The definition of the tablet in each case was based on an element of the tablet imaginary; advertising, software elements, the app store, recommendations from colleagues, comments made by the other participants or me the researcher, and countless other influences that form the tablet imaginary. I do not address every key concept – tablet imaginary, affordance ambiguity, subjectivity of Tom and Nathan as expert users, the emergent definition of the tablet – in my discussion of every theme. To avoid repetition, I focus on some of the key concepts when addressing each theme. Taken as a whole, the findings presented here should develop and explain these key themes.

Saving Money

Tom did have one clear idea of a change in lab practices that he wanted to occur. Early in the first interview, Tom stated that he wished to use software to manage the lab's inventory:

> Back home we've got a restaurant and we've got something called Macros. It's a software. So basically on Macros it tells you exactly what is the stock and where the stock is. So that's the one thing I wanted to have somewhere for the lab. Because we are spread in so many different areas, say if you want something like Sodium Chloride you need to run around ten thousand miles just to find it, whereas if you just had something like Macros, it just say 'oh you've got two grams there and five grams there'. You know and then, also when you are ordering stuff if you already know you've got a few bits spread around you can

> combine them to know 'oh I actually don't need to buy anything'. That saves money.

Tom did have a clear idea of a change in lab practices that he wanted to bring about; financial savings through inventory management. What was absent from this was any connection with tablet computers. Tom already knew of a PC app 'Macros' that did the job he wanted. This type of inventory management was something that Tom wanted to use in the lab and Tom recognised that the adoption of tablet computers might allow him to introduce it. But he did not have any clear idea of how tablets would make this change occur. He simply connected the arrival of a new technological device with the arrival of new practices. The idea that using tablets would help to save money was also expressed by Nathan, who had an idea to manage apparatus as well as inventory:

> I've got somewhere boxes and boxes of certain bits of apparatus. Now if no one else is aware of that, they're going to go out and buy them. Now if I've got them sitting there and I don't use them, it's sensible that someone has access to that. So there is a monetary gain there.

Nathan's idea to save money by maximising access to apparatus came about in response to Tom's desire for inventory management. It was not something that he had considered before buying the tablets and meeting with Tom and I to discuss using tablets in the lab. It should be noted that during the six months of these interviews, Tom and Nathan discussed as well as trialled several different lab-specific inventory management apps (such as Quartzy, LabGuru) that did exactly what Tom wanted, but Tom never used them beyond trialling.

In this case, analysing the management of failure shows how the mismatch between intention and result was never taken to be a failure. The fact that Tom and Nathan did not use the tablets to manage the inventory or apparatus was never conceived of as a failure because it was never conclusively tested. Rather than treating the use of tablets for inventory management as an experiment with a clear result (i.e. the tablet *can be* used for

inventory management; *this particular app* is the best one to use etc.), Tom and Nathan circuited through inconclusive and seemingly endless trialling. In one sense this could be explained as a form of 'experimenter's regress' where "it is hard for a test to have an unambiguous outcome because one can never be sure whether the test has been properly conducted until one knows what the correct outcome ought to be" (Collins and Pinch, 2014: p.3). The tablets were an unknown quantity and indeed this may help to explain why Tom and Nathan engaged in the perpetual beta, constantly trialling more apps for the same job. Yet a more convincing explanation lies in the idea of the tablet's affordance ambiguity and its emergent definition. Rather than a failure on Tom and Nathan's part to use the tablets or a lack of suitable and effective apps, the affordance ambiguity of the tablet meant that Tom and Nathan were never sure what it was for. This led to a compulsion to always find another thing to do with the tablet. Each successive trial of the tablet – as inventory management, as source of free material, as signifier of progress and so on – was conducted on the basis of a test of what the tablet could *be*. The combination of the expansive tablet imaginary and the affordance ambiguity of the tablet as a material object led to Tom and Nathan being able to experiment indefinitely with the definition of the object and, in turn, their own subject positions. At one moment they could cast themselves as scientists using tablets to save money, at another moment as scientists conducting research efficiently, at another as influential members of a faculty in which more and more people were adopting tablets as well.

Desire for Efficiency

Nathan also foresaw a gain in efficiency by using tablets to have information 'to hand' when he needed it:

> If I bump into people and meet people and say you know 'we want to meet at two o'clock on Thursday is that OK', whereas normally I'd have to say to people 'well you'll have to come back to my store room and I can find out'. But if I had all the information there I could actually do it and book it there and then. So it's more

> efficient, this is it. The other person can go on their way and I can go back and carry on what I was doing as well. Once you get used to the system, you're being more productive in some respects.

Nathan's idea of efficiency is based on changing the temporality of everyday encounters with colleagues, which links to the idea of ' incorporation' of technologies as discussed by Silverstone, Hirsch and Morley (Silverstone *et al.*, 1992) in the context of domestication.

Efficiency, monetary savings and reduction of waste were all articulated by Nathan when discussing 'going paperless':

> I mean one thing I aim to do, one thing that I was interested in getting a tablet for here was, go paperless. Get rid of it. I hate it. It's clutter everywhere. You receive it, you put it in the bin, or you scan it. […]And we had a grumble back yesterday from one of our administrators that we were using far too much photocopying and colour photocopying as well. Well I thought, why are we using paper at all?

Tom identified one particular change in his working practice since starting to use the tablet that he felt was particularly efficient:

> Coming on the train it has been quite useful, because all your emails are downloaded, even though it doesn't have Wi-Fi access, all the emails are downloaded on it. So you can write all of them and save them as drafts. So the moment you come on campus, all of them get sent. So it does save you time. Instead of sitting on the train for 10 minutes, 20 minutes, waiting for the journey to finish.

Tom expresses the sense of regaining lost time, expressed by ICT industry commentators as the Lazarus principle: the idea that "previously dead time can be revived and given back to individuals through mobile ICTs" (Bassett, 2009: p.50). Tom's train journey was transformed from "Just sitting there and watching cows" to "now going through the emails". Of course, this particular instance of increased efficiency is not manifested in the lab, it extends the space and time of the workplace, reinforcing the tablet's involvement in Tom's developing sense of personal productivity. The affordance ambiguity of the tablets allowed Tom and Nathan to easily move on from considering the

tablets as devices that could be used for inventory management to devices that could achieve efficiency in their working practices more generally. This displacement meant that the specificity of inventory management was forgotten as Tom and Nathan moved on to new applications. But 'moving on' did not involve a consideration of the tablet's efficacy as an inventory management device – inventory management was simply suspended. The tablet was just not an inventory management device any more. Neither success nor failure apply in this context, as the inexhaustible affordances of the tablet meant that its limits were never tested.

Two things are happening simultaneously here in the definition of the tablet. Firstly, the tablet is experienced in an emergent relationship between user and device. In that atemporal emergent 'moment', the tablet's affordance ambiguity leads to a surplus of possible uses such that it is never clear what the tablet is *for,* and thus the tablet can neither fail nor succeed. Secondly, this emergent relationship means that each individual use of the tablet stands alone and cannot be judged against a previous or subsequent use. When Tom and Nathan began discussing the tablet as a device that improved efficiency, it was striking that this was never mentioned in the context of its success or failure as an inventory management device. It was as though a totally new object was being discussed.

These two ideas that are based on the emergent definition of the tablet and its affordance ambiguity are an underlying theme throughout this chapter. Each new use or definition of the tablet was discussed by Tom and Nathan in complete isolation, as though discussing a thoroughly new object. The fact that each of them were carrying a physically identical object to work each day did not lend a sense of continuity to their treatment of the tablet.

In the following sections, the presentation of each theme should be treated as another instance of the definition of the tablet (and its user) being radically changed by Tom and Nathan, with previous definitions suspended – in effect, ignored. Each section should

therefore add some concrete examples to the abstract ideas presented in this regard thus far.

Gateway to free material and apps

A related but distinct aspect of Tom and Nathan's tablet imaginary was the idea that tablets were a gateway to unlimited free material and free apps. Even the inventory management apps that both Nathan and Tom had identified as potentially saving time and money were rejected if the app cost money or if there was a subscription cost for the inventory management service. In addition, Tom was keen to find, and find a use for, free material such as free ebooks of chemistry reference guides or public material from iTunesU chemistry courses. The search for free material was representative of their adoption of tablets more generally. Rather than identifying a problem or requirement and trying to find a way to resolve or fill it, they first found apps and resources and then tried to identify problems or requirements to apply them to. After describing a chemistry ebook that Tom had found on the iBook store, Nathan commented that they would need to decide what parts of the ebook they could use in the lab: "So again these are some of the things we need to extract and see what usefulness we can get out of it." The context of the discussion made it clear that Tom had not been intending to find specific course material, but had encountered this ebook by chance. There was nothing in their current course that was lacking or that they wanted to change, but they responded to the availability of new material by trying to find a way to make it fit.

Again it was striking when Tom began focusing on the tablet as a device that allowed access to free material that he made no mention of his previous idea that they could save money by subscribing to – and paying for if necessary – an inventory management app. Using the tablets to find free material was not conducted on the basis that this was much better than paying for apps as had previously been discussed. There was no comparison between previous conceptions of the tablet and the present one. The tablet at that stage

was nothing more and nothing less than a device that could be used to access free material. The idea that Tom would have to 'see what usefulness we can get out of it' when he found free material is indicative of the changing definition of the tablet. Again, there was no definitive sense of success or failure, either in the current definition of tablets as gateways to free material or in comparison to previous definitions.

Will change others' practices

Although it was not stated explicitly, another aim of Tom and Nathan's iPad trial was to involve others within the department. The sense that they wanted other department members to adopt iPads too developed gradually throughout the ethnography. At one stage in the penultimate interview they began counting the staff who use iPads, with Tom noting that of 16 chemistry faculty members, tablets are used by "five of us, that's more than 25%". Tom and Nathan were also both pleased and faintly amused to see that their (in their characterisation) infamously luddite colleague Gloria bought an iPad of her own:

> Tom: But the thing is, she's very reluctant to change anything. And she's actually using a tablet now.
>
> Nathan: Yes so that's good and I think that's been brought on by the fact that Tom and I have got one.
>
> Tom: That we were using them.
>
> Nathan: So I think it's sort of rubbing off in a way. And people see how useful they are I think quite honestly.

In these statements the subject positions of Tom and Nathan are stated and reaffirmed against that of Gloria. At stake here is more than Gloria's willingness or ability to use a tablet computer: her subjectivity is brought to account by Tom when he states that she is 'very reluctant to change *anything*'. The enactment of relations of power here falls along the lines of gender, with Tom and Nathan speaking on behalf of Gloria. In this type of discussion, Tom and Nathan's own positions are reinforced twofold. As well as being

expert testers who have the ability and knowledge to use the tablets, they are also innovators whose efforts allow others to engage with the technology. I did not regard their comments here as self-aggrandising, but it is clear to see that they are using their adoption of the tablet to position themselves as gatekeepers whose work and expertise allows colleagues, specifically non-expert technology users, to adopt the promising new technology.

Here, the tablet does not have an easily-identifiable function in the tool-like sense discussed in previous sections. It's a device used in the explicit statement of aptitudes and expertise that is part of the way that Tom and Nathan express their subject positions. The management of failure can still be analysed here. By bringing in colleagues to the network of users under consideration, Tom and Nathan allow for success and failure to be measured in terms of individual uses of the tablet. The management of failure here sees failure inscribed as *inability to use the tablet*, a subject position that is assigned to Gloria. Note the tablet is not under question here: it is the *user* who succeeds or fails. In fact, the implication of Tom and Nathan's discussion is that Gloria is actually competent in using the tablet; she needed only to be encouraged and helped along by expert users. This is another case of failure of the tablet being suspended. If Gloria had never adopted a tablet, it would have been her failure or unwillingness to adopt, rather than a problem with the tablet.

Requires others to adopt

This section deals more closely with the materiality of the tablet and how its design and structure invokes certain types of uses. More than simply drawing on affordances that enable and encourage Tom and Nathan to use the tablet in particular ways, Tom and Nathan's use of the tablet involved building a network of other users. Part of the desire to share was based on a recognition that the particular way in which tablets work depends on a lot of information being shared: "I can see it being very, very useful, but it depends if

people are up for it" (Nathan), "the more contacts you've got, the more useful it becomes, yes? Because you can send what you've just written to the person, or share it with people" (Tom), "by choosing your device well, you can have things, like these apps there, and create additional information which will be useful which you can actually share and communicate between each other" (Tom);

> So if there was a sort of inventory that we shared, or she created one and I created one, we could both look for things on that inventory. We're already talking about things like that. I've got a chemical store out there as well. That inventory could be shared with the rest of the academia in chemistry as well. (Nathan)

Describing these advantages as 'network effects', Jarrett argues that "the value of information, and the network within which it is transmitted, actually increases through widespread use" (Jarrett, 2003: p.339). The awareness that tablets and apps often operate based on a logic of the benefits of sharing is one concrete explanation for Tom and Nathan's desire to have others use the technology. Yet they both said that they were not at all evangelical about tablets and believed the reason that their colleagues were also beginning to adopt tablets was because they could see how useful they were. When asked whether he was evangelical and promoted the tablet, Tom responded: "I don't really say it's useful but when I use it then people kind of see how easy and useful it is." Talking about using his iPad in meetings, which he commented is acceptable unlike using a mobile phone, Nathan stated that: "The iPad's kind of acceptable and people will actually look. And I think that they might actually be encouraged as well to a certain extent". The physical presence of the tablet in the meeting is important here, but so too is the flashiness and impressiveness of the tablet. This resonates with Silverstone, Hirsh and Morley's account of 'objectification' of objects: "physical artifacts, in their arrangement and display, as well as in their construction and in the creation of the environment for their display, provide an objectification of the values, the aesthetic and the cognitive universe, of those who feel comfortable or identify with with" (Silverstone *et al.*, 1992: p.23). Tom's phrase "people will

actually look" indicates that the tablet's visual impact is key to the way that it encourages others to adopt. Bassett (2009) describes how the posture of somebody using a mobile device communicates their activity, which affects others' experience of the space in which the activity is taking place. Reflecting on these points, I recall how Tom and Nathan had the same red protective case for their tablet and would often stand the tablet in the most upright position possible. Whether intentionally or not, this had the effect of showing off the device, making sure that it would be seen. For Tom, the tablet is performing its usefulness just by being present: the imaginary of the tablet as a useful lab object is enacted by Tom simply by his using it.

The tablet's mere presence could be regarded as convincing or impressive because the tablet imaginary is content-ambivalent, meaning there is no objective measure of success or failure: and mere use of tablets therefore indicates success (a point developed further in the conclusion to this chapter). The measure of success is that tablets are being used at all, not that they are being used successfully for a particular task. This idea is found in Nathan and Tom's belief that colleagues are adopting tablets based on observing Tom and Nathan using them. With Tom and Nathan using the tablets in the lab every day, the appearance was that tablets were useful. This is despite the fact that the tablets were often present without being used, or were being used simply in order to try to find ways in which they would be useful. In this way, Tom and Nathan's use of tablets perpetuates the tablet imaginary. On this basis, colleagues such as Gloria bought tablets of their own, convinced by Tom and Nathan's apparent successful adoption of tablets to engage with the tablet imaginary themselves. This point will be clarified in the following section which discusses the perceived inevitability of change.

The idea that using tablets requires others to adopt is another way in which Tom and Nathan's use of tablets resembles Balsamo's discussion of innovation, reinforcing the strength of this paradigm as a way of thinking about users as innovators or productive

consumption. Balsamo (2011: pp.9-10) outlines how the "creation of new technologies requires the involvement of many people who contribute distinct forms of labour" including various functions: "coordination, facilitation, acquisition, maintenance, allocation, recruitment, and dispersion". Balsamo argues that these are all articulatory practices: "processes whereby the activities of individuals are organized as part of a collective effort identified as 'innovation'" (2011: p.9). Of interest in Tom and Nathan's case is the way that this same articulation work occurred despite it being a casual implementation. Tom and Nathan were not explicitly involved (and did not consider themselves to be involved) in an innovative process requiring this articulatory work and the engagement of other users to create a network. Their understanding was more simply that they believed tablets would be useful in the various ways discussed throughout this chapter. Unlike the innovators in Balsamo's case study, Tom and Nathan were not consciously trying to create a network with a common goal.

Rather than objects of innovation and work for a specified group, tablets are better understood in this context as 'affiliative objects'. Suchman (2005) discusses "the affiliative powers of objects", how different people can enact different subject positions in relation to any given object. When several people position themselves as affiliated to the same object (or disassociate themselves from that object), each affiliation enacts a particular definition of the object and the subject. One implication of this is that objects must be thought of not as innocent, "but fraught with significance for the relations that they materialize" (2005: p.379). Tablets exhibited significant affiliative powers, bringing about various relationships and acting in the development and maintenance of individual subject positions. The concept of the affiliative object goes beyond thinking of objects as either instruments or commodities (echoing Knorr-Cetina (1997) discussed earlier) and accounts both for the materiality of the object and the context in which it is used. The recursive nature of the tablet imaginary becomes clearer here. The tablet is regarded as an object that benefits

from being sited within a network of users. Constructing the tablet in this way *creates* that network of users. Tom and Nathan's practices draw on Jordan's conception of imaginaries, which "bond people into communities and, simultaneously, drive them to try to realise their fantasies" (1999: p.207). This recursive process is central to my discussion of the tablet imaginary as being formative of and formed by specific uses of tablets.

Star and Ruhleder (1994) term the advantages gained from increasing the number of people in the network 'positive network externalities'. They note that these same externalities can be negative depending on the user in question. If the network becomes hegemonic, then its positive externalities become a significant disadvantage to those who do not participate, whether by choice or otherwise.

> Externalities may be negative in that eventually, not being "hooked up" may make it impossible to participate effectively within a given community of work or discourse. For instance, the telephone network became a negative externality for those businesses without telephones sometime in the early 20th century. (Star and Ruhleder, 1994: pp.259-260)

Tom and Nathan treated tablets as beneficial if adopted by others and also as benefiting from others adopting. This definition performed the further work of affiliating their colleagues as part of a potential network of users who would all benefit if they all adopted. Non-adoption in this scenario is not an innocent or neutral position: it is constructed as an active barrier to what Tom and Nathan define as a mutually beneficial process.

Inevitability of change

A further aspect of the tablet imaginary was the idea that tablets were inevitably going to become important, perhaps essential, devices in laboratories and universities in general in the near future. This manifested in an unwavering belief in the tablets that was also found in the case study of the Lab. In both cases, the tablet imaginary includes the idea that just using tablets will change and improve working practices. Where in the Lab I

characterised this in terms of 'perfection', stating that tablets were perceived as perfect by users in that case, for Tom and Nathan this faith takes a different appearance. The infallibility of the tablet for Tom and Nathan is defined by the idea that the tablet has something extra to offer them and that they need only find the appropriate apps and material using the tablet to benefit from this potential. In other words, the suspension of failure is key for Tom and Nathan, while perfection in the Lab involved the *denial* of failure.

The main practical difference between the Lab and Tom and Nathan's experience is the level of institutional support or backing. In the Lab, there was a level of institutional and personal investment that contributed to, or perhaps ensured, the success of the paperless lab project. The context in the Lab meant that the tablets could not be allowed to fail, leading to a perpetual splitting of the object along the lines of what it could potentially and actually do, with the consequence that tablets remained perfect in the Lab. Tom and Nathan's situation was very different. Nathan's line manager did initially contact me about the possibility of Tom and Nathan using tablets, indicating managerial support. They bought an iPad Mini each with the chemistry department's budget, yet at the start of the second interview, Tom told me that further purchases were not to be supported by the managerial hierarchy: "Yes so we managed to, these were the only two that we managed to buy." The department financed the purchase of Tom and Nathan's iPad minis with some reluctance and would not provide iPads for other staff members nor money for apps. The institutional support in this case was minimal and did not manifest in any pressure or imperative for the use of iPads to be successful.

The apparent failure to adopt the iPads in the expected manner, combined with the lack of institutional support, could have led to Tom and Nathan losing interest and losing faith in the technology. Yet this did not happen; they kept their faith in the iPads and continued to look for ways to use them in the lab, never becoming discouraged. This develops the findings in the previous case study of the Lab, in which institutional support

and pressure was a key factor in the success of the Samsung Galaxy tablets. The case of Tom and Nathan shows that institutional support is not required for continued faith in tablets. The key factor in Tom and Nathan's adoption of tablets apparently against the odds is their belief in the tablet imaginary, which includes the belief in the inevitability of change.

Tom and Nathan wanted to use tablets in order to participate in this imaginary in which tablets are part of an imminent technological future. They felt that the coming importance of tablets was inevitable and that they would benefit by being part of a first wave of users to usher-in the technology, rather than being left behind: "I've sensed for a while now that we need to move on", "students, I think, they will just turn up with stuff like this in the future. And expect the university to provide all their stuff in electronic form", "I guess give it three or four years and laptops will be… this will take over, [tablets] definitely, will take over", "But you know I see the way and the future of this coming", "they're going to have a huge influence, you can see this already". The perceived inevitability of tablets being central to laboratory work and university life is clear in these statements. This inevitability is the central tenet of the tablet imaginary and the idea that encouraged Tom and Nathan to keep the faith and continue using and trying to adopt tablets in the lab. It is important to note that this inevitability lacks content and is not dependent on particular functions working well or becoming popular. The affordance ambiguity of the tablet meant that the perceived inevitability was similarly ambiguous. The inevitability is that tablets will be important; the sentiment is that everybody will be using tablets. The sentiment is content-ambivalent, it is not 'everybody will be using tablets *for*…' The content-ambivalent nature of this imaginary allows no judgement or evaluation. Without a specific role, task or function defined for tablets, the only measure of successful adoption is mere adoption itself. This is reflected in Tom and Nathan's satisfaction merely with using tablets in the lab, even simply with tablets being present in the lab. They were

never aiming to use tablets *for* a particular task, only to use tablets. Equally, this gave their colleagues the impression that the tablets were useful, despite it being difficult to give a concrete example of their utility.

Tablets are particularly suited to supporting this content-ambivalent idea of inevitability because of their affordance ambiguity. This is not to say that the imaginary has no content. There is of course content to the imaginary – throughout this chapter I have described the content of the tablet imaginary as it is expressed by Tom and Nathan – but the content is not fixed, the imaginary is fluid and can take on different forms and support many different ideas. In the final sections of this chapter I will develop my analysis of this point, arguing that the tablet imaginary is both a formative logic that influences the use of tablets and at the same time is formed in the process of using tablets. Before developing these ideas more generally, I must finish outlining the themes of the tablet imaginary as observed throughout the case study.

Barrier to adoption

One aspect of the tablet imaginary that was present before the adoption of tablets and then clearly changed with their adoption was the idea that tablets would be easy to use immediately. The difference between the imaginary and Tom and Nathan's actual experience is significant here. The ethnography shows that Tom and Nathan both found that their desire to use tablets in the lab was often unmatched by a willingness to try out new applications or practices. As an example, we can return to the two specific tasks that Tom and Nathan eventually came to want to use tablets for: Tom wanted an inventory management system and Nathan wanted an apparatus management system. They did not have a specific idea of how to use tablets for either purpose. In fact, there are several apps that do exactly this, including some apps that other research participants had told me about in other interviews. Over the course of the six month ethnography, we discussed the apps that I was aware of as well as finding several different apps or methods to achieve these

two requirements. For Tom's inventory management, we discussed using laboratory-specific apps that are specifically designed to manage a lab's inventory in exactly the way that Tom had outlined. Two apps were discussed in detail: LabGuru and Quartzy. LabGuru promises to allow users to:

> "Manage your materials collections, inventory, and storage
>
> Save time and money on ordering
>
> Schedule and maintain shared lab equipment"[26]

Although this app promises to fulfil the required task, Tom and Nathan were reluctant to use any app that required a subscription. A subscription to LabGuru would cost $10 per person per month. An alternative app that was discussed in more detail was Quartzy. Its equipment sign-up function, which schedules usage of shared apparatus, promises to "Minimize conflicts and maximize productivity"[27]. It also includes an inventory management system and its main claim is: "Quartzy helps you run your lab more efficiently, allowing you to stretch every dollar as far as it can go"[28]. These functions match perfectly with Tom and Nathan's requirements. Furthermore, Quartzy is a free service:

> "Quartzy is completely free, and always will be. Leading life-science vendors pay us to host their catalogs and make their products accessible to the tens of thousands of labs on Quartzy."[29]

Throughout the ethnography, Tom and Nathan repeatedly stated that they wanted to start using specific lab apps such as Quartzy, but that something was stopping them. The primary cause of their failure or inability to use these lab apps was the barrier of changing habits. They both mentioned 'habits' repeatedly:

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[26] LabGuru website http://www.labguru.com/features/lab-logistics/orders-and-inventory [Accessed 1st May 2014].
[27] Quartzy website https://www.quartzy.com/tour/equipment-sign-up [Accessed 1st May 2014].
[28] Quartzy website https://www.quartzy.com/tour [Accessed 1st May 2014].
[29] Quartzy website https://www.quartzy.com/why-is-it-free [Accessed 1st May 2014].

> "So it's a matter of getting into the habit and that is where I've stopped at the moment. I haven't got into the habit" (Tom)

> "Again it's getting into the habit of doing that and keeping things on there rather than writing down on bits of paper" (Tom)

> "Because you do have that big hurdle as we said of changing people's habits as well. That's the big big thing" (Nathan)

> "As far as the lab stuff goes, yes I was talking through it with Fred [a colleague] at lunchtime: it's just so hard to get into new habits. Even though you see the advantage there, you can edit the material, you can correct it, you can date it. It's just habit. It's tough breaking the old habits" (Nathan)

Tom and Nathan were consciously aware of this difficulty and mentioned it in every interview, yet it remained a problem and they never did manage to change their habits and start using Quartzy or an equivalent app or method. The reason that they gave for the continued failure to use the promising lab apps was that the apps required time and effort to 'get used to': "Once you come across a barrier you tend to drop it and go back to what you were doing before. That is the problem" (Tom). "Sometimes you try things and it just… When you reach an impasse and find that you can't get around things, that doesn't encourage you to carry on and use it, does it?" (Nathan).

Their comments reveal an ambivalence about who was to blame for this: themselves, for being lazy or not putting in enough time and effort to become familiar with the apps, or the apps, for not being attractive or simple enough to use without this period of learning. Nathan summed up this ambivalence:

> And I haven't used any of the software that is on here. Any of the lab stuff or anything like that yet. So I don't know if it's I've yet to be convinced. Or whether it's just my laziness generally. I don't know. But there is stuff that I could do on there certainly.

Tom and Nathan both elaborated the idea that they were 'yet to be convinced' elsewhere and the balance of comments weighed in favour of the apps being to blame rather than themselves:

> "at the moment there's nothing tempting me in to actually suddenly use to actually store data that I actually might record in a book or somewhere else at the moment. So something hasn't drawn me in" (Nathan)

> "at the moment haven't found anything that I like and love enough to actually alter my habit" (Tom)

> "the advantage has to be sometimes perhaps over-egged on these programs […] so you need something there to catch you sometimes. To actually draw your attention, to say 'yes I think this is worth doing, yes I'm going to alter my habits'" (Nathan).

Of interest here is the fact that Tom and Nathan bought tablets with the clear intention to change their working practices. Yet over the course of six months, despite finding promising apps that seemed to offer the exact functions they wished for, they did not actually change their habits.

Again an analysis of the management of failure can help to explain these findings. The comments from Tom and Nathan in this regard are the clearest point at which failure was discussed. Earlier I described the suspension of failure in terms of a rapid cycling between definitions of the tablet. One minute an inventory management tool, the next a way to gather free material, Tom and Nathan moved from one conception of the tablet to another without ever exhausting its potential for a given task. Failure was suspended because it was structurally disavowed, never being taken into account. In the discussion of barriers to adoption, the suspension of failure takes on a different form. It is much more consciously considered and is characterised as an inability to change habits. Failure is suspended here in the explicit definition of the tablet as as-yet-untested for a specific use. This suspension of failure is more static than that described earlier, with a given definition of the tablet – for example as an inventory management tool – being designated as untested.

The idea of barriers to adoption is particularly instructive in understanding the development of the tablet imaginary. The imaginary that Tom and Nathan began by envisaging before they used tablets developed as they actually used the devices. Tom and Nathan were engaging with the tablet imaginary; a set of ideas about what tablets can and should do. In this particular case, the tablet imaginary included the idea that adopting tablets would automatically change their practices. Their comments about a barrier, or needing to be 'tempted in', or that tablets and apps were not immediately easy enough to use suggest that they believed tablets would and should be adopted with no effort. Whether the user or the tablet and its apps are to blame, the imaginary remains that the tablets would be simply adopted with the effect of changing and improving working practices. Part of the tablet imaginary for Tom and Nathan was the idea that tablets would be simply integrated into their existing practices. The imaginary developed as they actually used tablets, becoming the idea that tablets and apps must have clear benefits and be easy to use in order to overcome inherent barriers to adoption such as ease of use and promise of eventual benefit. This aspect of the imaginary was maintained by their belief that they had not yet found the ideal app suitable for their purposes. As such, they continued searching for ways to use tablets, rather than concluding that these barriers to adoption were an unavoidable or inherent part of using a new technology.

Futuristic

The final two themes were expressed throughout the ethnography and were addressed explicitly in Tom and Nathan's responses to one question asked in the final interview: "what do tablets represent for you?" Nathan's response was: "Modern I'd say". Nathan argued that using tablets "could give red brick universities like us an edge. A real edge. And not only in the lab here but in other areas too". Nathan believed that using tablet computers would give the university a sense of being an up-to-date, forward-looking institution, which would have significant benefits on, for example, student recruitment:

> Because I think it looks good. It does. It looks good, it looks organised, it looks professional. And someone is going to flag it. Certainly at the registration desk, if the two people there have got something like that and they're calling people on, it will be noticed. It will. […] You want the technology there, because it does actually give such a sort of a forward impression, a futuristic impression sort of thing.

Nathan's belief that the cultural capital of tablets could be instrumentalised by the university is clear, and is only made more significant by the fact that he and Tom had no specific reason to use tablets. The gain in cultural capital is not a beneficial side effect of adopting tablets for a specific reason; it is a primary reason itself. Interestingly, this gain in cultural capital would be most significant at the level of the University's brand or public image. Tom and Nathan have nothing to gain directly themselves by this, other than the rather limited gain in cultural capital by association that would come from working for a 'futuristic' university. This supports my argument that they are engaging with the tablet imaginary; they do not have a specific gain in mind, but are aiming to benefit from a general improvement and unspecified benefit by using tablets.

Becomes indispensable

Tom's response to the question, 'what do tablets represent to you?', was as follows:

> It's like a child to me. The more you see it, the more you get attached to it, and the more you cannot live without it. You know like, you keep doing things again. It's just a Wi-Fi iPad. But sometimes I connect it to the iPhone for the internet just because I'm on the train or something. Whereas before I wasn't even thinking of that. So like you know you keep going on and keep getting more and more dependent on it which is bad but good at the same time.

Tom definitely entered into a relationship with the tablet that was more significant than that between a mere user and device. Describing the iPad as 'like a child to me', Tom also gave the iPad a name; "Because it's got its own name, its own identity now because it's Tommy, you know". Tom would sometimes hold the iPad like a baby, in a self-mocking gesture that was humorous and allowed him to express the genuine relationship that he clearly felt. While Tom was being playful in giving the tablet a name, he was also genuine in

his comments that he was becoming dependent on the iPad. The idea that the tablet becomes indispensable to the user was acknowledged by Tom as being bad and good at the same time. The 'good' aspect of this dependency formed part of the tablet imaginary that Tom and Nathan envisaged before buying the iPads: they *wanted* to become dependent on the devices because they wanted the devices to be useful and transformative of their laboratory practices. The 'bad' aspect of this dependency was unexpected and developed through use. Tom's example of tethering his iPad to his iPhone 'just because he was on the train' is indicative of the 'bad' aspect of this dependency. The tablet had crossed the boundary of being useful at work to being useful outside work. Tom and Nathan were both conscious about keeping the two separate. Nathan managed this separation by having an iPad for personal use at home and using the iPad Mini for work: "I've got a big iPad at home yes but I don't use it for work. And I haven't used any of the software that is on here. Any of the lab stuff or anything like that yet". Although this strategy did allow Nathan to have two physically separate devices, he found that maintaining this separation was not so easy with devices that are designed to sync, as he discovered when his Kindle app automatically downloaded ebooks from his personal account to his university iPad Mini:

> I've got here at the moment *The Great Book of Wonder* by Lord Dunsany. Which is nothing to do with chemistry or anything like that. […] The other concern I think that we had from the management here was the fact that you'd use them as playthings or something like that. I mean I haven't downloaded any games or anything like that on this. Yes, the other books did come, right. But I find that if I look at the books then I look at them on my tea breaks

Tom expressed similar sentiments about using the iPad only for work purposes, stating that:

> But at the moment it's been bought by [the University], I tend not to put my private life on it. I just leave it as work […] Like I wouldn't even let is sync with my laptop at home because then all my photos and all my music will go on it and people will think I'm using university resources for my own stuff.

A certain amount of internalised discipline is evident here, with Tom and Nathan aware that they should not be using their devices for anything other than work. The slippage between work and non-work applications created by the way that apps such as Kindle would sync mirrored the slippage described by Tom when he discussed using the iPad on the train. Here, the technical logic of the devices, which wants to connect and sync at every opportunity, is expressed in the user experience, which finds the iPad as a locus that connects work and non-work activities. There is a sense here in which the affordance ambiguity of the tablet becomes unnerving for Tom. Finding that the tablet is useful for many things is advantageous and pleasing but at the same time disconcerting. Not knowing the object's limits means that Tom does not know where to draw the line and stop using the tablet, stop trying to find new ways to adopt it, stop the permanent beta that is the main process of his casual adoption of the device.

More than this, there was a sense from Tom's characterisation of the tablet as 'bad but good at the same time' that the tablet *made demands of the user*. Its affordance ambiguity meant that the tablet was extremely limited – if not useless – without being subject to constant testing and trialling that Tom and Nathan engaged in. The permanent beta was not simply something that Tom and Nathan chose to do in order to develop their use of the tablet and achieve more complex tasks. It was fundamentally required in order for them to find out what the tablet was for. Against this reading an alternative process was also taking place. In defining and redefining the tablet, Tom and Nathan expressed their subjectivities as scientists and expert testers. The mutual constitution of subject and object enacted through the emergent construction of the tablet was not something that happened *to* Tom and Nathan. It was a process that they embodied and took control over. The fact that they were able to do so results from the specific situation in which they worked. The comparison with the hierarchical top-down insistence on a certain definition of the tablet in the Lab is stark.

In a trick of the discursive construction of the object, the tablet requires and demands ever-more definition. As an ambiguous technological object, the tablet initially requires some articulation. Of course much of this articulation is achieved in marketing and cultural discourses that initially frame the object for Tom and Nathan. In contrast to Gibson's affordances that are repeatable and dependable, the tablet's ambiguous affordances offer no stability. Each use of the tablet can be radically new. Indeed, this is echoed in the phenomenological experience of using an app-based device, in which each app 'takes over' the entire device in a totalising way, filling the screen and denying other functionalities any expression, with each app subsequently opened doing the same. Again, the experimenter's regress is instructive in understanding this perpetual experimentation and redefinition. Without a clear notion of success – a definitive use or set of uses of the tablet – Tom and Nathan were unable to define failure and had no choice but to engage in the perpetual beta in which they could only find more uses for the tablet, never 'the' use that would allow them to stop.

Tom and Nathan's position as scientists and expert testers led to two somewhat conflicting sentiments that help to explain their experience using the tablets. On the one hand, their subject positions contributed to their eagerness to test the tablets and may explain the tenacity with which they pursued this unending experimentation. On the other hand, the lack of a final result may have been particularly disconcerting given their experience as scientists whose work is founded on the idea of reliable, repeatable experimental results. The operation of these conflicting ideas may be one interpretation of Tom's phrase 'bad but good at the same time'.

Development of argument about tablet imaginary

Up to this point I have built up a picture of the content of the tablet imaginary as expressed by Tom and Nathan. In the concluding section, I would like to elaborate and

clarify certain points about this concept more generally, focusing on three key aspects: the tablet imaginary takes the shape of a future constructed in the present; it is content-ambivalent; and it is both formative *of* and formed *by* individual uses of tablets in particular contexts.

Future in the present

The tablet imaginary is constructed in the present based on an idea about the future. Crucially, it is constructed in the present with an aim to *bring about* the imagined future. Jordan argues that imaginaries "offer hopes and fears that often do not appear as hopes and fears, but as real projects just one or two steps away from completion […] meaning that people feel a need to act quickly to prevent the imagined disaster or bring on the imagined benefit" (1999: pp.183-184). Tom and Nathan's efforts to adopt tablets were based on the belief that using tablets would mean they would benefit from useful applications of a new technology in the present and at the same time bring about technological change in the future. This perpetual deferral to an imminent future affected how failure was understood. To illustrate this, I will return to the first theme that I identified above: the idea that tablets would be used to save money. This idea was originally content-ambivalent, with Tom and Nathan having no clear idea of how tablets would be used in practice to save money. Tom connected the idea of using tablets with the idea of implementing an inventory management system similar to the one he used in his restaurant back home. By using tablets to manage their own inventory in the present, they envisaged a future in which all lab inventory was totally rationalised, with zero wastage.

As it happened, I had recently interviewed another lab scientist who had mentioned a few inventory management systems that were specifically aimed at science laboratories, notably LabGuru and Quartzy. These apps perfectly fulfilled the function that Tom and Nathan had described and we discussed them in some detail. The tablet imaginary gained specific content at that stage. Yet, as outlined above, Tom and Nathan did not ever use

these apps other than to trial them, stating repeatedly that they had 'not yet got into the habit' of using an app. They never discussed the notion that they or the tablets had failed in this regard, only that they had not got into the habit *yet*. The temporality of the tablet imaginary – as a future constructed in the present – does something interesting to the idea of failure. After more than six months had passed since they had begun trialling various methods and apps for lab inventory management, I felt that Tom and Nathan's plan to save money using tablets had failed. They had spent a lot of time and energy (and a small amount of money to buy some of the paid apps) and had not started saving money in the way they had envisaged. But the slippage allowed by the imaginary future constructed in the present meant that failure never occurred, it was always deferred or suspended. Without a definable moment of judgement, the tablets were always in a state of 'being trialled'. Instead of admitting failure or dealing with the issue of saving money in any way, the idea of saving money simply drifted out of focus. Towards the end of the six months of the ethnography, Tom and Nathan had stopped mentioning saving money altogether and instead focused on another of the themes I outlined above: the idea that tablets will change others' practices. Again this process of emergent definition highlights the fluid ontology of the tablet and its affordance ambiguity.

Towards the end of the ethnography, Tom and Nathan most commonly discussed getting others to adopt tablets. Rather than dealing with the failure of tablets, Tom and Nathan had developed the imaginary in response to their actual experience of using tablets, and chosen to shift the focus onto part of the imaginary that was more achievable in practice. This is referred to as 'closure', the perception of a group of users that a problem has been solved: "Closure in technology involves the stabilization of an artifact and the 'disappearance' of problems" (Pinch and Bijker, 1987: p.44). Closure is not objectively proven, it is an issue of perception. Tom and Nathan achieved closure, stabilising the tablet object for themselves, by what Pinch and Bijker call 'closure by redefinition of the

problem' (Pinch and Bijker, 1987: p.44). The temporality of the tablet imaginary as a future constructed in the present is key to the closure that Tom and Nathan used in order to stabilize the object into something that made sense for their use in the lab. The deferral involved here means effectively that closure cannot be permanently or definitively achieved, in the same way that I argued above that failure is not definable in the absence of a clear moment of judgement. Closure is always temporary; always a negotiated state that must be actively performed by users in the way that they construct the object. The term 'closure' suggests a fixity and stabilisation that I reject in order to maintain an emphasis on the emergent definition outlined throughout the chapter. As Wynne notes,

> Closure of the system as the ideal pursued by both experimentalists and technologists can never be complete, and is more problematic the more socially and physically extended is a technological system. Interference effects as a routine fact of life repeatedly tend to upset attempts to organize closure, and as technologies become more extensive, the discourse of tidy closure only engenders more disorientation (1988: pp.163-164)

While closure is an ideal, the concept nevertheless describes well the process and aims of technologists in making sense of their objects. Closure in this context can be thought of as part of the tablet imaginary in the sense that it is a guiding aim or principle, but one that always recedes due to the atemporal and emergent nature of the definition of the tablet.

Content-ambivalent

The content-ambivalence of the tablet imaginary also contributes to the emergent and fluid definition of the tablet object through closure by redefinition of the problem. They are adopted on the assumption that they will have unspecified benefits. The tablet imaginary is a constellation of ideas about what these benefits are: a set of ideas that is content-ambivalent because it consists of abstract ideas as opposed to specific means or methods to achieve these ideas. There is a case-specific imaginary, which includes ideas about what the tablets can be used for in a particular context, such as Tom and Nathan's

university laboratory. These case-specific imaginaries combine to form a general imaginary, which is what tablets represent in a society. The general imaginary functions in two ways: firstly, as a repository of abstract ideas that are formed into specifics in any given case; and secondly, as a projection of an imminent technological future that would be achieved if tablets were generally adopted. With no clear content to this repository of abstract ideas, there is no right or wrong imaginary that operates in any given context. So Tom and Nathan could begin thinking of the tablet as a way to save money, then reject this in favour of the idea that tablets benefit from being used by many people. There are of course cultural and social biases towards particular uses, with advertising undoubtedly contributing to some stabilisation of what the tablet is and does along with the attitude or advice of colleagues (both users and non-users). Nevertheless, the tablet imaginary is nebulous and abstract, meaning there is no definitively right or wrong way to construct the object. This content-ambivalence, along with the affordance ambiguity of the material object, allows the imaginary to be actualised in various different ways and for the object to be stabilised in various ways. As a consequence, what might be considered 'failure' to use tablets as expected (i.e. to save money) in fact becomes a new emergent stabilisation of the object. For Tom and Nathan, the tablet began as an object primarily defined by saving money and eventually became an object primarily defined by its use when connected with a network of other users. These moments of stabilisation are always fluid and temporary, always being actively played out by the users.

The outline of themes from the ethnography in this chapter traces the development of the imaginary from a repository of ideas with no signified, through various stabilisations which fluidly changed in response to the actual experience of using the tablet. These stabilisations are moments in which Tom and Nathan treated the tablet as having a well-defined single use. The list is not exhaustive but is indicative of the various ways that they defined the tablet. What was striking was the lack of overlap between these stabilisations.

Where near the beginning the tablet was a device to save money, near the end it was a device that increases efficiency if everybody uses it. While evidently temporary, each definition was distinctly totalising, with the tablet at each stage being thoroughly defined in a particular way. The content-ambivalent nature of the tablet imaginary allows for this type of fluid development in the construction of the object. This goes against common sense understandings of tablet as an object that can do many things. The affordance ambiguity of the object was expressed in *single* definitions, according to which the tablet could do one thing. As an observer my impression of the tablet as used by Tom and Nathan was one of multiplicity over six months. But my impression of Tom and Nathan's experience of the tablet was one of singularity in emergent moments.

Formative of and formed by individual uses

The characteristics of the tablet imaginary as having a fluid temporality and being content-ambivalent combine in the recursive nature of the tablet imaginary. The tablet imaginary is both formative *of* and formed *by* individual uses of tablets. To illustrate this final point, I will return to one of the themes outlined above: the 'inevitability of change'. The development of the notion of the inevitability of change is insightful in understanding how the imaginary functions. Tom and Nathan had a clear sense that tablets would soon be very important in universities and university laboratories. This was a key theme in the tablet imaginary and was their motivation to adopt tablets: they wanted both to participate in this imminent future and to help bring it about.

Tom and Nathan set out to use tablets because they clearly believed that tablets would be very useful, if not essential, in the future. Subsequently, they bought and began using tablets in the lab. Here an interesting twist occurred. The fluid temporality and the content-ambivalence of the tablet imaginary mean that failure is impossible to define for these objects. With no way to define failure, Tom and Nathan's mere use of tablets appeared as a successful use, with the consequence that other people in the department also adopted

them. In Nathan's words, "I think it's sort of rubbing off in a way. And people see how useful they are I think quite honestly". The twist comes here: the fact that many people started using tablets *made them useful*. As with any networked device, the more people that use it, the more useful it becomes. And the more useful it becomes, the more people use it. The development of the imaginary in this case took on an almost self-fulfilling circular route. The only thing that Tom and Nathan ever did with tablets was use them to try to find something useful to use them for. They arguably did not succeed in this goal. They never really achieved the imaginary that they sought to actualise. Yet in failing to do so, they encouraged others to adopt tablets, which to some extent did bring about one primary aspect of the imaginary: the inevitability of tablets becoming important and widespread. From 'adopted because they will be useful', the tablets became 'useful because they have been adopted'. As an affiliative object (Suchman, 2005), the tablet did not have to succeed or fail to be used in any given way. What their use did successfully achieve was the definition of the tablet as an object generally regarded to have positive externalities (Star and Ruhleder, 1994); being of general benefit to the lab. In the same process, they achieved the definition of their group of colleagues as a potential network of tablet users.

The imaginary 'tablets will inevitably be adopted' was formative *of* Tom and Nathan's use; indeed it was instrumental in their adoption of tablets in the first place. The imaginary was then formed *by* their actual use, where this same abstract idea took on a very different guise. Subsequent adopters of tablets in the chemistry department may well have engaged with the tablet imaginary in this second guise; wanting to adopt primarily because it was useful to join the flourishing network. The specific tablet imaginary for the users was substantively differently than that which Tom and Nathan engaged with. Yet it worked in the same way, to the same end. Users adopt new technologies based on an imagined technological future that they aim both to participate in and to bring about.

Chapter 6. Expertise: The use of tablet computers in an interdisciplinary neuroscience research project

"All we need to do is get all the tech to work" (Grace, research participant)

Introduction

In this chapter, I use ethnographic research in a neuroscience laboratory to further question the role of tablet computers in the everyday practice of science. Concepts developed in previous chapters are deployed here, but a new focus is taken in response to my findings and observations in this final case study. Once again, I found the participants' efforts to define and understand the role of the tablet was fundamental to their work. And as with the previous chapters, the particular circumstances that I encountered in the ethnography lead me to focus my analysis in particular ways. In this case, the neuroscience research examined in this chapter meant that the question of *expertise* became central. The status of scientist as expert and the distinction between scientist and technologist were tacitly interrogated through the practices and discussions of the laboratory group. These questions are taken up throughout this chapter.

This chapter focuses on the use of tablets in a research project by the London Group: an interdisciplinary research group involved in neuroscience. In stark contrast to the previous chapter, the tablet was treated by this group as a totally static, stable object with a clear definition. Of particular interest here is how this definition was 'given away' to a temporary member of the research group designated as the tablet expert. By giving away responsibility for defining the object, the main group avoided confronting the tablet's affordance ambiguity. They also asserted their expertise as neuroscientists as superior to

that of technical expertise that they assigned to tablets. As such, the case study allows an analysis of the way that the tablet was constructed in order to reveal the performative operation of expertise amongst the group. At the same time, an analysis of the attribution of expertise gives an insight into how the group understood tablets.

The primary way in which the tablet imaginary manifested in the ethnography was in the treatment of tablets as neutral. The tablet imaginary does not feature as significantly in this ethnography as in others, though it plays a crucial role. What was so interesting about the London Group's use of tablets was how they narrowed the definition of tablets so radically. This constraining definition does not hold much space for expressions of the imagery, meanings and discourses that make up the tablet imaginary. Throughout the chapter I elaborate on the role of this narrow definition and how it was used in the construction of the scientific subjectivities of the participants.

I draw on discussions of expertise from STS (Galison, 1997, Lynch, 2007, Collins and Evans, 2009, Coopmans and Button, 2014) to consider the role and the standing of computing expertise within natural science research. I compare expertise to digital literacy (Gilster, 1997, Bassett *et al.*, 2013) and consider how these terms value particular skills or competences. Lynch writes that 'science', 'scientific', 'scientist' and 'expert' are membership categories, "used tendentiously to claim or confer authority and credibility" (2007: p.161). I trace how the tablet acts as a focal point for the policing of boundaries of technoscientific expertise leading to inclusion of certain skills and knowledge and the exclusion of others.

Description of Fieldwork

Between November 2013 and August 2014, I conducted ethnographic research with a group of scientists at a UK University based in London working on a neuroscience project

examining spatial cognition[30]. This consisted of several visits to the main laboratory where they conducted the majority of their research, associated office spaces and attached labs and individual offices of researchers. During this time, I also conducted several individual interviews with key members of the group. Where quotations are given, they are taken verbatim from interviews. Where details of the research project or impressions of technologies used are given, they are based on my own non-participant observation of the work as well as comments made by participants outside of formal interviews.

Due to their location and their research topic, which examined navigation through a specific area of central London, I term them here 'the London Group'. Members of the group worked together, in neuroscience, at the same university. The group had interdisciplinary elements, with secondary interests including architecture, psychology and virtual reality. This main group consisted of a lab head, a postdoc, two PhD students and a Master's student. Also working on the project were one Master's student and one Bachelor's student working in neuroscience, one Master's student in computer science and one Bachelor's student in medicine. The Master's student in computer science, Edgar, became central to my analysis of this ethnography, despite the fact that I never met him as he was based in Belgium working on the project remotely. While the main group all worked together on several projects, I focus in this chapter on one specific research project, 'the London Project'. For clarity and because of the similarities of the terms, I would like to point out that this is not intended to reflect the ideas of the 'core set/core group' as the nomenclature is used in STS:

> A core-set has been defined as being made up of those scientists deeply involved in experimentation or theorization which is directly relevant to a scientific controversy or debate. A core-set is often quite small – perhaps a dozen scientists, or half-a-dozen groups. A core-group is the much more solidaristic group of

[30] Names of people, roles and buildings have been changed for purposes of anonymity.

> scientists which emerges after a controversy has been settled for all practical purposes. (Collins and Evans, 2002: p.242)

Edgar's role working on the project without being a member of the group disrupts the distinction between core-group and core-set or any other definition of membership defined by the research role conducted by a given person. Where I use the phrase 'main group', it refers to those working on the London Project that belonged to the research lab, headed by principal investigator (PI) Ian. When referring to other people who worked on the project but were not part of that research lab, I use the more widely-encompassing phrase 'London Group'. These terms also reflect the way that the participants spoke about different people working on the project.

The main group collaborated on several projects relating to spatial cognition each with a different focus comprising a combination of psychology, neuroscience and architecture. The lab head and PI on the project, Ian, summed up his research interests as follows:

> The research I do is all related to spatial cognition. How people think about space, how they navigate through space, how they remember space. With a particular interest in our group on how the brain represents that. So trying to understand how different bits of the brain perform or represent space.

The London Project aimed to understand how the brain represents space by conducting experiments in central London, by following participants trying to navigate their way through the city. This research entailed the use of several advanced scientific technologies, including functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG) devices. Along with these large pieces of scientific apparatus, the Project entailed the use of a Google Nexus 7 tablet computer and a Google Nexus 5 smartphone, each named for the size of its screen. Ian was also considering using commercial products such as Google Glass[31], a wearable technology that offers a sort of

[31] http://www.google.com/glass/ [Accessed 12th September 2014].

augmented reality, and Oculus Rift[32], a virtual reality headset. These products had not been used in any research projects but were being considered for future research. Ian was also keen to show me around other labs in the same building that used 'cool kit'. This included, for example, a device that used a laser beam fired at a mound of sand to replicate (with the aim of predicting) the patterns that lava flows from volcanoes may take. One of the PhD students from the main group had a desk in this open-plan computer lab, so I had an opportunity to spend some time in there. The tell-tale signs of a tech culture of *making* were evident throughout: soldering irons placed next to coffee cups on many computer desks; kits for DIY computers like Raspberry Pi[33] and Arduino[34] laying half-built or wired to obscure devices; whispered discussions about the Makerbot Thing-O-Matic 3D printer that it was rumoured another lab would soon purchase. While the main group whose work I studied did not use any of these technologies, it was clear that they were not too far removed from this DIY tech culture.

Wayfinding: The London Group's research project

To outline how each device or apparatus was used and to describe the research project, I will summarise the process that one participant would go through. As I had been told about various elements of the experiment, I was unable to be a participant in the project.

The participant is given a briefing in which they are told about the aims of the project to examine the brain's function during 'wayfinding': navigating around the city. The participant is then taken on a two hour tour of a specific area in central London, where the researcher points out various landmarks to the participant. The next day, the participant visits the lab, a room around 2.5 metres square containing desks against two walls each

[32] http://www.oculusvr.com/ [Accessed 12th September 2014].
[33] http://www.raspberrypi.org/ [Accessed 28th January 2015].
[34] http://www.arduino.cc/ [Accessed 28th January 2015].

with two computer stations. The participant is fitted with an EEG cap with eight electrodes that record brain activity. The EEG cap is connected to a computer in an adjacent room, separated by a large window. The researcher sits in this room and can view the EEG readout, as well as watching to ensure the participant is comfortable. The participant can see the researcher and can attract their attention if they would like to stop or ask for a glass of water. Upon entering the main lab, the participant is led to one computer, the same one each time, and views the PC monitor. They are played a video clip of a walk through the area of central London they had toured the day before, aiming towards a given landmark with the instruction 'navigate to location A'. The clip stops at several road junctions and the participant is asked if they would turn left, right or continue straight on to get to the landmark. The participant thinks about the best way to navigate to the target location and uses the mouse and PC to click icons indicating left, right or straight on. The video continues towards the landmark. Participants are told in advance that the video may not follow their response. Occasionally the destination is changed, and the process repeats for twelve routes, the first two considered training routes and the results not collected. Throughout this time, the postdoc who acted as the EEG technician would observe and record the EEG data. Afterwards, the participant has a debriefing session with the researcher to ask about the experience, how well they remembered the routes, and whether they were pressing left or right randomly at any stage.

Another group of participants undergoes a different experiment. In this group, the participant receives the same walking tour of London but does not visit the lab the next day. Instead, the next day the participant returns to the streets of London and physically navigates through the routes depicted in the video. They are fitted with a portable EEG cap to record their brain activity. They are given a backpack containing a laptop, which acts as both the recording device for the EEG and as a local Wi-Fi network to connect and sync the tablet and smartphone. The participant is given the Nexus 5 smartphone, which

conveys information about the route that they should follow, such as saying 'navigate to location A'. These cues are relayed to the smartphone by the researcher who uses the Nexus 7 tablet computer to send cues at appropriate times. The smartphone and tablet both use an app written by the Master's student in computer science especially for the experiment to send and receive these cues. The participant is given twelve routes via the smartphone, the first two considered training routes, and navigates through the streets accordingly. A debriefing session is undertaken to ask about the experience of navigating and whether the participant was choosing the route with intention or at random.

At the time of my research, it was undecided whether the results of the two groups were best published as a single comparative experiment or as two individual experiments. Although the second group of participants were navigating through actual city streets, both experiments were understood to take place within a lab environment. The lab for the first group is easily identified as the room in a university building in which the participants watched videos while wearing an EEG cap. Yet the streets of London were also considered a lab. Although lacking the clearly designated boundaries of a walled laboratory space, the streets through which participants navigated were part of the material setting (Latour and Woolgar, 1979) that is the general condition of the production of scientific phenomena, in this case EEG data regarding a participant's brain function while making decisions when navigating. In addition, the material setting of the street lab contained experimental devices including the laptop, smartphone, tablet computer and EEG headset that can be considered scientific instruments because they facilitate or determine the production of scientific phenomena, in this case EEG data: a distinction that I will return to later.

Designation of expertise

The designation of expertise was used as a discursive tool to define different members of the group and their roles. The Master's student who was responsible for the tablet and the app was defined as a *particular type* of expert, against the tacitly assumed scientific

expertise of the rest of the group. This discursive work in turn defined the tablet itself: the way that expertise was assigned to the object allowed me to infer the ways in which the tablet was understood. My aim in this analysis is not to engage in a normative argument about expertise (after Collins and Evans, 2002), but instead to observe how expertise was deployed by participants. Their practices can then be read as a way to see how different members of the group define themselves and others as experts of a particular type. As Lynch argues in reference to his study of courtroom settings:

> "By considering 'expert' and 'scientist' as membership categories that are deployed in moment-to-moment, institutionally embedded, discursive interaction, we can become apprised of the way parties position themselves and one another with respect to those categories and their conventional associations. (Lynch, 2007: p.178)

Making a lateral step from Coopmans and Button's treatment of *expertise* and *tacit knowledge,* I treat the different types of expertise expressed by members of the London Group as actor's categories: "treating them, and the activities relating to them, in terms of how they are ordinarily understood by those involved" (Coopmans and Button, 2014: p.760). These categories are based on my observations of the group's practices (thus 'actor's categories') but are of course intended to impose a sense of order at the level of analysis. To gain an insight into the manner in which expertise was defined and deployed, it is necessary to discuss the way that the group encountered and dealt with the affordance ambiguity of the tablet and how this was manifested in 'getting the tech to work'. In the case of the London Group, the designation of expertise was key to their understanding of the role of the tablet in their research project. Before a discussion of getting the tech to work, I will therefore spend some time outlining the group dynamics that led to one group member being designated the tablet expert.

Chronologically this was the third research group that I had dealt with as part of the current research and my initial impressions were very different from the other two. For

both the Lab, and Tom and Nathan, the initial impression was that much of their work and discussion regarding the tablets entailed attempts to define the object, work out what it could be used for, consider its limitations and so on. For the London Group, this discursive work was noticeably absent. They had a clear sense of what the tablet would be used for and how it would fit into their experimental setup.

As a PhD student in the group stated early on: "the preparations for the experiment are done. All we need to do is get all the tech to work." This comment was literally waved away, indicating that getting the tech to work was a mere triviality. The phrase 'the tech' here referred to the whole experimental setup including the EEG, laptop, tablet computer and smartphone. At that stage, the equipment had all been chosen and bought, but the setup had not been tested. It actually took a further eight months of testing before the setup was ready to be used in the collection of data contributing to publications. This testing primarily involved designing and troubleshooting the app that would connect the tablet and smartphone, allowing the experimenter to give cues to the participant. The app also recorded GPS location data, so that the precise location of waymaking decisions could be recorded. The app was written by Edgar, the Master's student working in computer science, who was based in mainland Europe. The fact that Edgar worked with the group on the same project suggests that he had at least 'interactional expertise', the ability to interact interestingly with the other party; or even 'contributory expertise', enough to contribute to the science of the field being analysed (Collins and Evans, 2002). I will return to a discussion of these terms shortly. Edgar was generally referred to as 'working with us on the project' or a similar phrase that at the same time expressed his belonging and his otherness. The fact that his membership of the group had to be stated in this way served to emphasise that he was only a temporary member. In my terms, Edgar was part of the extended London Group, but not part of the main research group.

Edgar's status as a collaborator but not a longstanding member of the group was significant in the way that the main group treated the tablet. I outlined above the wide range of disciplines represented by members of the group: architecture, neuroscience, psychology, medicine and computer science. Yet despite this range of expertise, all of the group members except the computer scientist were linked by an interest in neuroscience, as one PhD student stated: "[it is] neuroscience which links us all up because we all work in neuroscience now, except for Edgar who doesn't have any expertise in this". Despite different specialities and disciplinary affiliations, all of the group members apart from Edgar had shared neuroscience expertise. When asked about Edgar's role, Quentin, a PhD student with interests in architecture and neuroscience, described Edgar as "the person that brings the technologies together, the tablet expert". Again this description served to reiterate Edgar's separation from the rest of the group on the basis that he was not a neuroscience expert.

Far from being presented as a lack, this separation served to emphasise the difference between Edgar and the rest of the group. When asked why the particular model of tablet computer was chosen, the lab head Ian quipped: "Yes good question, what are the reasons for that? The team told me to as the PI! As the person running the thing!" Ian found it amusing and slightly embarrassing (in his words) that he did not have the expertise to make decisions about equipment selection for the project. Reflecting on this, he went on to discuss his role as Principal Investigator on the project.

> So as the PI I get in the grants and employ people to do things. And I have a team for that project where we're using these [the tablet and smartphone] and it was really them that came to me and said 'we're going to need to run it on the Nexus 4 [sic] and 7. Because the application that's been written by the programmer that we've been working with is designed for those devices.

Ian's outline of his role ('I get in the grants and employ people to do things'), though evidently oversimplified, aligns with Latour's distinction between those members of

scientific groups who do lab work and those engaged in bureaucracy (Latour, 1986: pp.155-157). Latour's discussion concerns the boundaries of scientific practice, which he follows out of the lab into the world of institutional, governmental and cultural politics, arguing in short that the lab worker "is able to be deeply involved in her bench work *because* the boss is constantly outside bringing in new resources and supports" (Latour, 1986: p.156). Within the more limited lab context that is my focus here, it was clear that Ian's perspective on the project was that he had facilitated and brought together various types of expertise to supplement his own. Against his slightly embarrassed response to the innocuous question about choice of device, Ian's response can be read as a justification for his lack of expertise relating to tablet computers. It was not simply that he did not know, which might be seen as lazy or incompetent, it was that he had *no need to know*.

In fact, Ian's discussion of different members of the group indicate that to some degree he was *invested in not knowing* about what he saw as the 'merely technical' aspects of the tablet's function: a point that I will return to shortly. On more than one occasion he commented that one member of the group or another *could have* learned the required programming skills to do the job that had been given to Edgar. In a quote discussing the postdoc EEG technician's expertise (and that also further illustrates Ian's lack of knowledge about the tablet and app), Ian observed that:

> He can make sure that the electrodes are all placed properly, that it's all working properly, all the troubleshooting that's required just for the one device to work requires many years of expertise. He could in theory have taken his time to learn how to program a mobile application. I think it was – a good question I don't know – whether it was written in Java or some other programming language. But we didn't – he didn't do that job.

With EEG expertise being conceived as equivalent to experience or time spent using the technology, Ian noted that there was not time for the postdoctoral researcher – undoubtedly an expert user of advanced technologies – to learn how to write an app and become a tablet expert. At another time, Ian commented that one of the PhD students was

using pencil and paper to note down certain results that she *could have* recorded automatically if she learned how to write a program to do so, "but it would have taken longer than her possibly writing them all down." Ian was invested in not knowing about the technical aspects of the tablet and the app because of the time pressures of the research. He indicated at the outset that he aimed to be in a position to submit for publication within a year; this timeline had been revised as problems with the app delayed the process. While conceding that other members of the lab *could* obtain the necessary expertise, this was not practically possible within the timescale of the experiment. The contradiction in this understanding was characteristic of Ian's treatment of tablets. On the one hand, he treated the ability to use a tablet as a fairly mundane skill that merely needed to be learned. At other times, he treated it as an expertise that was so sophisticated that it was beyond his comprehension and indeed beyond scrutiny. This apparent contradiction can be explained in reference to the materiality of the tablet computer: a point that I will return to at the end of this chapter.

Edgar's expertise was 'bought in' on the basis that he would be able to write the app and troubleshoot the experimental setup without needing to discuss, explain or justify what he was doing. His job was to make the experiment work. If Ian or any of the group members understood Edgar's role, they could have done the programming themselves. Any effort to understand the coding or programming of the tablet was effectively time wasted. The gap between their expertise and Edgar's was thus important to justify the decision of including Edgar at all. This added to the sense that Edgar's expertise and his work writing the app was separate from the rest of the group's work. The designation of Edgar's work as separate was part of an on-going contestation about where to draw the boundaries of the experiment. Galison notes other examples of computing practices within science research that raise questions about the definition of experiment and experimenter:

> Who counted as the experimenter in the $700 million detector planned for the Superconducting Supercollider, or in the only slightly smaller activities at CERN during the 1990s? Is the activity of the software designer for a subassembly of the detector 'experimentation'? (Galison, 1997: p.7)

The main group's negotiation of Edgar's expertise as simultaneously included and excluded from the research project demonstrate how "the physical, temporal, and epistemic boundaries of 'experiment' have been and remain in flux" (Galison, 1997: p.7). It also raises the question of 'passing' and whether Edgar's presence could have gone unnoticed by the others. Lynch argues that:

> For some of the more rightly controlled membership categories it is possible, but not very easy, for an imposter to 'pass' without being noticed. In the case of the family of terms associated with science (and the related, but not identical, term 'expert'), their assignment of persons, activities and facts to that category has well known strategic advantages, and thus efforts are made to control such assignments. (Lynch, 2007: p.166)

It was not possible for Edgar to pass as a member of the neuroscience expert group because of *their* need to police the category of scientific expertise. While he might not have considered himself an 'imposter', the main group's status was threatened by his inclusion and could not allow him to pass. They had to account for Edgar's tablet expertise in order to reaffirm their own neuroscience expertise.

Efforts have been made to account for and define the different types of expertise that may contribute to the production of scientific knowledge. In Collins and Evans' terms (taken now from Collins and Evans, 2009), the main group had "beer mat knowledge": knowing *about* the principles of programming and of tablet computers without knowing enough to *do anything* in this regard (Collins and Evans, 2009: pp.18-19). Edgar had a similar level of knowledge of the main group's research. This would fail to fit the description of 'interactional expertise', in which a person "may be able to *understand* scientific things, and to *discuss* scientific things, but is still not able to *do* scientific things" (Collins and Evans, 2002: p.35). Yet they all worked on the same research project that did produce publishable

results recognised by the scientific community as reliable, suggesting that each party might have acquired 'contributory expertise': "what you need to do an activity with competence" (Collins and Evans, 2002: p.14). The way that expertise was attributed within the London Group suggests that none of these categories are applicable. By actively framing their respective domains of expertise as incommensurate, the London Group tacitly reject the categories that Collins and Evans make available. At the same time, this framing was necessary for the successful 'doing' of the research project in question. Collins and Evans do offer a more finely-grained series of options to define various levels of expertise (Collins and Evans, 2009: especially chapter one), but at this juncture the abstract categories are beginning to lead the research material. I will move away from this mode of discussion that focuses on what expertise *is* and instead begin to analyse what expertise *does*. In other words, rather than trying to state what precise analytical category best describes the types of expertise observed in the London Group, it is more instructive to consider expertise as it is expressed by the actors in the case study, and how their definition of tablets intersects with their designation of Edgar as the tablet expert.

The terms on which Edgar's role was defined also served to cast his technical expertise in subservience to the scientific expertise of the rest of the group. While bringing in this other type of expertise to the lab, the main group also held it at arm's length, not allowing the tablet expertise equal status with their own scientific expertise. Although the inclusion of Edgar could be read as an example of the main group "building links and trying to integrate what they know with what others want to, or should, know and do" (Nowotny, 2003: p.155) and thus perhaps producing socially more robust knowledge (ibid.), the fact that Edgar's tablet expertise was cast as inferior suggests otherwise. It was at this stage of the ethnography that I began to focus on how Edgar's expertise was formed by the main group and how this articulated and expressed their understanding of their own research work. The tablet was deployed as an affiliative object (Suchman, 2005), a locus

where different types of expertise could be expressed and assigned value. Discussing the Xerox 8200 photocopier – a mundane object that became the focus of research – Suchman writes that, "To be recognizable as a scientific object, the 8200 had to be rendered interesting in the terms of the disciplinary communities with which the group, and each of us as individuals were affiliated" (Suchman, 2005: 385). For the London Group, the tablet was not rendered interesting in terms of neuroscience and remained an unscientific object.

The group treated the tablet as an object that facilitated the production of experimental data, but did not determine it. They treated the tablet as both theory-neutral and value-neutral, like the water pipes in Latour and Woolgar's (1979) example. The tablets were theory-neutral and did not reify previous scientific theory in the way that more familiar scientific instruments do. In the case of the tablets being treated as value-neutral, however, the situation was rather more complex. What made the group treat the tablet as value-neutral was an understanding of technical expertise as neutral: *which is itself a cultural value*. The group introduced the cultural value of 'value-neutrality of expertly-produced apps' into the experiment by including a tablet expert to write the app. Edgar's expertise could be unproblematically introduced to the group because his role was seen as a technical expert, somebody who could be given a brief to write the app as required without influencing the experimental setup, at which point his impact on the research project would end.

This point of analysis is significantly abstracted from the ethnography: the group did not talk about value-neutrality or discuss Edgar's expertise as neutral. I hope that the description of the case study – in particular Edgar's role – that constitutes a large part of the material in this chapter makes this point. My argument that this is a normative cultural value suggests that it will necessarily remain hidden, implicit, unsaid.

It is not unexpected that the London Group thought of the app as a neutral technology. The idea of neutrality is a central tenet of technological imaginaries. As

Feenberg argues, the instrumental view of technology is the most widely accepted: "It is based on the commonsense idea that technologies are 'tools' standing ready to serve the purposes of their users. Technology is deemed 'neutral', without valuative content of its own" (Feenberg, 2002: p.5).

Considering this perception of neutrality using the more specific example of software, Fuller argues that software "is seen as a tool, something that you do something with. It is neutral, grey, or optimistically blue" (Fuller, 2008b: p.3). The idea that software is neutral was critiqued in more detail in chapter two. Further to this, the London Group's perception of the neutrality of the app is challenged by the recognition that cultural values apply to programming practices. A particularly pertinent cultural value that is recognised as applying to software and coding is that of 'elegance': a concept defined by four criteria according to Donald Knuth:

> the leanness of the code; the clarity with which the problem is defined; spareness of use of resources such as time and processor cycles; and, implementation in the most suitable language on the most suitable system for its execution (cited in Fuller, 2008a: p.87)

Although technically definable according to these and other criteria, the concept of elegance is itself not reducible to the realm of the 'merely technical'. As Fuller argues:

> Elegance, because it cannot be proven, comes down to a rule of thumb, something that emerges out of the interplay of [given] constraints, or as something more intuitively achievable as style (in Knuth's terminology, an "art") (2008a: p.89)

Whether a rule of thumb, a style or an art, achieving elegance in software code is clearly a value defined within the technical and social culture of programming. The idea that simple code is preferred to complex code has parallels with the discussion of lab management apps in chapter three, which were seen to inhere the cultural value of efficiency. All of which is not to deny that an elegantly coded app might be advantageous to the London Group (indeed, it is clear that the elegance valued by programmers has

pragmatic value in terms of testing and so on). The point is that the assumed value-neutrality of the app, and of Edgar's practice more generally, does not hold up to closer scrutiny. Nevertheless, the group *did* treat the app and tablet as necessarily neutral elements of the experimental setup, and the casting of Edgar's expertise and his work as neutral was essential to the whole design.

It might be thought that this treatment of the tablet and app as 'merely technical' was a result of a cultural bias in which computing technologies were considered beyond (perhaps beneath) the concern of the scientist. It was not my impression that arrogance or cultural bias informed the group's perception in this way. At the same time, the discursive work that set the tablet and app within the realm of the 'merely technical' was not unusual in the laboratory setting. Latour and Woolgar observe that "the relegation of material processes to the realm of the merely technical" (1979: p.63) is key to the understanding of scientific data – what they calls inscriptions – as representative of an *a priori* reality that the scientific experiment simply reveals. Latour and Woolgar argue that in fact the inscription produced by the experiment (in their example a bioassay, in mine an EEG readout) "constitutes the construction of the substance" (Latour and Woolgar, 1979: p.64). The phenomenon that the data represents – such as EEG readings – is produced by, for, and because of the experiment. In other words, the experimental data that the London Group used as the basis of their publications would not have existed without the 'merely technical' equipment such as the tablets.

On this basis, the tablet is as important in the production of experimental data as the EEG cap or any other material object. Despite this, the expertise pertaining to the tablet was regarded as different to that of, say, the EEG. While Ian and the rest of the group had a good understanding of EEG data – how it was produced, recorded, interpreted and so on – they did not have any understanding of how the tablet functioned. This understanding was a gap in the expertise of the group that Edgar filled.

This gap in expertise was manifested when installing the app on the tablet. Edgar had sent the files relating to the app to the rest of the group in London with instructions on how to install it. The group in London found they could not install the app correctly until they received additional instructions from Edgar. Grace, a PhD student, argued that Edgar's expertise led him to underestimate the amount of instruction that the group required. Certain things that he took for granted in the process were simply not known by the rest of the group. In a parallel with Ian's initial embarrassment at his lack of expertise in this regard, Grace commented, "it was so stupid – we all use tablets!", implying that she felt the group should have been able to install the app without any problems.

Grace's comment recalls debates around a specific type of expertise: digital literacy. Gilster's work, which helped to popularise the term, gives this definition:

> A literate person can read and write his or her native language. In contrast, although computers work with their own languages, such as Pascal and C++, digital literacy doesn't mean we have to become programmers or learn to puzzle out long lines of computer code. It refers to a way of reading and understanding information that differs from what we do when we sit down to read a book or a newspaper. The differences are inherent in the medium itself, and digital literacy involves mastering them (Gilster, 1997: pp.28-29)

For Gilster, the move from literacy to 'digital literacy' involves the loss of writing as a key skill. As Basset, Fotopoulou and Howland argue, "Literacy implies dual importance for reading and writing, but much of the focus so far in digital literacy has been on the reading aspect" (Bassett *et al.*, 2013: p.15). Using Gilster's terms but setting aside the prescriptive nature of Gilster's work, we can read Grace's comment and embarrassment as evidence of the problem with Gilster's conception of digital literacy. Grace was digitally literate: she could use the tablet to locate, read and understand information. Though literate, Grace did not have the ability to *write digitally:* to create and manipulate content. Her frustration arose from the mismatch between this inability to write and being a competent *digital reader* or user of tablets. The apparent ease with which tablets can be used (read) belied the ease with

which they could be used (written). Going on to reflect on what we might call (now mixing the terms from Gilster and the critique by Basset *et al.*) the gap in between expertise and literacy that led to Edgar taking certain elements of the installation for granted, Grace speculated that the mark of an expert is that their work "becomes second nature." Grace's comment implied that Edgar's involvement with the project was aimed at saving time. It also implied that tablet expertise, unlike neuroscience expertise, is simplistic enough to become second-nature. In the context of the time-pressured research environment, the London Group did not have the luxury of waiting until one of the established members had trained in programming such that these processes were similarly second-nature.

Testing vs failure

Throughout the process of testing and installation several bugs and problems were encountered leading to significant delays. If they ran into a problem when trying out the latest iteration of the app, the experimenters would make note of the fault and pass the information to Edgar, who would fix it. This process was very definitely regarded as *testing*. While evidently failing to work as required, the tablet and app were not treated as failing, but as 'not ready yet'. The researchers' attitude seemed to be that the tablet was not yet in a position to be regarded as faulty or failing because it had not yet been finished. It would be pointless to complain that it was not working while it was still being tested. This led to a curious situation in which the tablet and app setup was not regarded as finished until it was free from faults. And as long as it was faulty, it could not be judged as failing because it was not yet finished. While this felt similar to the 'permanent beta' that characterised Tom and Nathan's use of tablets described in the previous chapter, it was different because there was a definite end in sight: the tablet fulfilling its experimental role. In comparison, Tom and Nathan cycled through several radically different roles for the tablet, rather than testing its success in one defined role.

It could be argued that this situation was a result of the affordance ambiguity of the tablet, meaning that there was no reliable definition of what it meant for the tablet to be working (echoing the experimenter's regress, see Collins and Pinch, 2014). This would fit with the analysis of the tablets as used by Tom and Nathan, discussed in the previous chapter, where Tom and Nathan cycled through different constructions of the tablet, taking advantage of its affordance ambiguity to *suspend* failure. It might also be possible to draw a comparison to the Lab, discussed in an earlier chapter, where the tablet's failure was denied by participants who split the tablet into generic and specific elements, allowing the object to be maintained by definition as infallible. Yet the context in which the London Group worked meant that something altogether different was taking place in the way that the tablet was defined and understood.

Where the whole collective of participants in both the Lab case study, and that of Tom and Nathan, were responsible for defining the tablet and making it work, the experimenters in the London Group had no such responsibility. It was Edgar's role to make the tablet work. In 'giving away' responsibility for the working of the tablet and app to Edgar, the main group had also given away their ability to define the object. This was not a mistake or a dereliction of scientific duty: it was crucial to the successful inclusion of the tablet in the experimental setup. By designating Edgar as the expert, the main group avoided having to deal with the affordance ambiguity of the tablet: a process that required users to wrangle with the expansive definitions of tablets as described in other chapters. This designation of expertise characterised the whole group's attitude to the tablet computer. The tablet was part of the experimental setup for which the group as a whole was responsible. Yet Edgar alone was designated as the expert who had responsibility for ensuring the tablet worked as desired. The way that the tablet was constructed by the London Group is significantly different from the two other ethnographies addressed in this thesis.

In the other ethnographies, the participants 'got the tech to work' by going through complex, contested processes of articulation that focused on defining the tablet in certain ways. In each case, the affordance ambiguity of the tablet was key to the understanding of failure, as it allowed for a proliferation of definitions, roles and meanings to be ascribed to the tablet – an almost unlimited flexibility of definition that allowed for the idea of perfection to gain currency in the Lab, as well as the 'suspension of failure' approach of Tom and Nathan, where the tablet never stood still long enough to be thought of as failing.

Both Tom and Nathan, as well as the participants in the Lab, began with a clear sense of *what* they wanted the tablet to do: act as a paper replacement; save money. The struggle to define the tablet arose when they had to determine *how* the tablet would do this. For the London Group, this was not the case. By working with a tablet expert, they gave away responsibility for defining the tablet object or exploring its potential. By ceding control of the definition of the object, they stripped the tablet of its affordance ambiguity. Giving responsibility for defining the tablet to Edgar meant that the tablet was rigidly defined. Edgar, the designated expert, was assumed to know the tablet's possibilities and limits. In a sense, although the group did not use this terminology, Edgar's job was to disambiguate the tablet: to turn it into a concrete, well-defined tool. His expertise meant that from the group's perspective, whatever and however he made the tablet work, that was the best possible way for it to work. There was therefore nothing ambiguous about the tablet.

The sense that Edgar's job was to disambiguate the tablet and turn it into a simple tool was reflected in the occasionally dismissive manner in which other group members discussed Edgar's role or the nature of his expertise. The group were never dismissive of the importance of his work, but were dismissive of the idea that they needed to understand what he did. To give one example, when asked about how location data was collected, one PhD student stated, "this is something you'll have to talk to Edgar about, it's something to do with GPS, I don't know." The hand gestures and demeanour that accompanied this

comment gave the impression that the question was being both literally and figuratively waved away: it was Edgar's domain, and therefore of no concern. The PhD student did not know and had no reason to know or find out. The researchers, like those in the Lab, and Tom and Nathan, did not have the expertise to easily deal with the tablet's affordance ambiguity. What set the London Group apart was that they gave the tablet to somebody who did have this expertise.

The result of the relationship that developed between the main group and Edgar was that little or no consideration was given to the tablets by the main group except during the actual trials to test the equipment. During the trials, they identified problems with the tablets without ever having to think about why those problems had arisen or how they might be solved. For the main group, the tablet was a black box that simply fulfilled a role in the same way that the EEG fulfilled a role. For Edgar, of course, the story is different. He did have to deal with the problems encountered during trials and he did have to decide how best to make use of the tablet's potential.

Edgar's role was to this extent comparable with those of the members of the Lab, and Tom and Nathan, who had to take the tablet, assess its potential, and put it to use in the best way possible. I previously discussed the affordance ambiguity of the tablet as a way of characterising the bewilderment with which the participants in other case studies responded to the tablets. Without a clear use for the object they were overwhelmed by its potential and found it difficult to 'close down' its meanings into a well-defined object. Yet Edgar's role was different. His aim was not to find the best possible use for the tablet: he had been given a brief about what function the tablet needed to perform within the context of the London Group experiment and he had to create an app that would make this happen. The success of the app was measured by the group, based on whether it worked well in the trials and fulfilled the experimental role for which it was designed. The main group decided *what* the tablet should do, Edgar decided *how* it would do this.

The London Group 'solved' the problem of affordance ambiguity by commissioning an app that would allow the tablet simply to fulfil the required function. The scare quotes around 'solved' indicate that this was not the group's stated intention: the inclusion of Edgar was discussed as a requirement because of the group's own lack of expertise (and the phrase 'affordance ambiguity' was never used by the group). Yet this did not simply move the problem along, leaving Edgar with the same issue of having to deal with the tablet's affordance ambiguity and struggle to find the best possible way to make the app work. Giving the problem away changed it. In giving Edgar responsibility for the tablet, they also gave him a brief. His task was to make the tablet record location data and send cues to the research participant's smartphone. He was not required to make the *best* use of the tablet in the sense of using it to its full potential, whatever that might mean. He was required only to make the tablet fulfil a prescribed role defined by the rest of the group. In this way, the tablet was stripped of its excessive potential (which in other cases discussed in this thesis led to an overwhelmingly expansive flexibility of definition) and turned into a fixed, stable object with a discrete function.

One response to the affordance ambiguity of the tablet is to be enchanted by its potentiality, its seemingly unlimited ability to fulfil any function. This was the response observed in the previous chapters where participants tried to find the best function for the tablet *by using* it. Another response, found in the London Group, is to close down this ambiguity by defining the object *before using it*.

Crucial to this was Edgar's *designation* as the tablet expert. By describing and treating him in this way, the main group conferred the responsibility for defining the tablet to Edgar. At the same time, they limited his responsibilities by giving him a clear brief. By definition, whatever he made the tablet do could unquestionably be considered the best solution because he was the expert. As outlined above, the main group showed virtually no interest in how the app worked, their only concern was that it fulfilled the brief.

Somebody else's problem

Getting the app to work as required took longer than expected. As the lab head Ian explained:

> it wasn't a surprise but we were struck by it – the biggest challenge in that experiment was getting it all to sync and getting the app to work basically was technically quite demanding. I was more convinced that the EEG would be really problematic because any sort of walking movements cause problems in these experiments. But that seems to have been OK.

It is clear that 'getting the tech to work' is not a simple requirement. It involved testing the experimental setup, noting any issues and trying to solve them. These issues took two distinct forms: problems and observations. The group's understanding of scientific and technical expertise informed how they managed these points of potential failure. One issue that was designated an observation, was entirely beyond the group's control, as Ian noted:

> On the whole, it worked, the performance of the subjects it was good, the technology worked. Interestingly, there was one hotspot in central London where the wireless went down consistently. Some street where maybe MI5 are bunkered or something!

While a light-hearted quip, this 'hotspot' clearly impacted on the group's ability to collect research data. The group's evident inability to solve the problem meant that they simply ignored it, relegating it to an observation rather than a problem. This distinction was key in my observations of the way that the group thought about the tablet. *Problems were issues that needed to be solved in order for the experiment to work. Issues that practically could not or did not need to be solved were relegated to mere observations*. Another issue that took this form was the processing speed of the tablet. One PhD student, Quentin, described the issue as follows:

> There's two devices and they have to communicate one to the other. And also we have the EEG headset and time delay that might be between something happening in the brain, the mobile EEG headset registering it, the laptop recording it, and the finger being the one that confirms whatever's happening on the app. Having to inbuild all the time delays, this was something we were also having to look into with the kind of, the physical aspect of the different devices and how precise they would be. Because in the brain, milliseconds are important.

> […] When you're actually recording these things and each second counts, each millisecond counts, this is something where you have to see, how fast is this tablet actually? My old tablet, for example, it wouldn't give us the same results as a Nexus.

The processing speed of the tablet was crucial to the accuracy of the experiment. As with the EEG cap, the possibility of upgrading the technology in this case was not much of a concern to the researchers. They were used to working with advanced technology that was regularly superseded by newer models. It was normal for them to accept this as something beyond their control and focus on the smooth running of the experiment with the technology that they had to hand – devices chosen because they were the best available at the beginning of the experiments. Again, this issue did not affect the basic function of the experiment, so it was relegated to an observation. Although not expressed by the researchers, it is reasonable to speculate that an approach to experimental design that focused on having the best possible technology would be doomed to failure as researchers would end up chasing the tails of the latest technology. The time taken to upgrade to a new device, introduce it to the experimental setup and troubleshoot it until it was working adequately would surely mean that the next new device would be available. Upgrading devices was seen as an impractical solution to an issue, so issues of this type became mere observations.

Similarly, the electroencephalogram ("worth £15,000" noted Ian) had only eight electrodes, while newer models have more advanced software and include more electrodes. Ian pointed out that clinical EEG setups typically use 19 electrodes but can use anything up to around 250. Ian said they may look into investing in new EEG equipment for the experiment, but this did not happen during my time with the lab. This 'problem' was really only a speculative issue brought about because the technology used by the group had been superseded by more effective models. It was not a problem of 'getting the tech to work' but an observation that this was not the perfect possible setup. The group did not seem

concerned by this, appearing to aspire to a working experiment rather than a perfect one. This attitude may have been informed by the relatively high rate at which the technologies they used in experiments were outstripped by newer models or became obsolete. This was a normal and expected part of working with advanced technologies such as EEG, fMRI, virtual reality and so on.

Another example of the problem of getting the tech to work related to the laptop that provided the local Wi-Fi network for the tablet and smartphone as well as recording the EEG data. Grace explained:

> And it was little things like, no matter how sure we were it was going to work if we closed the laptop lid – and we'd installed programs to make sure it wouldn't shut down – sometimes it would still shut down. So in the end, for some of the pilots then we actually physically put a jumper or something in the middle of the laptop so that it wouldn't close, because it would just shut itself down and there was no way of knowing that halfway through the experiment because you can't keep checking.

This decidedly low-tech solution worked well and became part of the standard experimental setup. It was also observed that the laptop was quite heavy and could make the experiment rather uncomfortable for participants who had to carry it in a backpack for extended periods of time. This was treated as a matter that *could* be resolved by buying newer, smaller and lighter technology, but such investment was not necessary to the smooth running of the experiment. The same applied to the EEG cap, which was noted to be rather cumbersome. Again this was noted as a comment rather than a complaint: in the absence of a more suitable EEG cap, the observation that the cap was cumbersome did not reflect a desire to improve the setup.

Many of the issues encountered in testing were bugs in the programming code for the app that would be considered a normal part of the process of software development. These were dealt with straightforwardly by the tablet expert. Again from the perspective of the main group, this was 'testing' rather than 'failure': things for Edgar to fix. They never

counted as problems because they never affected the main group. Any such issue was designated Edgar's responsibility and the main group forgot about it: it was somebody else's problem.

A final example of a problem leads us back to the beginning of the experiment and explains the reason for Edgar's initial inclusion in the project. This is an example of a problem with the tablet computer being 'given away' to the designated tablet expert. One problem with the tablet that was not treated as a mere observation related to the accuracy of its GPS. As it happened, the problem affected the entire experimental setup and was the reason that both a tablet and a smartphone were used, rather than just one tablet. When walking through a street with tall buildings either side, the 'line of sight' connection between the satellites and the tablet, required to give an accurate GPS reading, can be disrupted. The original experimental design included an automated system of location-based triggers, so that the app would automatically relay a cue (also called a 'probe') to each participant's tablet computer when they reached a specific location such as a road junction. Although in principle this would work, the material setting of the urban landscape in which the experiments would take place prevented this method, as Quentin commented:

> Given that there is that room for error, we can't risk programming when a probe comes up according to GPS location because it might be too soon, it might be too late, which means that we have to trigger these probing events ourselves.

This *was* treated as a problem: the experiment could not go ahead without relaying accurate cues to the research participant. This problem was resolved by changing the experimental method to have a researcher use the tablet to manually trigger the cue, which would be relayed to the participant's smartphone.

Nobody in the group knew how to do this. It was the identification of this gap in expertise that led to the group seeking a tablet expert and inviting Edgar to join the research project. Edgar was given the brief of writing an app to connect the tablet and

smartphone, as outlined above. In this way, the problem that might have caused the research project to fail was relegated to an issue 'given away' to the expert. At all stages of Edgar's involvement in the project, his status as the designated expert allowed the group to sidestep problems that would otherwise have arisen. Thus alongside the observations (issues that could not or did not need to be solved for the experiment to work) there were *problems designated to the expert*, which by definition were not problems for the main group as they were not of their concern.

Conclusions

In this chapter, the status of technical expertise compared to scientific expertise has been questioned by examining the ways in which a tablet computer expert was included in a neuroscience research project. These questions, in turn, open up analysis of the way that the tablet computer is understood in this context.

The inclusion of a tablet expert in the research project suggested that the main group considered this expertise to be on a par with their own scientific expertise. Yet Edgar was positioned as an outside expert who could be given a brief to write an app that could be simply given to the group. This illustrates that the group believed his expertise to be beyond the type of scrutiny typically allotted to scientific work. His expertise, along with the app that he produced, was considered to be value-neutral: contributing to the production of scientific phenomena without influencing the type of phenomena produced.

In designating Edgar as an expert in the sense described here, the group also implicitly gave a strict definition of the tablet computer as a tool for relaying cues from the researcher to the participant in their project. By identifying a process that needed to take place and then subsequently selecting a tablet computer to mediate that process, the group locked down the affordance ambiguity that was observed in other ethnographies to lead to a spiralling definition that required management, expressed in different ways in each case. It

was the designation of Edgar as the tablet expert that allowed this stable, fixed definition of the tablet to be maintained. By giving away responsibility for the tablet and app to a designated expert, the group by definition removed themselves from the process of working out the best way to use the tablet. Should they have tried to do Edgar's work themselves, I would speculate that they would have encountered the problems of definition that characterised the use of tablets described in the two previous thesis chapters.

As it was, the problems that might have been encountered were relegated to issues for which the expert was responsible. This discursive action meant that the main group never dealt with the tablet other than as a tool that worked. When it did not work during testing, this was never seen as a failure but rather as a normal (indeed essential) feature of testing, at which point the problem was 'given away' to the expert and the tablet was not seen or thought of again until it had been fixed. With responsibility for failure of the tablet designated to an external expert, the group never had to confront failure. Where the participants in the Lab *denied* failure by treating the tablet as perfect, and Tom and Nathan *suspended* failure by cycling definitions of the tablet, the London Group *designated* failure to an expert. In each case, the sheer amount of work that goes into preventing the tablet from failing is striking. In the concluding chapter I will make further comments on the idea of technologies that never fail, examining the power relations that are manifested in what seems to be an almost inevitable success of tablets.

In a final note, I would like to reflect on a response to a question that I asked Ian, the lab head, in an interview at the very end of my time with the group. I asked 'in general, what makes an expert tablet user?' I had expected his response to be clearly aligned to characteristics and attributes that he knew and admired about Edgar, the designated tablet expert. I was surprised by his responses, which I give in full below:

> What makes an expert tablet user? It depends what kind of expertise and again how are you thinking about [it]. You could be thinking about someone who's a software developer for tablets, you could think of them as being an expert tablet

> user, they're using it to generate something. There could be someone who's really good at making… I mean it's a device that you could run PowerPoint presentations off, you could take to meetings and talk to people about work and graphics with the way that other people wouldn't. You could use it for so many different things. And someone who's using it in the most flexible possible way, I'd imagine they would be an expert tablet user. But it's a curious question because it's so, it's not like a device where – so an expert in EEG as we were just discussing – you can clearly be an expert in technically how to get it working, how to get the most out of it and how to analyse the data and how to sell the data to the field. And how to review other people's work. All those things go into being an expert EEG person. But the tablet's so diverse that it's quite hard I think to answer that question. So I don't know if that's useful, but it's quite hard to answer it, yes. (Ian)

Ian still clearly thought of the tablet as an ambiguous object. Despite having worked through a research project in which the tablet was understood as a well-defined, stable object, Ian still thought of the tablet as multiple and expansive. I argue that this is further indication that the tablet was simply *not thought about* by the main group. Not that the main group were unaware of the affordance ambiguity that other participants had encountered. This final comment from Ian convinced me that the articulation of Edgar, the tablet and expertise achieved by him and his research group was not a coincidence. Perhaps it was not a conscious decision, but the designation of the tablet as unambiguous functioned as a strategy to mitigate against the problems that can arise from opening up the tablet's ambiguity. By designating Edgar as the expert, Ian did not have to think about tablets or their role at all. The ambiguous materiality of the tablet supported this contradiction. The tablet was a specific and well-defined object when being used by Edgar in his prescribed role. But this was not definitive. Outside of that specific context, the tablet was still ambiguous and expansive. Ian could not easily define what tablet expertise might be because he could not easily define what it was to use a tablet. The word 'use' in this sense is itself ambiguous. The argument that I outlined in relation to the case of Tom and Nathan, namely that the tablet is an emergent object, applies here too. The difference in this case is that the ambiguity was contained by designating an expert to handle a well-defined brief.

In terms of expertise, Ian's comments support an argument made by Coopmans and Button, that:

> people (scientists and others) do not move through the world as experts; whenever this is relevant as a description, they move through the world as experts in 'something' (Coopmans and Button, 2014: p.767)

As well as the definition of the tablet being emergent, the definition of expertise here is emergent. Edgar was not treated by the main group as 'an expert' in some general sense. And although they referred to him as 'the tablet expert', Ian's comments make it clear that he was not seen as a general tablet expert. Rather, he was designated as being an expert at the specific task designated to him: writing an app that would sync with the smartphone and tablet computer. This designation had a performative function that allowed Edgar to enact his expertise, through the practice of writing the app, and for the rest of the group to enact their expertise, by giving away responsibility for the tablet. In all this, the tablet retained its flexibility of definition, being treated as a specific, expert object when used by Edgar and as a general or 'merely technical' computing tool that required no consideration when used by the main group.

The expression of the main group's subjectivities as experts of a higher order than Edgar relied on a particular understanding of the tablet. The tablet's mundane everydayness was essential to the negotiation of expertise. It should be noted that the idea of the tablet as mundane would not have been part of the tablet imaginary at a different place or time. By 2014, the tablet had indeed become very widespread in many contexts. And the London Group's lab was already very tech-friendly, with much more exciting technologies to be found than tablets. The specificities of the site allowed for this particular construction. The main group affiliated Edgar and his expertise with the tablet defined as a banal technological device, disassociating themselves from it. There is a comparison to be made

with the 8200 Xerox photocopier that Suchman uses as an example of an affiliative object when it was being studied by researchers at PARC (Suchman, 2005). Suchman writes:

> Although the copier's mundane status was the thing that made it relevant for users and for the majority of the company, this very commonality continually threatened to undermine its, and our own, scientific standing. (Suchman, 2005: p.394)

Why should scientists concern themselves with a photocopier? Why bother thinking about a tablet computer? The neuroscientists constructed the tablet as a non-scientific object. This definition both allowed the tablet to be used within the experiment – it was treated as merely technical – and also asserted their expertise as neuroscientists who worked with fMRI and other impressive and recognisably scientific technologies. This draws on the tablet imaginary, especially certain advertising discourses that define the tablet as a commonplace, everyday device. The variety of settings (cafés, parks, living rooms, baths) and users depicted in advertisements for tablets supports – and is in turn supported by – the London Group's construction of the tablet as mundane, and their expertise as the opposite.

Chapter 7. Conclusion: The Year of the Tablet

Why 2010 Will Be the Year of the Tablet[35]

Deloitte: 2011 Will Be The Year Of The Tablet (Say Goodbye To Your Laptop)[36]

2012: The Year of the Tablet (Finally)?[37]

Will 2013 Be the Year of the Tablet?[38]

2014: The year of the tablet?[39]

The year of the tablet: Gartner predicts global shipments will finally overtake PCs in 2015[40]

2016: The year of the tablet[41]

Introduction

Throughout this thesis I have considered tablets and technological practices as part of a process of a future being constructed in the present. In chapter two I compared tablet users to Balsamo's designers: "they hack the present to create the conditions of the future" (2011: p.6). In chapter three I commented that "tablet computers, although not considered instruments today, may be considered instruments in future". Ben, the IT solution manager in chapter four, stated that cloud storage was "the direction of the future". In chapter five

[35] http://www.wired.com/2009/08/dell-intel-tablet/ [Accessed 4th February 2015].
[36] http://techcrunch.com/2011/01/20/deloitte-2011-will-be-the-year-of-the-tablet-say-goodbye-to-your-laptop/ [Accessed 4th February 2015].
[37] http://www.cio.com/article/2401144/it-strategy/2012--the-year-of-the-tablet--finally--.html [Accessed 4th February 2015].
[38] http://www.pcmag.com/article2/0,2817,2414200,00.asp [Accessed 4th February 2015].
[39] http://www.techradar.com/news/mobile-computing/tablets/2014-the-year-of-the-tablet-1225236 [Accessed 4th February 2015].
[40] http://thenextweb.com/mobile/2014/07/07/the-year-of-the-tablet-gartner-predicts-global-shipments-will-finally-overtake-pcs-in-2015/ [Accessed 4th February 2015].
[41] http://fortune.com/2012/07/12/2016-the-year-of-the-tablet/ [Accessed 4th February 2015].

Nathan said that tablets give "a futuristic impression". The only chapter in which this did not feature prominently was chapter six, where the participants gave very little consideration to this. The headlines that open this chapter are taken from mainstream or tech press, and demonstrate that the idea of a future constructed in the present is central to the tablet imaginary at the level of popular tech culture. The iterative process of claiming the certain triumph of the tablet computer in the near future works in the present to construct the device as essential *now*. Whether we define it as 2012, 2013, 2014 or any other year, the effect of such a statement is that the year of the tablet is always now.

As Atkinson's ill-fated *A Bitter Pill: The Rise and Fall of the Tablet Computer* (2008) demonstrates, you predict the demise of the tablet at your peril. It looks like the tablet computer is not going away any time soon. And I choose these words carefully, because this is precisely how the tablet imaginary works. As long as tablets promise to remain a going concern, they continue to be consumed, fulfilling the promise. This is not zombie media (Hertz and Parikka, 2012), obsolete and abandoned within the logic of capitalism, but lively media, full of potential for recuperation. In my analysis, it would make more sense to say that tablets and other mainstream everyday technologies are always actively being recuperated. There is no period of normal use in which they are current, before falling out of favour. A great deal of discursive work and embodied practices are required to construct tablets as in favour in the first place.

Yet this is not to say that there is any inevitability about the dominance of this media form. I hope that the detailed analysis of tablets being used shows the great fragility that characterises tablets' cultural position as popular media technologies. The fact that the tablet imaginary is the product of such a great deal of embodied and discursive work indicates that the appearance of easy dominance is itself a hard-fought and continuing battle.

At the same time as suggesting fragility, the fact that this continuing battle *is* fought – and by people with seemingly little investment in the success of the tablet in and of itself – gives reason for further reflection on the apparent ruthlessness of tablets' success. In the ethnographic research there is a noticeable absence of any clear discussion by participants of resistance or counter-hegemonic uses or descriptions of tablets. There were no naysayers who outright refused to use tablets. Of the many people that I spoke to, only one – an undergraduate student in a tablet lab trial – was vocally in opposition to using tablets, and this was specifically a rejection of the Apple brand. Of course I was actively seeking to speak to tablet users. An inherent selection bias means that people interested in using tablets are inevitably overrepresented. On the other hand, within the large group of people that I chatted with, observed and interviewed during the research, who were all invested in using tablets 'successfully', whatever that might mean in their particular context, there was in fact a great variety of uses.

Thinking in terms of resistance or counter-hegemony seems a rather blunt analytical perspective here. The concept of affordance ambiguity is based on the idea that there is no clear, obvious, normal or common sense use of tablets. Without a clearly defined way that one should use the tablet, it is difficult to identify ways in which this idea was challenged. Rather the use of tablets is a constant process of definition in which the normal or right way to use tablets is always being constructed. While a tablet user certainly *implies* several 'wrong' uses in this process, they only ever exhibit 'right' uses. Evidently there are significant intersections with dominant cultural discourses. A person's 'best' use of the tablet might look a lot like the type of tablet use set out in advertisements. The value of efficiency expressed in many uses of tablets was one way in which individual uses of tablets could be said to be of the dominant-hegemonic order. Conversely, somebody who establishes that the right way to use the tablet is to chop onions could be described as engaging in a counter-hegemonic practice, intentionally or not. The point is that each

individual user constructs the right way to use the tablet for themselves through the everyday practices that they undertake. While these practices draw on and are situated within an imaginary consisting of sets of cultural meanings related to tablets, they are not determined by these meanings. The everyday practices and the cultural meanings are mutually constituted in the process of using, defining and discussing tablets. The tablet imaginary is an analytical concept that can be used to connect micro everyday practices with broader cultural meanings, without favouring either.

Empirical Findings and Theoretical Implications

The ethnographies discussed in the thesis show a wide range of uses of tablets even within what appeared likely to be a fairly limiting context of science laboratories. When using lab management apps (LMAs), tablets functioned as objects of reified practice, bringing cultural values into scientific practice. This supports previous work on the production of scientific knowledge (for example: Latour and Woolgar, 1979, Latour, 1986, Kuhn, 1996, Galison, 1997) that highlights the way that scientific objectivity is itself a cultural construction. It also extends this work by considering the role of material digital objects as carriers of these cultural values. LMAs present efficiency as a common sense advantage and enact this value in ways that are obscure and difficult to challenge.

The tablet was used as a way to support the infallibility of the managerial hierarchy of the university in question in the Lab. This supported Barthes' account of myth as something that orders our thoughts about ideas, objects and people (Barthes and Lavers, 1993: p.109). The mythological power of tablets was shown in conjunction with a reflection on Sellen and Harper's (2002) work into paper replacement technologies. The unsuitability of tablets as a paper replacement in the Lab supported both Sellen and Harper's work – showing that the role of paper is often overlooked or misunderstood – and Barthes' work, showing that the objective utility of a technology can be overridden by mythical discourse.

This research demonstrated how the idea of objective utility is itself a mythical discourse. It contributed to understandings of myth by accounting for the ways that myths can be articulated in the definition of objects as 'potentialful'. The mythical power of tablets required both a general belief in technology broadly speaking as progressive, and a context-specific desire to focus on the potential of the tablet device itself. These two aspects operated concurrently in the Lab and were manifested in definitions of the tablet that 'slipped' between its actual and its potential functions.

The tablet was used by Tom and Nathan as a way of expressing their scientific subjectivities, shown most clearly in their perpetual testing of the device, always trying to find something else that it might be used for. The tablet here functioned as an affiliative object (Suchman, 2005), with Tom and Nathan using the material presence of the tablet in meetings to interpellate their colleagues as subjects of the ideology that tablets were useful and should be used by as many people as possible. The London Group used tablets to express sociality with objects (Knorr-Cetina, 1997) to very different ends. They defined the tablet as non-scientific and explicitly disassociated themselves from the object. They enacted their scientific subjectivities by constructing Edgar as a tablet expert, a role carefully defined as distinct from and inferior to their own expert roles.

The London Group used the paradigm of expertise to enact hierarchies of knowledge. Their inclusion of Edgar in the production of scientific knowledge served to simultaneously include and exclude tablet expertise from science. It was included by being framed as a functional, background element of the experimental setup, and simultaneously excluded by that same framing. The way that expertise was deployed by the London Group did not fit the categories of expertise offered by Collins and Evans (Collins and Evans, 2002, Collins and Evans, 2009). In my analysis, expertise did not function in a way that led easily to a schematic definition of this kind. The role of expertise was performative and its analytical interest was found in the relationships that it structured and how this was

expressed in definitions of the tablet. This supported feminist readings of expertise as a characteristic or category that is constructed along lines of gender and other identity paradigms (McNeil, 1987a, Jasanoff, 2006), which can be used to reveal the political effects of the designation of this category and its effects in people's lived experiences.

On the one hand, the tablet offers a multiplicity of uses, suggesting it is radically open to a variety of expressions of expertise and could be co-opted by otherwise disenfranchised groups or individuals to use on their own terms. On the other hand, the research does not offer such an optimistic view, instead suggesting that the tablet provides only new ways for existing power relations to be manifested. Tom and Nathan's relationship with Gloria; the London Group's management of Edgar's expertise; the Campus Regeneration Board's position of power over academic staff in the Lab in terms of defining the tablet; the value of (productive) efficiency being presented as a common sense benefit in LMAs. All of these examples demonstrate how uses of tablets had the effect of normalising dominant discourses as defined by those in existing positions of power. Alternative uses or expressions of expertise would not register as such, as tablets were used within contexts that included existing hierarchical social structures. Uses that threatened these structures were carefully managed by participants who had the existing social power to define right and wrong uses.

As well as these specific instances in which the research supported or challenged existing concepts and framings, the thesis as a whole has demonstrated how the fields of Media and Cultural Studies and Science and Technology Studies can be coherently linked within a research project. The focus within Media and Cultural Studies on everyday practices can be developed in studies of science and technology so that, firstly, the roles of people less obviously involved in science are recognised and accounted for and, secondly, the roles of mundane technologies such as tablets are taken seriously within the material setting of the laboratory. The role of app-based technologies has been shown to be

expansive and emergent and can never be assumed. Science and Technology Studies understandings of material objects can account for the variously enabling, disabling, determining or facilitating function of technological objects and the politics inherent in their use. These insights can be applied within media and cultural studies research to account for the role of media objects without falling into simple cultural constructivism or technological determinism, nor into chasing one's tail debating these positions. In this way, this thesis extends work undertaken in *Media Technologies* (Gillespie *et al.*, 2014), each chapter of which demonstrates the benefits of drawing these two fields together.

I have drawn on Gibson's (1986) concept of affordances to examine the role of tablets in the laboratory. Affordance ambiguity has developed and extended Gibson's original conception by applying it to a complex technological object that could not be accounted for by the idea as developed by Gibson in terms of visual perception. The thesis also challenges other adoptions of this concept, especially that of Norman (2002), arguing that this way of understanding objects, while offering an excellent prescription for design work, has a depoliticising effect. Considering the politics of technologies and their uses is an essential part of research and analysis in fields such as Media and Cultural Studies and Science and Technology Studies. Affordance ambiguity returns users to their central role in thinking about affordances as emergent properties constructed in the relationship between people and objects in specific, situated contexts of use. This reinforces the idea that the way that an object is defined is performative and inherently political.

Limitations

All of the research took place within university laboratories. The technoscientific culture that operates in these labs is very different from industry labs. The absence of industry laboratories is a gap in this research that could be explored in future. The academic structure of UK universities may have played a significant role in the way that

tablets were understood. The cultural context of the UK certainly did. The research was conducted within a Russell Group university, a former 1994 Group university and a former polytechnic university. This range of types of institution may help to give a broader understanding of the roles and effects of tablets in science labs. This breadth of course also comes with its own pitfalls as it loses the potential insight from examining the similarities and differences between two similar institutions.

Working with a new media technology such as the tablet computer means that the research is vulnerable to being superseded by the latest device or a significant shift in the cultural construction of tablets. While tablets remain a popular media form, the imaginary has certainly developed throughout the process of this research. When I began researching tablets they were still very much a novel and exciting device. Many people that I spoke to in the early stages of my research had never heard the term 'tablet computer'. In January 2012, not long after starting the research, I bought a Samsung Galaxy Tab 10.1. Colleagues, friends and family were all keen to have a play with the funky new device. A year later in January 2013 I bought an iPad Mini. Nobody cared. The novel had already become mundane, the uncommon had become commonplace. I mention this to highlight one way in which I personally experienced the development of the tablet imaginary and observed the changing cultural position of the tablet. What the tablet *is* has changed.

I believe that this limitation is curbed in two ways. Firstly, the research at the very least can stand as a record of the ways that the tablet was understood in the particular contexts described at that particular historical and cultural moment. Secondly, and somewhat in contradiction of the first point, the focus on emergent meaning indicates that there is never a stable or fixed meaning ascribed to tablets. The thesis has sought to unravel definitions of tablets in different contexts. But this has never been with the aim of stating what tablets are definitively. The aim has been to understand the effects of the process of definition. In this

way, the newness or oldness of the research material should neither increase nor diminish the value of the analysis.

On a similar note, the ethnographic approach and reliance on understanding meaning as emergent and situated means that the work is not directly generalisable. It is not possible to say that a lab study of tablet use in another lab is likely to follow any patterns observed in the work presented here. But this does not mean it does not help to make connections with, challenge or justify other research. Suchman, citing Mol and Law (2002), puts it like this:

> […] Methodologically, it means that the value of a case such as that offered here lies not in its instantiation of a general theory but in its suggestions for further – comparative and contrastive – investigation. Cases, like objects, are multiple, affiliative and subject to mutual interferences as well as partial connections. (Suchman 2005, pp.394-395)

Other investigations into the use of tablets in labs may well find that they are used in totally different ways than observed in this research. This does not mean that we must map every use of tablets before a useful understanding of their adoption can be gained. Each ethnographic case study is indicative of ways that tablets are used in particular ways for particular effects. Differences in use may belie similarities in the fundamental operation: expressions of different subjectivities may be achieved in very similar processes. This point connects to Tom and Nathan's interpellation of colleagues as potential members of a mutually beneficial network. On its own, research into the uses of tablets can achieve a great deal. Combine this research with others and the benefits are exponential. A greater body of research allows for a better understanding of the processes that are specific to a given case study and those that operate more generally.

Recommendations for future research

There are some clear directions that future research in this area could follow to build on the strengths and remedy the weaknesses of this work. Firstly, the concept of

affordance ambiguity could be developed in other contexts. I believe that this concept can be beneficial in the analysis of uses of tablets and other app-based technologies. Smartphones can be addressed in this manner. More recent Windows PC operating systems have adopted the app paradigm. Thinking about affordance ambiguity in relation to these devices may open up the politics of these devices and platforms. Research presented at the MeCCSA conference in January 2015 (Yates *et al.*, 2015) considered how the concept of affordances might help to theorise digital access in terms of cultural capital, exposing the politics of inclusion and exclusion behind drives to digital literacy. This suggests a clear direction for the application of affordance ambiguity in other research contexts.

While the laboratory has been the site of research presented here, these themes can be developed both within and beyond laboratories. Different contexts of practice may be considered. Some obvious suggestions would include considering affordance ambiguity and the management of failure of paper replacement technologies in office contexts or commercial or educational settings.

One specific area for further research raised by this thesis concerns lab management apps. The adoption of LMAs could act as a focal point for considerations of sociality with objects, the automation of the cultural value of efficiency and the role that new media technologies play in instantiating new research practices within science labs. Research that took this direction would be more explicitly focused on analysis and critique of the production of scientific knowledge. This is another more general area in which concepts from this thesis such as the tablet imaginary could be developed.

Finally, the thesis indicates that studies of technology adoption can benefit from being situated at the intersection of Media and Cultural Studies, and Science and Technology Studies, as I have presented it here. Theoretical analysis of the correspondences and conflicts of these fields may in turn indicate further areas for research.

Conclusion

This research has focused on the situated practices of technology users. I have presented a range of ways that tablets can be used in the definition of subject positions, the expression of institutional power and the regulation of boundaries of knowledge production. In every case, it has been shown how the definition of tablets is an active process. Some users, such as Tom and Nathan, seemed overall to be empowered by the actions of definition. Others, such as Edgar, seemed to be the *object* of the process of definition, not the subject. At times during this research I was dismayed to observe instances where I felt individual users were unable to define the tablet on their own terms. For example, the tablet being defined as perfect according to the preferences of the university institution in the Lab, or Edgar's disenfranchisement as his expertise was downgraded by the careful boundary management of the main neuroscience group. I now see that the real value in this research has been outlining the sheer amount of work that goes into the definition of an object. The dominant meaning is not easily come by and it does not support itself: it must be maintained in the perpetual process of definition. It is in specific uses of a technological device that its definition is expressed. This means that it is users who are doing the defining. In one sense, this is an incredibly empowering position. On the other hand, the definitions that users enacted served to structure and reiterate existing power relations. There is a final unanswered contradiction in this analysis. Is the vast amount of work that users must undertake to support the definition of the tablet best understood as a fragile basis for a dominant ideology, or a ruthless process of technoscientific ideological dominance that draws on the unpaid (or in fact paying) labour of users to support itself? Are users emancipated by the power to define, or are they exploited by the same process?

These questions were the root of my interest in failure. Failure structured power relationships. Observing practices where users defined tablets in one way, then used them

in others, cycling through a range of definitions that appeared never to correspond to a single material object, I wanted to interrogate the role of failure in discursively managing the object and the power relations relating to it. Failure can be an empowering claim in practices of resistance. It would have been easy to imagine the users in the Lab claiming – against the desires of the management hierarchy – that the tablets just did not work. The power dynamic between the London Group and Edgar was characterised by a play between the failure of tablets and the failure of Edgar to make the tablets work, in favour of the latter interpretation. Tom and Nathan's personal and professional investment in their own tablet project similarly led them to strive to avoid failure. Each of these examples speaks to ways in which disciplinary power functioned to avoid or disavow the claim of failure of a technological device. This indicates that much more is at stake in the management of failure than the simple desire to make a device work.

In the introduction I argued that the imagery of the stone tablets of the ten commandments was relevant to today's tablet computers because buying a tablet computer involves "accepting particular beliefs, adopting a particular value system, and carrying out certain ritualistic everyday practices." The irresistible draw of the tablet comes from its promise to offer a wide range of everyday practices (affordance ambiguity) that make sense within a variety of value systems (tablet imaginary). The tablet is not the sole property of the geek, nor the business person, nor the scientist, nor the person watching iPlayer in bed. The lack of restraint of uses or meanings pertaining to the tablet means that it can always fulfil its promise, whatever that promise may be.

Tablet computer users can relatively easily find a range of beneficial uses for their tablets. Deciding what they had originally wanted it for seems to be a secondary – and far more challenging – problem. It is in the work of definition, of matching the actual uses to the imagined promise, that tablet users create and maintain a dominant definition of tablets as indispensable, futuristic, and inevitably successful. Working out what a tablet is for

entails using it. And finding new uses entails creating new imaginaries. New imaginaries demand further articulation, and the process reiterates in what I described earlier as a perpetual beta. Does this process suggest that this dominant definition of tablets is fragile or ruthless? I would argue that this perpetual beta is a fragile basis for any particular dominant ideology. The idea of tablets as futuristic might not make sense this time next year, and it seems unlikely that tablet users will forever continue to enact this discourse.

By promising such a range of uses, tablets open themselves up to the challenging of dominant meanings. The idea that tablets are efficient work tools seems particularly open to opposition – intentionally or otherwise – by the practices of streaming film and TV, for example. The way that boundaries of home/work are policed or self-policed suggests that this is a concern for companies or institutions that wish for the dominance of a work-oriented understanding of the tablet as a modern-day Filofax, rather than a modern-day Walkman. Of course, really the tablet is both at the same time. Perhaps the most likely form of opposition, the most viable mode of users being emancipated, not exploited, by their power to define the tablet, comes from this ambiguity. Tablets might offer a particularly simple means to engage in 'la perruque' (de Certeau, 1988: pp.24-28), the cooption of the means and time of capitalist production (or service provision or some equivalent) for one's own ends. It may well be that behind the adoption of efficient, futuristic tablets is a rational decision by users to put on a front of efficiency in order to get away with its opposite. While perhaps not changing existing power relations, tablets may offer users a means of subterfuge and self-expression that is enabled, but not constrained, by those power relations. In this sense, the idea of playbour (Kücklich, 2005, Goggin, 2011) might be recuperated as a means of disguising counter-hegemonic practices. Learning to use a tablet may well entail learning to labour, but it may also entail learning to avoid work, to find moments and means of personal fulfilment provided within the digital spaces of capital. While certainly not revolutionary, these practices at least show the potential for

tablets to offer ways and means of resistance to imposed capitalist practices. In contrast to this optimistic picture, Jordan (2015: p.152) reminds us that the idea of playbour, effected within 'fun' working environments, is a standard working practice for employees of companies such as Google and Microsoft, whose practices are evidently not counter-hegemonic or resistant to capitalism. Furthermore, entry into this potentially liberating space is itself an entry into capital. This fundamental point about any tablet computer practice is best exemplified by the ironically named 'Ultimate App' (Miller and Matviyenko, 2014), part of an art project exploring the role of the app as an impossible object. The Ultimate App, once opened, simply takes a payment then shuts itself down and has no further application.

The tablet computer's openness to interpretation and different uses suggests that there will never be a clear dominant definition of what it is for (although I would suggest that the Ultimate App elegantly expresses its most basic function). The definition seems to be so context-dependent that the idea of a single dominant *definition* may be impossible. But this does not mean tablets cannot support a single dominant *ideology*. The process of perpetual beta is a solid basis to maintain a dominant ideology of technological rationality. All the time that tablets are used – whether as prescribed by marketing discourses, as demanded by workplace hierarchies, or as preferred by an individual – there is a sense that tablets are paradigmatic of technological progress. The discourse of new technologies as futuristic or efficient might feasibly change as uses of tablets change, but the ideology of technological rationality will not.

One summary of the findings of this research would be that, according to their users, tablets can do anything, except fail. As Tom and Nathan's view of their colleagues showed, even the non-adoption of tablets is in some way determined by a discourse of network effects in which non-users are considered not only to be not benefitting themselves, but to be actively detrimental to technoscientific progress in general. Combined with this,

affordance ambiguity – expressed as the idea that tablets can do anything – leaves no room for a person to argue that they do not want or need to use a tablet. How can you not need something that does everything? There is something both ruthless and irresistible about the framing of this question. No matter what a tablet computer *is*, it will always be able to fulfil its promise: a promise constructed in its own self-fulfilment.

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