Augmented Postphenomenology

A (post)phenomenological and ethical exploration of Google Glass

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Abstract

On April 4, 2012 Google publicly announced the existence of a new wearable computer we know today as Google Glass. Over the past two years Google Glass has provoked considerable discussion due to its functionality, design, and the concerns it raised about privacy. In my thesis I first assess the various claims and expectations that have been raised about Google Glass. I base this analysis on the history of wearable computing, and the ethics of new and emerging science and technologies (NEST ethics). I conclude this assessment with a nuanced picture of what Google Glass currently is, might become in the near future when a consumer edition comes out, and could potentially become in the far future (~2019).

Based on this assessment, I perform a philosophical analysis of the speech and gesture recognition features of Google Glass, and its augmented reality applications, using postphenomenology. Additionally, I explore the current ethical debate on Google Glass through comedy. Postphenomenology is a theory that describes how specific technologies change the way we perceive and act in the world. In my thesis I argue that Google Glass raises two main challenges for postphenomenology. First, the Google Glass gesture and speech recognition features do not really fit the typical visual metaphors, and the level of abstraction that postphenomenology currently adopts. Neither does it capture the social effects that looking upwards to a screen slightly above your line of sight, or speaking to a wearable computer on your face, have on people nearby. Second, some Google Glass explorers have developed augmented reality applications for Google Glass. However, the way these applications change the way we interpret (hermeneutics) and know (epistemology) the world and people seem hard to address from a postphenomenological point of view. More specifically, it is not clear *why* people accept the interpretations of the world offered by Google Glass. For example, why do I accept and follow the route provided by a navigation system? Nor does it address, how alternating my focus between the Google Glass screen and the world, and thereby the Google Glass interpretation of the world, and my interpretation of the world, influence each other. For example, WatchMeTalk allows deaf people to see a transcription of what another person is saying. However, thereby the deaf person has to focus on the screen and does not notice the non-verbal communication of the person he is talking to. Nor does the deaf person make eye contact when the other person is speaking. In turn, the other person is able to notice both the deaf person's gestures, as well as his speech. I address both challenges to postphenomenology by drawing on a number of philosophers. Based on the work Maurice Merleau-Ponty, Alva Noë, and Don Ihde I augment postphenomenology, and thereby address the first challenge. Based on the work of Hans-Georg Gadamer I address the second challenge.

In the final chapter I approach five comical YouTube skits as scenarios that explore the ethical issues raised by Google Glass. In that way we can discover which ethical issues are currently being raised by Google Glass. After we have gained a broad overview of this ethical debate, I use the augmented version of postphenomenology to explore and clarify the privacy issues raised by Google Glass.

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Chapter 1 - Introduction

On the 4th of April 2012, Google publicly announced the existence of Project Glass, a technology that would be “there when you need it,” and gets “out of the way when you don’t”(Google Glass, 2012). Their announcement also contained a brief mock-up video that illustrated a day in the life of a future Project Glass user. During his day the user receives various notifications, is able to view maps, take pictures, and video-chat with his girlfriend, all within his field of view (cf. Google, 2012). Furthermore, he interacts with the device through speech. As the makers of the video chose to demonstrate the technology from a first person perspective, it remained unclear what the actual device looked like. On June 27, 2012, Google revealed the actual device at their annual I/O conference through a spectacular demonstration with sky-divers, stunt bikers, and abseilers, followed by a talk of the lead designer and engineer (minipcpro, 2012). The device turned out to be a wearable computer that could be worn like a pair of glasses (see Figure 1-1). However, the Glass team designed this computer with only one prismatic glass that functioned as its display. Furthermore, the team located the display slightly above the right eye, so that it would not block the users view. The company also announced that only US-based attendees could pre-order the product at the conference for $ 1500,-(, t. 27:54-30:43).

Figure 1-1 - Google Glass. Official press picture.

In the past two years, many things have happened with regard to Project Glass, including a name change to Google Glass. At the moment the product is available to anyone in the USA and the UK, Google has published documentation for both users and software developers, and Google Glass has received considerable attention from the press, comedians, companies, entrepreneurs, and a wide variety of users (e.g. Angelini, 2013; Assad-Kottner, 2013b; Google, 2014f, 2014k, 2014p; Google Glass, 2014e, 2014h; Huzieran, 2013; Misslinger, 2013).

With all these developments going on, why would I want to write a master thesis about it? First, I wrote this thesis because Google Glass raises several interesting philosophical questions. More specifically, in this thesis I argue that Google Glass raises two challenges for postphenomenology. Here postphenomenology refers to a philosophical theory that describes how specific technologies change the way we perceive and act in the world (see chapter 3) [1]. The first challenge for postphenomenology is that the gestures and voice commands by which the user interacts with Google Glass, and the social effects these interactions have on people

[1] I have chosen to focus on postphenomenology in this thesis, as the changes in perception, action, and interpretation that Google Glass provides, are key features of this technology(cf. Pavlus, 2013; Selinger, 2012; Topolsky, 2013). Postphenomenology is a theory that systematically analyses how specific technologies change action and perception. Hence it provides a good point of departure to analyse a technology such as Google Glass.

near the Google Glass user, cannot be analysed substantially by postphenomenology. The second challenge arises when Google Glass displays information that fits well within our current context. In that case we often start to interpret that context differently as well. For example, when I receive navigation instructions on Google Glass, the road before me is no longer just a road, but has become part of a route to my destination. Postphenomenology does not offer a systematic way to analyse how such new interpretations arise. That is the second challenge. In addition to these two postphenomenological challenges, Google Glass raises a number of ethical issues with regard to privacy, the appropriate ways to use Google Glass, and several other things. In this thesis I will address these two postphenomenological challenges, and aim to describe, clarify, and resolve some of these ethical issues. Second, another reason to write a master thesis about Google Glass is because fairly little has been written about actually resolving the ethical issues that are raised by wearable computers and augmented reality (i.e. the virtual context-aware notifications Google Glass provides to its users). Most literature tends to describe these issues, but does not offer concrete guidelines or design suggestions to resolve them (cf. Pase, 2012; Viseu, 2003).

1.1 Aims and research questions

Based on the above considerations the aims of this thesis are twofold. First, I aim to resolve the postphenomenological challenges in order to arrive at an adequate description of how Google Glass influences the way we perceive, interpret, and act within the world. Second, in my view an adequate description of Google Glass can in turn help to describe, clarify, and possibly resolve the ethical issues raised by Google Glass. In that way, I aim to contribute to the ethical debate on Google Glass, and more generally to the debate on ethical aspects of wearable computer and augmented reality technology. As this thesis pursues two aims, I have formulated two main research questions:

1. *How can we describe Google Glass from a (post)phenomenological perspective? (MQ 1)*
2. *How can we use this (post)phenomenological description to clarify and possibly resolve the ethical issues raised by Google Glass?(MQ 2)*

In the above two questions, and in the title of this thesis as well, I have deliberately added parentheses around ‘post’ in ‘(post)phenomenological’, because I will regularly draw on classical phenomenological studies and methods as well. Apart from that remark I have formulated the following subquestions:

Subquestions for MQ 1

1. Given the many claims made about Google Glass, what can we realistically say that Google Glass is at the time of writing?
2. In what ways does Google Glass challenge postphenomenology as it is presented by Verbeek, and how do we address those challenges?
    a. How do the speech and gesture recognition features of Google Glass, challenge postphenomenology?
    b. How do the ways in which Google Glass augments the user’s interpretation of reality challenge postphenomenology?
    c. How do we augment postphenomenology to address these challenges?

Subquestions for MQ 2

1. How did Google Glass stimulate the moral imagination of comedians and which ethical issues did they raise?
    a. How was the moral imagination of these comedians stimulated by Google Glass?
    b. Which issues were raised?
    c. Which issues are currently missing in this debate?
2. How can we use the augmented postphenomenological methodology developed earlier (MQ 1, subquestion 2), in a normative analysis of the privacy issues raised by Google Glass?

Let's now turn to a brief outline of this thesis, to see how I plan to answer these questions.

1.2 Outline of this thesis

Chapter 2 answers the first sub-question for MQ 1. Many people have made claims about what Google Glass is, but not all of these claims are correct. In this chapter I therefore aim to separate the proverbial wheat from the chaff, based on the history of wearable computing, and a method from the ethics of new and emerging science and technologies (NEST-ethics) described by Lucivero, Swierstra, and Boenink (2011). This chapter ends with a brief taxonomy of claims and expectations of what Google Glass currently is (~August 2014), and might become in the near future (~end of 2014, Q1 2015), and far future (~2019).

Chapter 3 answers sub question 2a, and provides the first part of my answer to subquestion 2c, both for MQ 1. In this chapter I first introduce phenomenology and postphenomenology. Next, I use postphenomenology to analyse the gesture and speech recognition features of Google Glass. I argue that each of these features raises two challenges for postphenomenology. In turn, inspired by the work of Alva Noë I introduce the new concept 'mode of exploration' to postphenomenological theory. I define a mode of exploration as a way in which both humans and technologies, interact with *and* perceive one another, or interact with *and* perceive the world. I then operationalise this concept by using the work of Maurice Merleau-Ponty and Alva Noë to substantiate the gestural mode of exploration, and thereby address the challenges raised by the Google Glass gesture recognition features. Additionally, I use Don Ihde's work on the phenomenologies of sound to substantiate the auditory mode of exploration, and use that to address the challenges raised by the speech recognition features of Google Glass. I end this chapter with some notes on how to apply this in various practices.

Chapter 4 answers subquestion 2b, and provides the second part of my answer to subquestion 2c, both for MQ 1. There has been some debate on whether Google Glass provides augmented reality technology. I start this chapter with an analysis of two often used definitions of augmented reality, and argue that under these definitions Google Glass does not provide augmented reality. However, these definitions only focus on the ontological aspects of augmented reality (i.e. on the structural features of the technology), and thereby overlook the hermeneutic and epistemological aspects of augmented reality. In other words, these ontological definitions do not explain how Google Glass augmented reality software changes my interpretation (hermeneutics) or knowledge (epistemology) of the world. Next, I provide a definition of augmented reality that specifically includes these aspects. Based on this alternative definition I explore whether postphenomenology and the augmented version of postphenomenology presented in chapter 3 (i.e. augmented postphenomenology) are able to analyse 4 augmented reality applications for Google Glass. I argue that these applications raise two additional challenges for augmented postphenomenology. In turn I use five concepts from the German hermeneutic philosopher Hans-Georg Gadamer to address these challenges.

Chapter 5 addresses MQ 2 and all of its subquestions. I first argue that comical Youtube skits can be approached as scenarios to explore the current ethical discussion about Google Glass. Based on this argument, I discuss five skits that reveal a number of ethical issues raised by Google Glass. Based on this discussion, I focus on the privacy issues, and use augmented postphenomenology to explore which issues are currently missing in the debate, how these issues can be clarified, and how augmented postphenomenology can be used to suggest alternative designs to resolve these issues.

Chapter 6 briefly summarises this thesis and provides some suggestions for further research.

Let's now turn to chapter 2 and explore what Google Glass currently is, and might become in the near and far future.

Chapter 2 - Assessing claims about Google Glass

Many people and parties have voiced claims about Google Glass, wearable computers, and augmented reality technology. For example, some have argued that the camera that is part of most wearable computers, including Google Glass, will raise a lot of privacy issues(Flanders & Chomsky, 2013; Knevel, van den Brink, Hoogerwerf, & Engelen, 2013, t. 5:20-5:30), while another has acknowledged these issues, but argues that these wearable cameras stimulate reflection on their use within society by corporations and governmental parties that use them to provide security to clients and citizens(Mann, 1998). A less abstract example is the question whether Google Glass provides users with augmented reality technology(Misslinger, 2013; White, 2013a), or not(Dale & Richardson, 2013a). Amid all these claims it is hard to see what we can realistically expect from the actual technology that Google and the Glass explorers[2] develop, and slowly introduce in our societies. Therefore this chapter aims to provide a realistic overview of what Google Glass currently is, at the time of writing (~ June 2014), and what we can likely expect from it in the near and distant future. In other words, this chapter aims to separate the proverbial wheat from the chaff.

In order to do this, I will first discuss the work of Lucivero, et al. (2011), who discuss how expectations about new and emerging technologies can be assessed in terms of their plausibility. More specifically, they describe three dimensions of expectations and associated methods to assess the plausibility of these expectations: technological feasibility, societal usability, and ethical desirability. Even though I agree their methodology focuses more on *emerging* technologies that have not yet left the laboratory, as indicated by their use of the term expectations, I argue that their three dimensions and associated methods, albeit with a few adjustments, still work for technologies that have already entered our society partially (section 2.1). I then follow Lucivero et al.'s suggestion to study the history of the technology, of its uses, and the ethical debate about the technology, in order to assess the current claims made about the technology(pp. 139-140). Specifically, I first compile a brief American history of wearable computing (section 2.2), and then use this history and Lucivero et al.'s three dimensions to discuss claims and expectations about the contemporary wearable computer Google Glass (section 2.3). Based on this analysis I conclude with a taxonomy of Google Glass claims consisting of three categories: Google Glass explorer edition (now - August 2014), near future: Google Glass consumer edition (~ end of 2014, 2015), and far future: Google Glass... One Day (~2019).

Let's now begin our exploration by discussing the work of Lucivero et al. (2011), and see how it applies to the Google Glass case discussed in this thesis.

2.1 Assessing expectations and claims about Emerging Technologies

Lucivero, et al. (2011) define an emerging technology as one that "yet, exists mainly in the form of visions, promises and expectations"(pp. 129-130). However, if a technology only exists in terms of social constructs such as promises, visions and expectations, then there are reasons to be sceptical about them. Lucivero and her colleagues offer three such reasons. First, because these expectations can be financially

[2] i.e. the limited group of users that test Google Glass, and help to develop the technology and software for it further.

motivated. Lucivero et al. write: “All too often expectations are coloured by the strategic aim to mobilise support and funding”(p. 130). Second, because they are often incorrect or incomplete(ibid). Third, technologies in practice often “do more, or less” than the expectations initially voiced about them implied (ibid). For instance, users often come up with creative and unexpected new ways to use a technology(cf. Latour, 1992/2009, p. 168; Verbeek, 2005, p. 136), or ethical issues pop up that were not foreseen initially(cf. Verbeek, 2011, pp. 23-27). Based on these three reasons Lucivero et al. introduce their main research question: “in the context of an early ethical reflection on the desirability of new and emerging technologies, how to assess expectations and promises on emerging technologies?”(ibid). Nordmann and Rip (2009) provide a first answer to this question, by arguing that ethicists should focus on the technical feasibility implied by expectations and promises, and that they should focus on specific technologies, rather than general expectations and promises about technologies. However, Lucivero et al. deem this approach inadequate, as it does not take into account “the strategic and rhetorical role of expectations,” and thereby lacks an account of the societal usability and ethical desirability of the technology, which belong to the structure of expectations about emerging technologies as well(pp. 131-133). Furthermore, in line with their rhetorical approach Lucivero et al argue that “for each of these aspects [i.e. technical feasibility, societal usability, and ethical desirability, BvdH], we cannot assess their objective reality or truth, however, we can analyse to what extent and at which conditions a specific audience, holding a more or less specific knowledge on the topic, considers these expectations plausible.”(pp. 131-133).

Let’s now briefly look at how the claims presented so far, apply to Google Glass. Even though I agree with Lucivero et. al. that claims about emerging technologies, and in this case Google Glass, play a strategic and rhetorical role in debates about Google Glass, I do not think that we should therefore limit our analysis to the discourse about Google Glass alone, and thereby focus solely on the plausibility of the claims made about Google Glass. For Google Glass does not only exist as a name used in a discourse, but it has a material dimension as well. It exists as a material artifact that about 10 000 people used in July 2013, and likely more today as Google expanded their program through an invitation system over the past half year(cf. Dale & Richardson, 2013c; Google Glass, 2013b).[3] In turn, the fact that Google Glass has a material dimension allows us to verify or rebuke certain technical feasibility claims about Google Glass. After all, because Google Glass exists as a material artifact, claims about what Glass can and cannot do, can simply be tested by using the device. With regard to claims about societal usability this material dimension might also be relevant, but it will need to be supplemented by the rhetorical analysis proposed by Lucivero et. al. For not every imagined societal practice, may be *plausible* in practice. So here a discussion with relevant stakeholders could help to put these claims about societal usability in the right societal perspective. Furthermore, given the user base of Google

[3] At this point, it may be objected that Google Glass should no longer be seen as an emerging technology, as there are already more than 10 000 users, and with so many devices in society, it no longer seems to match Lucivero et al.'s definition of an emerging technology. However, most of these 10 000 users mainly reside within the USA and their main task is still to help Google to test and develop the device further(cf. Google Glass, 2014j, Myth 4; Steinhauser & Robinson, 2013). Furthermore, most of the work these users do, tends to have a prototypical character(ibid). Moreover their publications on their experiments with Glass tend to act as visions, promises, and expectations, rather than as descriptions of widely used and accepted practices with Google Glass.

Glass and wearable computers throughout the years, several reports on wearable computing practices have already been written that could also be used to assess which practices within a particular context are socially accepted and which are not(cf. Choudhury, 2004; Dale & Richardson, 2013b; Mann, 1998, 2013a). Finally, as Verbeek (2011) has argued, things "have moral significance" as well(p. 2). That is, they "shape our existence and the moral decisions we take, which undeniably gives them a moral dimension as well"(ibid). Consequently, when assessing the ethical desirability of Google Glass, we should not just look at the societal discourse about the ethical desirability of Google Glass, but also include the way Google Glass shapes our moral decisions. Let's now study these three dimensions of Google Glass in more detail.

2.1.1 Technical feasibility

The first dimension Lucivero, et al. (2011) discuss is technical feasibility. As I mentioned in section 2.1, there are at least two reasons to assess claims regarding this dimension critically. The first of these is based on the history of technology, which "illustrates that many such claims by scientists never materialise"(2011, p. 133). In other words, it happens often that the claims voiced by scientists and engineers about the technology they are working on turn out to be technically infeasible. The ideas are there, but the technology does not match them. This brings us to the second point. Why would scientists and engineers make such technically *infeasible* claims? Because they often help them "to attract support and funding"(Brown & Michael, 2003; Lucivero, et al., 2011, p. 133). In addition to this latter aim, the audience also plays an important role. Some audiences might not have sufficient background knowledge to fully understand all the technical details. Consequently, they may come to believe that certain things are technically feasible due to the simplified explanation of the technology, which in fact, are infeasible due to certain technical constraints(cf. Lucivero, et al., 2011, p. 133). So when assessing technical feasibility claims Lucivero et. al. (2011, p. 133) suggest questioning these claims using the following questions:

1. "What is the background knowledge of a person uttering an expectation?"
2. "What is the audience s/he is addressing?"
3. "What could be the strategic role of the expectation under examination?"

Furthermore, in order to help answer these questions, they suggest looking for the controversies and the justifications of a technology in laboratories. For there "an ethicist comes across controversies and uncertainties that are covered-up in more public arenas, and may analyse the conceptual and material building blocks of expectations"(2011, p. 134). Finally, they also suggest studying historical sources about the technology to "ground" the discussion "in experience, at least to some extent"(2011, p. 139).

As I remarked in section 2.1, the above methodology mainly covers Google Glass *as a concept within a discourse*, and pays some attention to Google Glass *as a device,* by suggesting we should study technical feasibility claims about Google Glass within the laboratory. However, in order to pay more attention to this material dimension of Google Glass, I suggest we expand the conception of laboratory used by Lucivero et. al to include several PhD theses and papers from the history of wearable computing, social media posts (e.g. blog posts, videos, photos) that describe the experiments of

Google Glass explorers to develop new applications and software for Google Glass[4], and the results of two semi-structured interviews I had with three people who have been involved in Google Glass projects in health care[5]. I see two reasons for such an expansion. First, due to commercial nature of Google Glass, the actual Google Glass laboratory is not viably accessible for European master students such as myself, nor is the Google Glass device itself easily obtainable for Europeans.[6] Therefore I think these publications from the history of wearable computing, social media posts, and two semi-structured interviews provide a good, and at least feasible, alternative for an actual visit to the Google laboratories in Mountain View (CA, USA), or an actual Glass device. Secondly, because I've noticed that most Google Glass explorers tend to be fairly honest about the limitations, problems and opportunities they encountered when working with Google Glass(e.g. Alt, Meier, & Kuhn, 2013; DiGiovanni, 2013; Engelen, Hooijer, Göttgens, Engelen, & van de Belt, 2013), while Google, understandably, publishes mainly positive information on the opportunities offered by Google Glass.

In conclusion, to assess the technical feasibility of claims about Google Glass, I will rely on historical sources from the field of wearable computing, social media reports from Glass explorers that have first-hand experience with the technology, official factual information from Google on Google Glass (e.g. patents, technical specifications, terms of service), and two semi-structured interviews with three Dutch Glass Explorers in health care.

2.1.2 Societal Usability

The second dimension Lucivero, et al. (2011) discuss is societal usability. For not every technically feasible feature of Glass embeds well in existing societal practices. In order to assess the societal usability of a claim about an emerging technology, Lucivero et. al. propose to follow three steps. In the first step we analyse the envisioned practice using the script theory introduced by Akrich (1992). This theory aims to capture the social dynamics between how the designer initially imagines the user will use a technological artifact - the so-called script- which in turn inspires the design of that artifact, and the actual practice that arises when the technological artifact enters society. By de-scribing the actual practice - i.e. by putting it into words(Akrich & Latour, 1992, pp. 259-260) - the relevant differences between the imagined user and accompanying practice, and the actual user and accompanying practice, can be made explicit, and in turn be used to improve the design of the technological artifact. To arrive at a de-scription of the imagined practice and user, Lucivero, et al. (2011) suggest answering questions such as how the artifact will be distributed to the users, what social structures are needed for this distribution, and which steps users need to follow to achieve certain goals using the artifact. For these answers help to "point out the social conditions that are implicit in the expectations

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[4] An even more detailed account could be obtained if public (software) code repositories (e.g. Google Code, Github) were taken into account in this study. Especially, because such repositories provide logs of the incremental changes made to the software in order fix problems or add new features. However, due to a lack of knowledge on Android (i.e. the operating system running on Google Glass) and Java development on my behalf, I have left these out of this study. This might, however, still be interesting for follow-up work.

[5] I will say more about these interviews in section 2.3.

[6] (L. Engelen, personal communication, March 11, 2014), also see EurActiv (2013), and Steinhauser and Robinson (2013)

on an emerging technology"(ibid). In the second step, Lucivero et al.(2011) suggest confronting the script with people involved in the actual practices in which the technological artifact is to be embedded. For often those people "have some expertise on how they work," which could help to explicate the "implausible" assumptions in the script and/or artifact design. Furthermore, they could also suggest possible changes to the script, artifact, or actual practices that may be necessary to embed the technology successfully in society(ibid). In the third step, we assess the plausibility of such changes to practices, laws, or the artifact, in order to detect where possible resistance to the technological artifact could come from, and to assess the overall plausibility of the societal usability dimension of the claim about the technological artifact(ibid).

Just as I argued in section 2.1.1. we could again extend the above analysis by making good use of the information published by the Google Glass Explorers, journalists who have tried Google Glass, and reports from the history of wearable computing on how users and people nearby responded to the use of wearable computers in various settings and for various purposes. Thad Starner, for example, who has a PhD on wearable computing from MIT and currently leads the Glass team at Google, devotes a whole chapter in his PhD thesis to describe how various people responded to him wearing his wearable computing platform. Such anecdotal evidence does not provide a definite answer to which wearable computing practices are socially accepted, but at least helps to identify recurring themes in the societal responses to wearable computers and Google Glass. In my view, such an approach would help to add some empirical grounding to the discussion, rather than have it rely solely on the potential users' imagination.

2.1.3 Ethical Desirability

The third and final dimension Lucivero, et al. (2011) discuss is ethical desirability. In their discussion, they distinguish between three problems regarding the morality of claims about an emerging technology. The first problem is the ambiguity of the moral concepts in claims about the technology.[7] As Lucivero et al., following Nordmann (2007), explain: "(...) on further inspection such general claims often prove quite vague and ambiguous, or even inconsistent, because they are entangled in multiple views of what is 'good' ."(Lucivero, et al., 2011, p. 136). As a solution to this problem, they propose to state clearly which different *interpretations* of *concepts and values* are held by the various stakeholders, in order to stimulate a fruitful discussion on the ethical desirability of the emerging technology(Lucivero, et al., 2011, p. 136; for examples see Nordmann, 2007). The second problem lies at the heart of most ethical discussions: different people hold different moral views. As a solution Lucivero et al. propose a strategy similar to the one for the first problem: make the differences explicit and "point out eventual controversies."(2011, p. 136). The final and third problem is that emerging technologies change existing human practices in unexpected ways(p. 137). According to Lucivero et al. these changes may be unexpected from a sociological (STS) point of view, however, they surprise less when techno-moral change is taken into account(ibid). That is, the phenomenon in which technologies raise new moral issues that "existing moral resources [i.e. norms, values, BvdH] cannot cope

[7] For example, when someone claims that Google should take its moral responsibility with regard to privacy issues raised by Google Glass, not every person may have the same understanding of what that 'moral responsibility' entails.

with"(ibid). In turn, new norms, values, and interpretations of concepts might arise, which reshape our technological and moral practices(Swierstra, Stemmerding, & Boenink, 2009, p. 120; Swierstra, van Est, & Boenink, 2009). Finally, Lucivero et. al. (2011) describe the role of the ethicist as the one who creates awareness among stakeholders about the possible moral changes a technology brings about. The ethicist does so using fictive scenarios based on past occurrences of techno-moral change which are technologically similar to the technology under investigation(p. 138).

In my view, Verbeek (2011) develops this idea of techno-moral change further by connecting it to the way technological artifacts shape our perceptions and actions. In my view, he thereby offers a more systematic and material account of techno-moral change than Lucivero et. al (2011). His key example is ultrasound imaging of the foetus. In that case, we no longer experience the foetus in a visually hidden way in terms of the belly of a pregnant woman, but through ultrasound imaging the foetus becomes visually present and looks much more like a person(Verbeek, 2011, pp. 24-25). Furthermore, due to the diagnostic measures present in the ultrasound scanner it becomes possible to calculate the chances of bearing a child with Down Syndrome or spina bifida, and thereby treat and view the foetus as a patient(pp. vii,25). Both ways of perceiving the foetus in turn raise various moral dilemmas for the parents: Do I want more testing to gain more certainty on whether I will bear a child with Down Syndrome? Do I want to risk losing my child (through miscarriage) by having such a test performed(cf., p. 27)? In other words, as these dilemmas show, these new perceptions of the foetus cannot easily be separated from possible medical actions performed on the foetus with permission from the parents. In the words of Lucivero et. al. (2011): the ultrasound scanner changes our moral practices around, and possibly our moral views of, the foetus.

To conclude, in order to assess the ethical desirability of Google Glass, I will adopt Lucivero et. al's solutions to the first two problems they discuss (i.e. explicating different conceptions of values and concepts among various stakeholders, and pointing out likely controversies), while I combine the approach of Lucivero et. al. (2011) with that of Verbeek (2011) for the third problem relating to techno-moral change. For not only will past cases of techno-moral change provide a good source of developing grounded techno-moral scenarios of Google Glass, but also current experiences with Google Glass that raise moral controversies. For example, a man in a Dutch train shouted angrily that he would "rip Glass from his head" if the journalist sitting opposite him and wearing Glass, did not take Glass off voluntarily. For the man was sure the journalist was filming him due to the lit up display - which in fact lit up because the journalist was viewing Twitter messages(Verlaan, 2014). Note though, that most of these current issues will only be discussed briefly here in view of the question of what Google Glass is, does, and might become. A more in depth discussion of ethical controversies raised by Glass will follow in chapter 5.

2.1.4 Summary

In this section I have discussed and extended the framework presented by Lucivero, et al. (2011). As Lucivero et al. mainly approach emerging technologies as social constructions (i.e. visions, promises and expectations), and Google Glass no longer exists solely as a social construct, but exists too as a wearable computing platform used by more than 10 000 people, it would be unfortunate to exclude the experiences of those many users. Therefore I have extended their framework by suggesting that the technical feasibility claims can also be assessed using (social) media posts by Glass Explorers and academic literature from the history of wearable computing. With regard to societal usability, I suggested that these same sources, and the two semi-structured interviews carried out at the Radboud REshape Center in Nijmegen, could provide some empirical grounding to the discussion about the societal usability of Google Glass, rather than have it rely solely on the potential user's imagination. Finally, I have suggested that Verbeek's postphenomenological approach may supplement the techno-moral scenario approach adopted by Lucivero, et al. (2011) to take into account current ethical controversies about Google Glass, when assessing its ethical desirability.

In the next two sections I will discuss various sources that will help us to assess the claims made about the technical feasibility, societal usability, and ethical desirability of Google Glass. In section 2.2, I will provide a brief and limited[8] overview of the history of wearable computing that is mainly based on academic literature. In section 2.3 I will focus specifically on a variety of sources about the contemporary wearable computer named Google Glass. These will range from patents and official documentation, to semi-structured interviews with Glass users and official demo videos from Google. In the final section (2.4) I will provide a taxonomy of claims about Google Glass that will provide insight into what Google Glass currently is, and might become in the near and far future.

Let's now embark on our trip down memory lane to explore the history of wearable computing.

2.2 An American history of wearable computing

When the history of wearable computing started, depends largely on how we define a wearable computer(Mann, 2013b, section 23.5; cf. Starner, 1999, pp. 19-21). Even though Steve Mann is considered by some as the father of wearable computing(Ishii, 2012), I noticed that his definitions of a wearable computers also frame the history of wearable computing in such a way that two efforts before Steve Mann entered the field, can no longer be considered as wearable computers, and thereby allowed Mann to become one of the first people to design, build, and use wearable computers(also cf. Balaban, 2014, t. 2:55-3:25). For one of Mann's criteria to define wearable computers is that they are "controllable" in such a way that "the input means" allow "the functionality of the data processing system (e.g. instruction set) to be modified"(Mann, 1997b, pp. 205-206). As a consequence of this criterion, two efforts before Mann, that only ran a single software program, are excluded from the history of 'wearable computing' as they did not allow the functionality of the system to be modified -i.e. you could not switch software programs and thereby modify the functionality of the system, as there was only one program running on these early systems. Therefore I will use a slightly adjusted version of a combination of two of Mann's definitions of a wearable computer, in order to avoid excluding these two early efforts. For the purpose of this thesis I define a wearable computer as:

[8] This history mainly focuses on personal applications of wearable computers, and some professional applications of wearable computers, both being developed in the USA. I have chosen to focus on these research fields as most work on Google Glass seems to be done in these fields. Furthermore, wearable computing started in the USA, Google Glass started there, and is still largely being used there. For a history of wearable computing that also includes European and Australian efforts see Amft and Lukowicz (2009).

An electronic[9] "data processing system attached to the body, with one or more" input and "output devices" that is both operationally constant and interactionally constant(Mann, 1997b, p. 205). Here operational constancy denotes that the system is "never completely shutdown," and interactional constancy denotes that the system's inputs and outputs are always directly available to the user to interact with(Mann, 2001, p. 11).

Based on this definition we will start our exploration of the history of wearable computing by looking at the two early efforts in the 1960s mentioned above(section 2.2.1). We then move on to the work of Steve Mann, who started building his first wearable computers as a teenager during the 1970s, and later in 1997 obtained a PhD in the field(section 2.2.2). About two years later, Thad Starner too obtained his PhD in wearable computing from the Massachusetts Institute of Technology (MIT) by introducing a new research platform for (personal) wearable computing named Lizzy (section 2.2.3). This platform made it easier for other researchers to build their own wearable computers from standardised components(Starner, 1999). One of these researchers was Richard DeVaul who attempted to make the Lizzy platform useful and practical for mainstream users by hiding the hardware in a vest, and by developing software that provided the user with context-aware notifications that served as memory aids. In other words, apart from making the hardware more usable and giving this new platform the name Mithril, DeVaul (2004) also worked on developing principles for good human-computer interaction with wearable computers (section 2.2.4). Furthermore, both Thad Starner and Richard DeVaul currently work at Google, and have contributed to Google Glass in different ways(DeVaul, 2012 , 9:05-9:45 ; minipcpro, 2012, 13:10-13:30; Starner, 2013b). In the same year that Richard DeVaul obtained his PhD from the MIT Media Lab, another Media Lab PhD, Tanzeem Choudhury, also defended her dissertation on using wearable computers to study human interaction networks(Choudhury, 2004). Even though I agree that this type of application might fall into the far-future category of my taxonomy (given the ethical and legal considerations involved), I think it is nonetheless interesting to explore this area in order to gain a broader perspective on what wearable computers and Google Glass could (potentially) be used for (section 2.2.5). Finally, as most of the authors so far have been educated at MIT's Media Lab, which has mainly focused on developing wearable computers for *personal* use(Starner, 1999, p. 53), and there is also a branch of wearable computing research carried out at Carnegie Mellon University that focuses on wearable devices for *professional* use (e.g. maintenance and knowledge sharing applications), I will discuss these professional applications in the final subsection of this section (section 2.2.6). Let's now explore the work of Claude Shannon, Edward Thorp, and Hubert Upton, who set their first steps into the field that later became known as wearable computing.

[9] Underlined parts are my own additions to Mann's definition. Electronic is added to avoid qualifying an ancient Chinese ring with an abacus as a wearable computer (Mann, 2013b, fig. 23.12 caption). 'input' has only moved, as it was part of Mann's definition, but only in such a way that it was associated with the controllability criterion. Finally, operational and interactional constancy, were not part of this specific definition, but were mentioned in both his earlier PhD thesis and in later work(Mann, 1997c, p. 183; 2001, p. 11). In my view these two terms were more precise than the perceptual constancy term used in the Mann (1997b, p. 205) definition which attempted to gather both interactional and operational constancy under one term.

2.2.1 Early wearable computing efforts

Our history of wearable computing starts in 1955, when UCLA physicist Edward Thorp wondered how he could win systematically in the gambling game of roulette using mathematical techniques(Thorp, 1998, p. 4). He bought himself half a roulette wheel and started taking measurements. Unfortunately, it turned out his wheel had more irregularities than the ones he saw in the casinos, and therefore his wheel was more difficult to model and could not act as a substitute to develop a theory that would help him make actual wins in the casinos (ibid). Later on, in 1959, his roulette work continued at M.I.T. with the help of the mathematician and engineer Claude Shannon. Together they bought themselves a full roulette wheel and continued experimenting until they found a model that predicted the octant the ball would stop in, within reasonable limits(pp. 5-6). In practice, though, just having the model available was not enough. For obviously the casino should not notice that Thorp and Shannon were able to predict the outcome of the roulette game while the wheel was still spinning. Therefore Thorp had already decided that they needed to hide the computer system carrying out these calculations and that it's use should remain unnoticed as well(p. 4). With this in mind, the idea for the first wearable computer system was born. Basically, Thorp and Shannon constructed a computer system "with the size of a pack of cigarettes" which Shannon, standing near the roulette wheel, wore around his waist(also see Melanson, 2013; Thorp, 1998, p. 7). To operate the computer system, Shannon pressed two microswitches in his shoes using his toes, of which the signals were transmitted through a set of wires connected to the computer(Melanson, 2013). As output the computer played a musical scale of eight tones, each tone representing one octant, which both Shannon and Thorp could hear through a small in-ear speaker. In Shannon's case this speaker was connected to the computer system using thin steel wires painted in the colour of his hair, while Thorp, placing bets at the betting table, had connected his in-ear speaker using similar wires, to a wireless receiver. When Shannon signalled the timer at the right times, the tone scale would stop and the last tone indicated the recommended octant to bet on. In case Shannon made a mistake with the timings, the scale continued to play(Thorp, 1998, p. 7). In practice, the system did deliver the wins at the casino Shannon and Thorp had hoped for, however, the thin steel wires used to connect the in-ear speaker often broke down and needed to be replaced. So they tested the system only once in Las Vegas(ibid). Finally, in a way Thorp ethically justifies using this system in a casino in 1961 by stating that the Mafia was already controlling the casinos in those days(ibid).

The second early wearable computing effort came around 1967, when electrical engineer Hubert W. Upton from Bell Helicopter developed a wearable computer system that aided him in lipreading(Rhodes, 2002; Upton & Goodman, 1982).[10] Upton himself had a hearing problem and thus relied on lipreading to understand what people were talking about(Upton, 2010, t. 0:20-0:30). To make lipreading easier he developed a speech analyser that could distinguish between 5 phonemes[11]. He wore this speech analyser in his pocket, which received input from a tiny microphone worn on his tie clip, and showed him which phoneme was spoken using coloured LED's

[10] Upton(1968) originally presented wearable lipreading aid. Unfortunately, I could not access this paper and have therefore relied on later publications.

[11] Phonemes are the auditory building blocks that help us distinguish words from one another such as the k, b, q, and p sounds.

being projected within his field of view by means of a tiny mirror placed on one of the lenses from his pair of glasses(Upton, 2010, t. 0:35-1:43; Upton & Goodman, 1982). In practice, the coloured light from these LED's was thus projected either above or below the lips of the person speaking to Upton (see Figure 2-1).

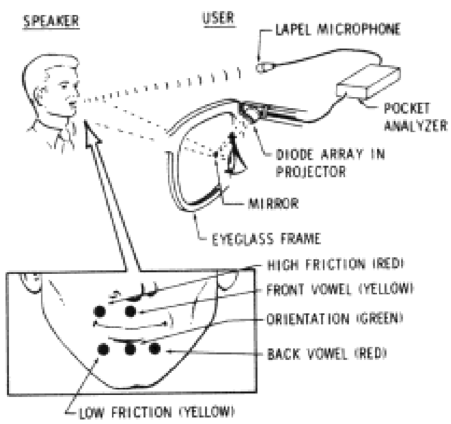

FIG. 1. Visual speechreader.

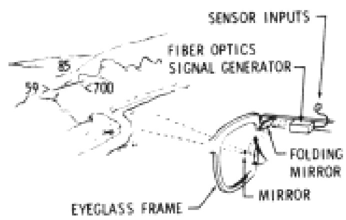

FIG. 2. Micro-HUD pilot display.

Figure 2-1 - Hubert Upton's wearable lipreading aid. The upper part shows how the microphone records a speaker, which the speech analyser analyses and turns into a visual signal using the diode array, projector and tiny mirror connected to the eyeglass frame. The middle picture shows how the visual signal appears above or below the speaker's lips, while the lower picture shows the system from a signal processing perspective. Picture taken from Upton and Goodman (1982).

In this section we have have looked at two early efforts in the field of wearable computing. Not everyone acknowledges both efforts as wearable computing efforts. For example, in his overview of the history of wearable computing Mann (2013b) only mentions the effort by Thorp and Shannon. Thad Starner acknowledged both efforts progressively, as at first he mentions the Thorp and Shannon effort implicitly(Starner, 1999, p. 80), later explicitly(Starner, 2001b, p. 58), and again later described Upton's effort as "one of the first wearable computers" in a post on Google Plus(Starner, 2013a). One explanation why some exclude these early efforts is given by technology journalists Donald Melanson and Michael Gorman who explain that both of these early efforts were designed for specific purposes, while computers, and here they draw on Alan Turing's thinking, were designed as general purpose machines aimed at emulating the functionality of multiple devices such as calculators and radios(Melanson & Gorman, 2012). Finally, these days there are at least some journalists and scholars who acknowledge that both efforts belong to the field of wearable computing (e.g. Amft & Lukowicz, 2009; Miller, 2012).

Let's now move on to the work of that other pioneer in the field of wearable computing: Steve Mann.

2.2.2 Steve Mann: one of the first longterm wearable computer users

For Steve Mann his wearable computing efforts started as a teenager during the 1970s, when he designed, built and used his own wearable computer system to perform photographic experiments(Mann, 1997a). These early wearable computers, named WearCompo and WearComp1, consisted of two parts, a wearable computer part with various light sources as peripherals and "a base station with imaging apparatus"(p. 67). The main goal of this system was to explore how various photographic scenes "responded" to various levels of illumination generated by WearComp's peripheral light sources(ibid). It could be argued here that this still sounds like a fairly specialised wearable computer, and would therefore fall outside the scope of Mann's own definition of a wearable computer. However, as Mann notes, the system allowed the transmission of "computer data, voice, or video" through antennas worn on top of a helmet and thereby allowed communication through voice as well(pp. 67-68). Furthermore, the wearable computer system also had a one-hand keyboard consisting of "six spring-lever switches" that allowed Mann to operate, and thereby program, how the various light sources illuminated the scene(p. 67). In other words, in contrast to the earlier wearable computers discussed in the previous section, Mann's early systems could be programmed while using them, and could be used for more than one application (i.e. communication and photography). That is not to say, though, that WearCompo and WearComp1 always worked flawlessly. In Mann's words:

> "However, there were many technical failures. In particular, the bulky nature of the apparatus rendered it often more of a photographer's burden than a photographer's assistant. Furthermore the reliability problems associated with so many different system components were particularly troublesome, given the nature of typical usage patterns: walking around on rough terrain where wiring and the like would be shaken or pulled loose. Interconnections between components were found to be one of the major hurdles."(Mann, 1997a, p. 69)

These technical failures, lead to newer designs, first by moving much of the computation hardware into a steel frame worn on the back, and by adding new software capabilities such as voice recording and playback, and by translating illumination settings into music-like sounds(Mann, 1997a, pp. 67-68), just as we saw with the early roulette wearable by Thorp and Shannon. This system was known as WearComp2 and Mann completed it in 1981. In 1982, Mann further improved the design by sewing the wires into his cloths, rather than have them hanging loosely on his cloths. This system became known as WearComp3. It was more comfortable to wear, but took more time to get all wired up and ready to use the system(Mann, 1997a, pp. 69,71). Furthermore, starting in the mid-1980s and during the 1990s more WearComp designs arose (i.e. WearComp 4-7) which integrated more of the electronics into cloths, by making use of conducive fabrics, and by integrating them in ordinary sunglasses, so that the hardware became less visible. Finally,[12] around 2001 Mann came up with a new type of wearable computer called an Eyetap.(cf. Mann, 2001, pp. 12,14-15). In contrast, to the earlier WearComp computers, the EyeTap wearable mediates the user's vision by placing both a display and a camera in front of

[12] Actually there is another type of wearable computer that Steve Mann currently works on, which he calls the MindMesh. This wearable computer is permanently attached to the user's head and works with "implantable and surface electrodes" in order to remedy loss of vision or associative memory (Mann, 2013b). However, apart from some general details and photos, I have not found any scientific or specific publications on this system so far.

the user's eye. Through a system of mirrors and other optical hardware (together called an aremac) every image the camera captures is first processed, and when necessary altered, and then shown on the display in front of the user's eye. Furthermore, different from the fixed lens system to display the processed image at a fixed distance used by Google Glass, the EyeTap uses the aremac optical system to display the processed image at a variable distance determined by the focal length of the eye. In other words, the aremac system keeps track of the focal length of the eye (i.e. does it focus nearby or on objects far away), adjusts the processed image and camera focus accordingly, and thereby prevents the eye with the EyeTap from focusing at one distance, while the eye without the EyeTap focuses at another distance(Mann, 2013a, pp. 46-47). In practice, Mann used the mediated vision technology provided by the EyeTap to develop a better welding mask. For often these masks make the iron to dark to see it clearly, while the flash of the welding torch is still too bright(cf. Mann, 2013a, p. 45). By combining an overexposed and an underexposed image of the torch, metal, and filler, the EyeTap shows a clearer image of all components in the welding practice(see Lo, Mann, Huang, Rampersad, & Ai, 2012, for a demonstration).

Now that we have discussed what is technically feasible and what kind of practical purposes Mann's wearables had and still have (e.g. photography, welding, communication), I want to move on to the ethical desirability of Mann's wearables.[13] In my view, a large part of Mann's normative perspective on wearable computers and the academic field of wearable computing is shaped by enlightenment or modernist values. In an introduction to a special issue on wearable computers he writes:

> "Moreover, early work in wearable computing was characterised by a healthy absence of any hegemonic 'alpha male' phenomenon - it was driven by a passion for truth, discovery, and exploration, free of vociferous assertion for the purpose of building an empire. (...) It is my hope that we will see a return to some of these values in the coming years, and that thoughts and ideas will follow a stream of meritocracy (advancement based on ability or past achievement) rather than any vociferous leader. (...) The true spirit of science (including the true spirit of the high-school hobbyist tinkering in the basement at home) is one of verification of basic 'facts' and of personal empowerment through reliance on self."(Mann, 1997b, p. 203)

Note how Mann emphasises the values of autonomy, scientific and technological progress, and the empowerment science and technology bring to the individual(cf. Mitcham, 1994, p. 299). Moreover, he argues against authority too(cf. Gadamer, 1960/2004, pp. 274,279), as he tends to focus on relying on oneself, rather than collaborate with others. I mention these observations, because Mann's way of dealing with the privacy issues of wearable computers is largely shaped by these modernist values. For when it comes to camera surveillance, Mann argues that it should be individuals who control the cameras, rather than governmental or corporate organisations (Mann, 2012, p. 12). He calls this new perspective sousveillance - i.e. rather than looking from above (literal translation of surveillance), we should look

[13] The attentive reader may note that I'm skipping an explicit discussion of the societal usability criterion here. However, I do so because Mann does not discuss the societal usability of his wearables that much. If he does discuss it, his descriptions tend to be fairly normative and general. Technology journalist Paul Miller suggests one reason why this may be the case: "While much of Starner's research has been on the practical, immediate applications of wearable computers, Mann always trended more philosophical, and his ideas have aged better"(Miller, 2012) . Taking this cue from Miller, I will thus discuss the societal usability of wearable computers in the other subsections that follow (2.2.3-2.2.6)

from below (literal translation of sousveillance) with cameras from smartphones and wearable computers (Mann, 2004; 2012, p. 12). Mann (2004) briefly describes his experiences with sousveillance in practice. He notes that when he started experimenting with sousveillance, around 1985, people responded negatively in two ways. First of all, individuals sometimes violently expressed their dislike of Mann's weird looking wearable computer, or the parts of it that were located below or in his skin. Mann calls this peer discrimination (p. 623). Secondly, places with much camera surveillance, such as jewellers, museums, and casinos, also repeatedly refused Mann from entering their buildings. Mann calls this official discrimination (pp. 623,625). During the 1990s the peer discrimination disappeared as wearables took on a more usual look, and according to Mann, transhumanism slowly gained acceptance (p. 624). However, the official discrimination became worse, and thus invited further investigation (ibid). Mann noticed that when he changed the appearance of the wearable camera to that of a necklace with the camera as a large pendant, that he gained positive responses from jewellers and security personnel alike, even when he explicitly told them the pendant was a camera. Some jewellers even wanted to sell such camera necklaces to their customers. Mann ascribes this positive acceptance to the necklace fitting better "within their genre"(Mann, 2004, p. 625). Furthermore, he notes that with sousveillance "it is possible for the locus of control [i.e. who is recording, BvdH] to be more distributed, and in particular to rest with the individual"(Mann, 2004), which again stresses the value of autonomy. Obviously, this redistribution of responsibilities does not fully address the privacy issues, as having other and more people record images does not necessarily lead to better privacy of those who are being recorded. In later work, Mann addresses these issues in three ways. First, he mentions that when people approached him with questions about his wearable computer with camera, he always explained why he used that system, and how it helped him(Mann, 2012, pp. 10-11). This often put people at ease(ibid). Secondly, he argues that when his camera records images that he keeps to himself, he is not violating a person's privacy(p. 11). I note that this argument can only be sound when the person recording the images operates within the boundaries of the law, or when the person being recorded does not deem these recordings a violation of his or her privacy if he or she discovered that someone made these recordings.[14] Third, by noting that the cameras used for mediated vision applications, or for intelligent systems such as street lights that brighten when cars approach them, do not record data, and thereby these cameras challenge our common understanding of what a camera is and does(pp. 12-13).

In summary, Steve Mann's work in the field of wearable computing thus contributed mainly to turning wearable computers into general purpose machines with multiple applications. Furthermore, apart from designing, building, and using these machines, I think it's fair to say he was one of the first engineers who started to think deeply about the ethical and philosophical implications these wearable computers might have. Let's now turn to work of Thad Starner who adopted a more practical approach to wearable computing.

[14] Note that with sousveillance cameras, people discover such cameras more easily as they are not 'hidden' above them, but often tend to be used at the height we usually look(cf. Mann, 2004, pp. 626-627).

2.2.3 Thad Starner: the first wearable computer research platform

For Thad Starner wearable computing really started in 1993, when he got his first wearable computer built for him by Douglas Platt(Starner, 1999, p. 184 ; 2008, t. 00:12:45-00:12:55). Around 1996, the MIT Media Lab started to fund wearable computing research, and this allowed Starner to develop a standardised wearable computer for research purposes(Starner, 1999, p. 30). This wearable computer became known as the Lizzy wearable computing platform(ibid). Basically, the Lizzy consists of a head-mounted display, a one-hand keyboard with built-in mouse called the Twiddler, and small form-factor computing hardware (e.g. processor, memory, harddisk etc.)(p. 32). In practice, it turned out that affixing the head-mounted display to a British cabbie hat was the most comfortable way to wear the display(Rhodes in: Starner, 1999, pp. 225-228). Consequently, this meant that the display would be slightly above one eye, rather than directly in front of an eye which would have caused the displayed image to merge with what is seen by the other eye(ibid). Furthermore, Starner carried the computing hardware in a satchel(p. 193), while the Twiddler was in his hand, and the head-mounted display on his head(p. 32). With regard to software, the Lizzy ran the Linux operating system. On top of that platform Starner explored and developed a variety of software applications such as an American Sign Language (ASL) recogniser, and a location-based augmented reality system that showed virtual annotations (a.k.a. the Locust) that helped the Lizzy know where it was located within a building(, pp.34-35 and chapter 4-5). Moreover, at the hardware level, Starner also explored several design options regarding heat dissipation of the computer system by means of the human body, locations on the body to bear the weight of the system, and ways to generate power for the system by making use of bodily movements(Starner, 1999, chapter 7-9; also see Starner, 2001a). Finally, over the years the Lizzy research platform changed incrementally as new hardware became available, while at the software level Starner continued to explore ASL applications for wearable computers, and investigated how speech recognition could help users to interact pleasantly with wearable computers by taking their context into account(Starner, 2008, t. 00:31:15-00:38:40).

Next to technical feasibility, Starner has contributed significantly to the societal usability of wearable computers as well. In contrast to Steve Mann, whose main focus is the mediation of perception through wearable computers, Starner attributes a more modest role to wearable computers. For in his view, the ideal wearable computer interface is that of “a continuously worn, intelligent assistant that *augments* memory, intellect, creativity, communication, and physical senses and abilities”(Starner, 2001b, pp. 54, emph. mine). So rather than altering what the user perceives, as Steve Mann’s EyeTap did, Starner’s wearable computer aims to augment what the user perceives. One example of this is the Remembrance Agent - a software agent that runs within the Emacs text editor, and brings up relevant or interesting information for the document or e-mail the user works on at the moment. Starner originally wrote this application as an undergraduate, and later Bradley Rhodes continued its development for his dissertation research, and evaluated it thoroughly afterwards(Rhodes, 2000, pp. 102-115). This evaluation showed that users followed about 25% of the suggestions made by the Remembrance Agent (RA), and that the application influenced the content of e-mails or documents because it either already provided the answer to a question posed in the e-mail, or because it suggested notes or e-mails that provided a creative alternative direction of inquiry for the document-in-progress(pp. 102-107). Furthermore, several people who did not have the RA, started to ask more questions (e.g. does anyone know who is working on X?) to those running the RA, as information retrieval for this latter group became a breeze(p. 114). Besides the RA, Starner observed two related social phenomena associated with the interaction patterns with his wearable computer. The first phenomenon had to do with knowing the time. Starner just needed a glance at his head-mounted display to know what time it was. However, this puzzled most people in the 1990s as they expected Starner to uncover his wristwatch and look at it(Starner, 1999, pp. 53-54). The second phenomenon showed up in experiments with wearable computers and speech recognition. For direct commands spoken to a computer could sound rather unfriendly, unnatural, or confusing, when spoken in a conversation with people. Therefore, Starner suggested two strategies to overcome this awkward phenomenon. First, he suggested to start each command with a specific phrase that made it clear he was talking to his wearable computer - the 'OK Glass' phrase is a good example of this strategy. The second strategy suggests to equip the user with a push button, to activate the speech recognition software at the right times during the conversation. For example, the user runs a calendar application on his wearable, and someone asks him if he has time to meet on Monday. "On [user pushes button] Monday April 28 [user releases button and calendar shows appointments on April 28] you say?" In this way, the system preserves the privacy of the user as well, as the speech recogniser only 'hears' what it needs to hear(Starner, 2008, t. 00:31:15-00:38:40).

Finally, Starner's work discusses two ethical issues raised by wearable computers. First, privacy comes up again. With regard to this issue, Starner draws on a principle first coined by Steve Mann(1997b, p. 205) that we might call the bits-on-body principle. This principle states that personal information should be stored on the wearable computer itself and not in its environment (e.g. on servers, or on other digital storage systems that are not part of the wearable computer itself). Even though Mann first coined this principle, it is Starner who kept emphasising it throughout the years, while Mann moved on to his broader sousveillance perspective. Secondly, in his dissertation Starner describes one anecdote that raises the ethical question whether wearable computers that augment our abilities should be allowed everywhere at any time. In this anecdote he describes that his doctoral committee questioned him near the end of an oral exam to obtain his PhD, on whether he had the RA running during that exam. Starner confirmed that the RA was indeed running during the exam, but, in reply to a second question, that his modem was not working. The doctoral committee, in the end allowed it, but decided that in future cases Internet modems would have to be handed in before the exam(Starner, 1999, pp. 61-62).

In summary, in Starner's work we saw how new ways of interacting with wearable computers and how new applications for wearable computers arose. These novelties coincided with puzzled societal responses with regard to what Starner was doing on his wearable and how he interacted with this device. Let's now turn to the work of Richard DeVaul who worked on making wearable computers more usable for mainstream users, and on software that does not distract the user from other activities, but does support those activities.

2.2.4 Richard DeVaul: Mithril and memory support

For Richard DeVaul his research in the field of wearable computing started in 1998, and resulted in a PhD thesis in 2004(DeVaul, 2004, p. 3). Like many of his colleagues, DeVaul's first wearable computer was a Lizzy(p. 45). However, soon enough, in 1999, he decided to develop a new wearable computing research platform for two reasons. First, because the Lizzy wasn't a very comfortable platform to wear on a day-to-day basis. Secondly, because wearables still had an image of looking strange and obtrusive (see 2.2.2), and if DeVaul wanted to test his wearable successfully with an audience broader than MIT Media Lab researchers alone, then he needed a wearable computer that was both unobtrusive and comfortable to wear(pp. 45-47). DeVaul named the first version of this new wearable computing platform MiThril 2000. To improve the ergonomics of the system, DeVaul decided to use a vest, rather than a satchel, to carry around the hardware. Furthermore, compared to the Lizzy, the Mithril 2000 system had more powerful hardware, supported wired and wireless networking, and could work with a wide variety of sensors - e.g. GPS, medical sensors, an IR tag reader, and an accelerometer(pp. 52-53,55). Like the Lizzy, DeVaul's system also used the Twiddler keyboard for input, but his system had a less obtrusive head-mounted display. Overall, the system consumed 4 Watts of electrical power on average (with peaks of 6 or 8 Watts) and weighed about 1.7 kg(p. 53). In practice, the system proved to be robust and worked well, but due to its high costs and complexity, the Media Lab researchers made no more than 20 systems. Furthermore, as we saw with Mann's early systems, DeVaul's system too had problems with broken wires due to bodily motion(pp. 62-63). To remedy this problem, and to reduce the complexity and costs of the wearable research platform, DeVaul developed a new version of the MiThril platform in collaboration with Michael Sung, called MiThril 2003(DeVaul, 2004, pp. 64-68; DeVaul, Sung, Gips, & Pentland, 2003). Rather than spreading the various hardware components over a vest, as it was the case with MiThril 2000, this new platform utilised a Sharp Zaurus PDA to replace many components that were once separated, and thereby lessened the size and cost of the platform considerably(cf. DeVaul, et al., 2003, p. 4; Sung, 2005, p. 34). Moreover, as the new platform had less components (i.e. a PDA, a sensor hub that includes a power supply, and one or more sensors), it became possible to use different ways of carrying around the hardware. The basic way to carry around the hardware was through a holster-belt; if the researchers needed an IR tag reader or microphone, though, then they attached these sensors to a shoulder strap which in turn was fastened to the holster-belt(Sung, 2005, pp. 45-48).

When it comes to societal usability, DeVaul adopts a somewhat different approach than the researchers mentioned in the previous subsections. Rather than designing applications for specific purposes and practices like Starner and Mann did, DeVaul designed software that generally made memory support possible.[15] Therefore DeVaul focused a large part of his efforts on developing a software toolkit that made it easy to infer the context of a user, and in turn use that context to support the user's

[15] If there was a specific purpose or application for DeVaul's MiThril system, it would indeed be memory support. That is, trying to help the user remember all sorts of things. However, given the broad scope and complexity of this task, and the wide variety of users, I'm inclined to say that DeVaul's approach differs from the work of Starner and Mann, who worked on more specific applications for wearables (e.g. photography, the Remembrance Agent).

mental recalling activities. In order to make this possible, DeVaul distinguishes between four types of context-awareness(DeVaul, 2004, pp. 34-35). First, there is time-awareness which can easily be tracked using a digital clock(p. 34). Second, there is location-awareness (i.e. where is the user?) made possible through an IR tag system(Weaver, 2002), and GPS(DeVaul, 2004, pp. 56,74). Third, there is activity awareness (i.e. what does the user do?) which MiThril software inferred for a few activities (e.g. walking, running, standing still) using an accelerometer(pp. 76-82). Fourth and finally, there is social awareness (i.e. who is the user talking to?) which MiThril inferred using IR tags worn by experimental subjects, originally in order to help amnesia patients remember who a person is[16](pp. 101-102). In practice, though, this system did not work as planned, as MiThril always showed the last tag it read successfully, even though the person to which the tag belonged was long gone. In other words, DeVaul had to adjust the system so that it could make these inferences in real-time, thereby combining time awareness and social awareness(pp. 102-103). Next to these small-scale tests with context awareness, DeVaul also focused on the issue of not distracting users from their primary task in the actual world. Even though Steve Mann and Thad Starner have mentioned this issue as part of their vision of what an ideal wearable computing practice looks like(e.g. Mann, 1997b, pp. 205-206; Starner, 2001a, p. 46), it was not until Richard DeVaul's research that this issue started to be studied empirically. Several principles that helped to minimise the distractions beforehand guided DeVaul's empirical investigations :

1. Design hardware and software in such a way that they hinder users as little as possible when perceiving and working(DeVaul, 2004, p. 97).
2. Design software in such a way that it interacts minimally with the user, and only when necessary. If software can infer things from the user's context or data measured in the past, it should not ask the user about it(ibid).
3. Design the interface in such a way that it can be used at a first glance. Make interaction with the interface direct and immediate. When the interface displays information it should be relevant, timely, and personal (i.e. fit within the user's context). Furthermore, this information should require as little interpretation as possible(pp. 97-98).
4. Design interactive applications in such a way that steps are simple to perform and easily understandable. For complex procedures follow the principle: "Easy things should be easy, hard things should be possible." If a primary task in the actual world interrupts the user temporarily, then it should be easy to continue the secondary task on the wearable when the user finds time to continue this secondary task(p. 98).
5. Don't use a mouse pointer (or interactive elements that require a mouse pointer) on a wearable computer. It requires the user to use his or her hand, tends to require "complex hand-eye coordination", and assumes "that the wearable interface has the user's undivided attention"(ibid).

Based on these principles DeVaul designed an interface for his memory glasses application, and started to experiment with overt and subliminal cues that helped or

[16] For bureaucratic reasons this system was not tested with actual amnesia patients, but with researchers from the Media Lab(DeVaul, 2004, pp. 102-103).

mislead users in associating names with faces. Apart from having three types of cues (i.e. no cue, correct cue, incorrect cue), DeVaul also experimented with three ways of presenting these cues (i.e. overt visual cues, subliminal visual cues, and superliminal auditory cues). In practice, the correct visual overt, correct visual subliminal, and incorrect visual subliminal cues had a significantly positive effect on correctly associating a name with a particular face(pp. 153-162). The superliminal auditory cues (i.e. the voice could be heard, but not understood) had no positive effects on associating names with faces(pp. 162-168). So basically, correct visual subliminal and overt cues help a user to remember the name belonging to a person's face.

Finally, DeVaul also discusses one ethical[17] issue raised by his memory supporting wearable computer. Namely, that of undermining our own memorisation skills(cf. DeVaul, 2004, pp. 32,140). To illustrate this point DeVaul relies on a few anecdotes from his own life (e.g. no longer being able to remember telephone numbers because his telephone 'remembers' them), and the empirical studies of Jennifer Ockerman, who observed an over-reliance effect on checklists for aircraft inspections displayed by a wearable computer. The checklists caused pilots to overlook certain faults and failures that were not included on their wearable computer's checklist(DeVaul, 2004, p. 32; Ockerman & Pritchett, 1998). This over-reliance effect, though, is not just limited to this preliminary small-scale study (n=15) by Ockerman and Pritchett. In a later review, they cite several studies in which other researchers observed a similar effect, and they suggest several solutions to minimise the effect(see Ockerman & Pritchett, 2000, pp. 204-207).

In summary, in DeVaul's work we see an attempt to make wearable computers more accessible, and usable for mainstream users. Rather than stating principles and ideal practices with wearables, DeVaul, like Starner, started to investigate how such principles (i.e. context awareness, not distracting the user) could be put into practice and incorporated into the design of wearable computers. Let's now turn to Tanzeem Choudhury's work, which describes how to use wearable computers to do social scientific research, and explores the privacy issues of context-aware wearable computers empirically.

2.2.5 Tanzeem Choudhury: doing social science with wearable computers

A few months before Richard DeVaul obtained his PhD in wearable computing, another MIT Media Lab PhD named Tanzeem Choudhury obtained her PhD on using wearable computers to study human interaction networks. For often when social scientists study face-to-face interaction networks they run into several problems. First, it turns out that when experimental participants have to recall when a conversation took place, with whom they talked, and for how long, they often fail to provide a complete list of all conversations they had within the relevant time span. Social scientists know this through comparison with lists from independent observers(Choudhury, 2004, p. 20). However, these independent observers raise a second problem. Even though they provide a more reliable list of research data, hiring them to gather data on a large scale social network is often not feasible due to the high

[17] I have called the over-reliance effect an ethical issue as it seems very similar to the discussion on deskilling (i.e. whether technology causes us to lose certain skills) taking place at the intersection of the history of technology and the history of labour during the 1970's and 1980's. For a brief overview see MacKenzie (1984, pp. 493-494)

costs involved in hiring that many observers(ibid). Therefore, Choudhury has explored the possibility of using low-cost wearable computers to study these face-to-face interactions. Her wearable computer, called the sociometer, consists of one modified part of DeVaul's MiThril system: the hoarder sensor board. Choudhury describes this board, and the way it is worn, in the following way:

> "The board has an IR transceiver, a microphone, two accelerometers, on-board storage, and its own power supply. The wearable stores the data locally on a 256MB compact flashcard and is powered by four AAA batteries. A set of four AAA batteries is enough to power the device for 24 hours. Everything is packaged into a shoulder mount [so] that it can be worn all day without any discomfort"(p. 32).

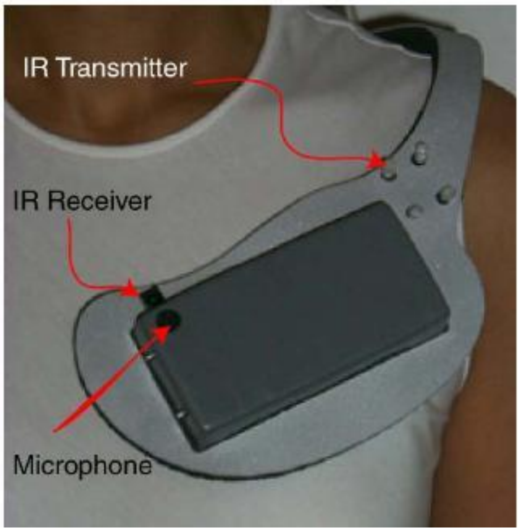

Figure 2-2 – The sociometer worn on the shoulder. Picture from Choudhury (2004, p. 33)

See Figure 2-2 for an illustration of how the user wears the sociometer. As this figure illustrates, Choudhury took great strides in designing a comfortable and aesthetically pleasing system (cf. , pp. 30-32). In practice, though, only the aesthetic efforts gained a clear positive response from a majority of the users (17 out of 21) in an exit survey on the usability of the sociometer(p. 37). With regard to the comfort of the system, a slight majority (9 out of 21 described the system as 'somewhat uncomfortable' (ibid). Apart from these detailed issues, there is also the broader practice of using the system - i.e. what Lucivero, et al. (2011) call societal usability (see section 2.1.2). In practice, when two people meet, both wearing a sociometer, these sociometers record two types of information. First, through the IR transceiver and unique infrared ID tags, the sociometer knows which other sociometer(s) is/are nearby (Choudhury, 2004, p. 41). Second, through high-level audio features (e.g. energy, various frequency spectrum features), the sociometer is able to determine when two or more people are talking to each other, "how often and for how long" they talk to each other, and what the turn-taking dynamics of the conversation are(ibid). Note that Choudhury answers these latter questions purely based on these high-level audio features, and therefore has no need to know *what* the actual conversation between two or more people is about(pp. 35-36).[18] Choudhury did this to preserve the

[18] In order to train the statistical classifier, though, Choudhury did have 4 participants in her experiment label two days of their own conversations with the two labels used by the statistical classifier: voiced (i.e. auditory fragment that contains speech from the conversation of the participant) and unvoiced (i.e. does not contain speech, or no speech from a conversation the participant was having)(Choudhury, 2004, pp. 35-36,60-62)

privacy of the experimental participants(pp. 35-36,96). By collecting this data from 25 participants from different departments at the MIT Media Lab for the duration of two weeks, Choudhury described this human-interaction network between these researchers successfully.

As I mentioned before, privacy was one of the important ethical issues Choudhury encountered in her research. In fact, when Choudhury asked participants in her exit survey whether they would "wear an audio collection device only if transcription is not done," a majority of the participants in the survey (12 out of 21) answered affirmatively(p. 37). Thus the acceptance of the sociometer depended considerably on the degree to which it harmed or promoted the privacy of its users. In later work, where Choudhury was one of the participating researchers, she and her colleagues pursued this empirical inquiry on privacy issues further. In a qualitative study with 24 participants Klasnja, Consolvo, Choudhury, Beckwith, and Hightower (2009) described some of the factors that influence the moral deliberation on privacy issues for five types of data - raw audio, high-level audio features, air pressure, bodily movement, and location- collected by four types of sensors - microphone, barometer, accelerometer, and GPS. Two points made in their discussion are important for our discussion here. First, that the responses with regard to privacy, differed per sensor(pp. 179-180). While all participants in the 3 month field study of the UbiFit wearable computer did not mind that the accelerometer and barometer[19] gathered data on their physical activities 24/7, and stored it "indefinitely" on their mobile phones(p. 179), participants did express their concerns when it came to GPS data being recorded all-day every day (14 out of 24 participants found this problematic), and even more so when it came to raw audio being recorded 24/7 (22 out of 24 participants responded negatively to this)(ibid). Only when the device would use high-level audio features (e.g. energy, single frequencies) for activity inferences, did the acceptance of audio recording go up again, but only slightly (6 out of 24 participants accepted this). Second, when the authors enquired further into the reasons why people accepted some forms of sensing, while they rejected others, they discovered three factors that played an important role in participant's considerations on privacy issues. The first factor was *what* type of data the sensors collected. Participants considered accelerometer and barometer data to be fairly general and harmless, while they found GPS data to be much more specific, and they argued that GPS data had a larger potential for abuse by "controlling husbands"(pp. 179-181). For audio, a second factor played a larger role in participants' privacy considerations: "the *context* in which the sensing takes place"(p. 183). For example, one psychologist who participated in the study feared that audio recordings of both kinds (i.e. raw and high-level) could be requested by a judge, and be used in court cases her patients *could* lodge against her(p. 180). Participants with other jobs that "required confidentiality" also deemed audio recordings and GPS unacceptable(pp. 180-181). Finally, the third factor the authors discovered was "the perceived *value* provided by the sensor data"(p. 181). For example, one female participant would have found it very interesting to see how she emotionally responded during dates (such responses could be inferred from high-level audio recordings), but in the end she did not decide to use such an application, as she

[19] The activity classifying software uses barometer data to detect particular types of movement such as moving up and down in an elevator, and climbing the stairway(Lester, Choudhury, Kern, Borrielo, & Hannaford, 2005, p. 770).

felt obliged to explain her friends and dates that she was recording them too, and she feared that she thereby hurt the relationships(p. 181).

In summary, in Tanzeem Choudhury's work we see a further shift in focus on testing wearable computers empirically in two senses. First, Choudhury uses wearable computers to *gather empirical data* that would otherwise have been costly and hard to obtain. Second, she *studied* both societal usability and ethical desirability claims empirically, and thereby offered an interesting perspective on privacy issues from a user's point of view. Let's now turn to the final section of this history of wearable computing and have a look at how researchers from Carnegie Mellon University designed various wearable computers for professional uses.

2.2.6 Smailagic and Sieworek: professional applications of wearable computers

The research on wearable computers at Carnegie Mellon University started in the summer of 1991, when computer science faculty members taught a continuing education course on engineering design methodology. During project work for the course the students from the industry had to develop a small wearable computer system to display "construction blueprints"(Smailagic & Siewiorek, 1993, p. 2). This wearable computer system later became known as the VuMan 1(ibid). Like Thad Starner's wearable computer, the VuMan 1 also made use of the Private Eye head-mounted display. Apart from that similarity, it's design differed significantly. For rather than being a general purpose wearable computer, the designers developed the VuMan 1 specifically to show these blueprints. This resulted in a 1.5 kg and 30 x 13 x 6 cm (height x width x depth) device with three push-buttons which contained all the hardware, and was connected to the Private Eye(p. 3). A year later CMU researchers redesigned the VuMan, resulting in VuMan 2. This system was considerably lighter and smaller(1993, pp. 6-8). As time progressed the CMU researchers redesigned the VuMan one more time, but also built several other wearable computer systems for other purposes such as manufacturing, medical, language translation, and plant operation, ultimately resulting in a total of 27 wearable computer designs and working artifacts in 2001(cf. Smailagic & Siewiorek, 2002, p. 21). For the sake of brevity, I will not discuss every design here, but rather explore the question why Carnegie Mellon researchers have been able to come up with so many new wearable computer designs in the 10 years between 1991 and 2001.

In my view, the core of the answer lies in the systematic approach the Carnegie Mellon researchers use to design wearable computers. Remarkably, their approach has a lot in common with the methodology Lucivero, et al. (2011) describe to analyse the societal usability claims of a particular technology (see section 2.1.2). Like Lucivero et al., the Carnegie Mellon researchers too, start their research projects with a study of the current practices of the end-users they collaborate with(Smailagic & Siewiorek, 1999, p. 43). They do so by visiting the work site, having interviews with end-users, developing scenarios of current practices and of future practices that include the new wearable computer (i.e. they develop screen mock-ups and storyboards of the artifact in use), and by having end-users give feedback on the iteratively developing designs regularly(pp. 43-45). After this conceptual design phase that results in the mock-ups, storyboards, and a list of general design constraints based on the practice scenarios(pp. 43-44), the researchers continue the development with a more detailed and concrete design by developing a software prototype running on an older version of an existing wearable computer, and by developing wooden mock-ups of the input controls, and a plastic mock-up of the housing. The researchers base these designs on the end-user feedback on the storyboards, scenarios, and mock-up screens(pp. 44-45). Finally, the researchers build the actual system, have users give feedback on it once again, after which the researchers deliver the final system “for field trial evaluation”(pp. 43,45). Over the years this methodology has also resulted in four general design principles for wearable computers. The first principle is to look for an appropriate interface metaphor(Smailagic & Siewiorek, 2002, p. 21). For example, while designing the VuMan 3 wearable computer for US Army vehicle maintenance, the designers adopted the checklist as the main metaphor for the user interface (rather than the desktop or spreadsheet), as the maintenance personnel already used checklists in their work (cf. Smailagic & Siewiorek, 1999, pp. 47, figure 47; 2002, p. 21). The second principle is to design input and output devices in such a way that they fit the interface metaphor, do not put a great burden on the wearable’s limited system resources (e.g. system memory, processor load), and allow for accurate input and output while not requiring a lot of training to be used. For example, when designing the VuMan 3, the researchers designed a dial that could be rotated to operate the interface(Smailagic & Siewiorek, 2002, pp. 21-22). This was necessary as maintenance personnel often wore gloves while working, which made it difficult to carry out accurate eye-coordinated hand movements(Smailagic & Siewiorek, 1999, p. 44). This did require from the interface designers, though, that they designed interactive elements in such a way that they could be operated using a dial, rather than with a mouse or keyboard(p. 46). The third principle is to match “capabilities with application requirements”(Smailagic & Siewiorek, 2002, p. 22). In other words, designers should “resist the temptation to provide extra capabilities simply because they’re available”(ibid). To illustrate, the VuMan 3 only provided the necessary forms and documentation to carry out maintenance work, and does not offer other functionality such as video-conferencing or web-browsing(Smailagic & Siewiorek, 1999, p. 46). Finally, the fourth principle is to quickly evaluate the user interface, and focus on “decreasing human errors and frustration.” For example, the VuMan 3 design process reflects this principle by making use of story-boards and regular end-user feedback to inform the design of the dial, which allows for accurate input while wearing gloves.

To summarise and conclude, rather than trying to design general purpose wearable computers for personal use, the Carnegie Mellon wearable computer researchers have focused on developing application-specific wearable computers that fit well into existing professional practices. Furthermore, by using a clear design methodology, and by involving the end-user in the design process from the start, their wearables have made many practices a lot more efficient. For example, the VuMan 3 reduced the inspection time of an army vehicle “up to 40%” because maintenance engineers no longer had to climb in and out of a vehicle to read paper documentation outside the vehicle(Smailagic & Siewiorek, 1999, p. 51).

2.2.7 Final thoughts

In the previous subsections (2.2.1-2.2.6), I have attempted to provide some insights in the diverse history of wearable computing, and into the recurring themes that characterise the academic field of wearable computing. In the next section, this history will provide at least some ground to asses the technical feasibility, societal usability, and ethical desirability claims about Google Glass. At least, that is what Lucivero, et al. (2011) claim in their paper on assessing expectations about emerging technologies(pp. 139-140). However, while working on this history of wearable computing, I noticed that some sources I used to compile this history (mainly journal articles) tended to be coloured by the very same strategic purposes that Lucivero et. al. are so careful to avoid while assessing expectations of emerging technologies. For example, as early as 2001 Steve Mann already made the following claim:

> "We are at a pivotal era in which the convergence of measurement, communications, and computation, in the intersecting domains of wireless communications, mobile computing, and personal imaging, will give rise to a simple device we wear that replaces all the separate informatic items we normally carry."(Mann, 2001)

Looking at this claim in retrospect, I would say that it took at least twelve more years before a somewhat well-known and popular wearable computer came out in the form of Google Glass. However, even Google Glass does not currently replace all our "informatic items", and is not meant for that purpose either(cf. Fingas, 2013). Furthermore, four years earlier Steve Mann already made the following explicit remark on funding in an introduction to a first special issue on wearable computers, while distinguishing those who developed non-functional electronic devices as fashion items (which he disliked), from the serious efforts of hobbyist wearable computer hackers (which he applauded): "It is these very efforts that should be built upon using *the vast funding and infrastructure* of major academic research labs, while leaving the hype to be taken care of by the spectacular commodity society outside the academic environment"(Mann, 1997b, pp. 203, emph. mine). Finally, as Mann made his 2001 remark in another introduction to a special issue on wearable computing, I'm inclined to conclude that it is at least plausible that he made this remark for strategic reasons as well, to mobilise funding and support for the field. In contrast, I found that most of the PhD theses and conference papers I used, tended to be fairly open about the controversies within the field of wearable computing.

So what does this observation mean for Lucivero et al.'s (2011) framework? First of all, I think that the implicit assumption underlying their framework, that the history of a field provides some kind of objective interpretational framework that could be used to assess future-oriented expectations about emerging technologies, is not entirely correct. For as I hope to have illustrated some of the historical sources used in this investigation tended to be coloured by strategic purposes as well. Secondly and nonetheless, I think Lucivero, et al. (2011) also provide a good methodology to adequately handle these strategic purposes. As I mentioned in section 2.1.1, Lucivero et. al provide three questions to analyse the rhetorical and strategic context of a claim, which basically enquired into the background knowledge of the person voicing the claim, the audience he/she addresses, and the strategic purpose of his/her claim(p. 133). While writing this history of wearable computing, I basically applied the same three questions to my historical material to avoid supporting an author's strategic aim.

With this in mind, let's now move on to a wearable computer that is American wearable computer history in the making. Let's assess the expectations and claims about Google Glass.

2.3 Assessing expectations and claims about Google Glass

In this section, I will assess claims about Google Glass from a variety of official and unofficial sources. As most claims and information about Google Glass tend to be spread across these various sources, I will again adopt Lucivero et al.'s three dimensions to structure this section. So first I will discuss technical feasibility claims about Google Glass, by exploring the current, near, and far future technical capabilities of Google Glass (section 2.3.1). Second, I discuss the societal usability of Google Glass, by exploring the aesthetics, human-computer interaction (HCI) model, a selection of applications, and the distribution of Google Glass (section 2.3.2). Third, I discuss the ethical claims made about Google Glass, by exploring the current ethical discussions on Google Glass and what these discussions imply for the current, near, and far future ethical desirability of Google Glass (section 2.3.3). Let's now turn to the technical feasibility claims about Google Glass.

2.3.1 Technical feasibility

Basically, the Google Glass Explorer Edition is a two-component wearable computer consisting of a computing unit with a head-up display, and a titanium frame to wear Glass on the head (Google, 2014d; Mendis, Olsson, Lee, & Jordan, 2013, t. 1:48-6:00; Rassweiler, 2014). On the inside, the computing unit contains a Texas Instruments OMAP 4430 dual core processor, 1 GB of Random Access Memory (RAM)[20], and 16GB of flash memory[21] of which 12GB are available to the user(Google, 2014s; J. Lee, 2013; Rassweiler, 2014). Additionally, it contains several sensors: two accelerometers(cf. Rassweiler, 2014), a gyroscope, a magnetometer (i.e. compass), and a GPS processor which likely uses the GPS antenna from a mobile phone, as users need to pair their phones to Glass in order to use GPS(Google, 2014c, 2014m; Nanek, 2013c; Techinsights, 2014). Furthermore, on the outside the system contains a 5 megapixel camera(Google, 2014s), a bone-conduction speaker (ibid), a microphone(minipcpro, 2012, t. 12:16-12:32), a 640 x 360 "liquid-crystal on silicon (LCOS) projector display"(Rassweiler, 2014), a touchpad(ibid), and a "light sensor" that is used for on-head and wink detection[22](Google, 2014w; Torborg & Simpson, 2013).Finally, with regard to networking capabilities, Google Glass supports Bluetooth, and Wi-Fi 802.11 b/g(Google, 2014s; also cf. Ho, Amirparviz, Gomez, & Starner, 2012).

As a whole the system weighs about 42 grams, excluding shades or spectacle frames(Angelini, 2013; Engelen, et al., 2013, appendix 1), and comes in a variety of form-factors. First of all, there is the basic bar-shaped titanium frame, that optionally allows the user to attach 'shades' or 'shields' to protect the user's eyes from the sun or rain, while still being able to use Google Glass(Google, 2014q). Second, since the end of January 2014, Google also offers four titanium spectacle frames that allow users with prescription glasses to use Google Glass(Google Glass, 2014g). For the consumer

[20] Google recently introduced a third version of Google Glass that includes 2 GB of RAM (Google Glass, 2014i).

[21] Flash memory is the type of permanent storage memory you find in most USB sticks and solid-state harddrives.

[22] Note that the wink detection only works on devices produced after October 28, 2013(Google, 2014w). On that date Google released a new version of the Google Glass Explorer edition, and allowed all their Explorers to swap their devices for free(Google, 2013c). So the specifications described in this section apply to this newer edition, unless stated otherwise.

edition of Google Glass, Google might make more spectacle frames available, given the recent deal between the Luxottica Group[23] and Google(Google Glass, 2014f). Third, as two Dutch Glass Explorers told me in a semi-structured interview, a logical next step *might* be that Glass becomes a contact lens, rather than a frame worn on the head.[24] Indeed, Google's Brian Otis and Babak Parviz have recently published more information on a smart contact lens they are testing that is able to measure glucose levels from small amounts of tear moisture(Otis & Parviz, 2014). However, as two tech reporters conclude their review of research in this area: "So whether or not Google X is looking in this direction [i.e. smart contact lenses] now, it seems a possible avenue of *future research*, if not a probable one"(Temple & Gannes, 2014, emph. Mine). They base this conclusion on the fact that adding light sources to a contact lens has only been demonstrated to cause no eye-damage with a single-pixel display on an anaesthetised rabbit's eye(Lingley et al., 2011). Furthermore, in an interview with these same tech reporters, Google's smart contact lens project leader Brian Otis states that "Google *does* know that it *doesn't* want to manufacture and sell the product," but rather that Google looks for companies that want to develop this product further(Gannes & Temple, 2014, emph. Mine). Therefore, even though a contact lens might sound like the obvious next generation of Google Glass, still a lot of research and corporate support is needed before it becomes a technical reality(cf. Henn, 2014; also cf. Lingley, et al., 2011, pp. 7-8; Temple & Gannes, 2014).

Next to these basic hardware features, Google Glass still faces two[25] main challenges at the hardware level: durability and power-consumption. Let's start with durability problems. The first Google Glass Explorer edition – made available before October 28, 2013 – mainly had mechanical problems with the connection between the battery and the computing unit. Several Glass explorers reported that at some time Glass physically broke at this connection(e.g. Engelen, 2014; Sales, 2013). Additionally, other Explorers reported that the foil protecting the display came off in humid environments(e.g. Hurley, 2013; Poltrack, 2014). To resolve these issues Google has replaced these devices, by a second edition of their Google Glass Explorer device, and published a video giving Glass Explorers and others insight into how Google tested this second edition(Google, 2013c; Google Glass, 2014a). An issue still facing Glass users today, though, is power consumption. Basically Glass contains a 570 mAh battery(Techinsights, 2014; Torborg & Simpson, 2013). The amount of time a single charge lasts depends largely on whether the device is new, the way the user uses Google Glass, and the software version the user is running on Glass. For several Explorers who just got their new device reported that their battery drained fairly quickly – usually 20% charge left or less, after 30 minutes of use(also cf.Ibarra, 2014; Pastushkov, 2014; Tsukayama, 2014c, t. 1:30-1:40). In response to these problems Glass guide[26] Vasili Karamanos posted an article on the official Glass community website[27]

[23] The Luxottica group is the company behind eyewear brands such as Ray-Ban, Oakley, and Alain Mikli.

[24] (R. Hooijer and T.H. Van de Belt, personal communication, February 20, 2014)

[25] A third challenge facing Glass is heat generation(Lake, 2014, p. 1; Tsukayama, 2014b). However, so far I have not been able to find any response from Google to this issue. Furthermore, even though users describe Glass becoming too hot as a nuisance, this issue only led a few to stop using Glass entirely(Lake, 2014, p. 1). Thus I have decided to limit the discussion of this issue to this footnote.

[26] Glass guides are employees from Google who offer first line support to the Glass explorers. For more advanced questions explorers rely mainly on one another through the official glass community website (L. Engelen, personal communication, March 11, 2014).

that advised these Explorers to recalibrate the software by depleting the battery through normal use, and then charge the battery using the wall charger up to 90 minutes past the point where Glass shows the user the battery has been charged fully. Users should repeat this process two or three times(Karamanos, 2014). When users take these steps they should see an increase in battery life, and arrive at some of the values mentioned by other Glass explorers. For example, tech reporter Chris Angelini found that the Glass battery lasted for 52 minutes and 32 seconds while recording a video all the time[28](Angelini, 2013, p. 4), while another tech reporter found that the battery charge lasted 4 hours and 40 minutes with "mixed use" of Glass(Eadicicco, 2013). Finally, Glass explorer and Google employee Ryan Stroman reports that his Glass' battery lasted up to 14 hours with the XE12 software release for Google Glass, while the XE16 update, which directly followed XE12, reduced battery life to 5 hours, and a day later to 7 hours(Stroman, 2014a, 2014b). In other words, many factors influence how long Glass runs on a single battery charge. At the Google I/O conference Google's Glass team openly admitted that battery technology is a "key" area where they wish to see improvements(Mendis, et al., 2013, t. 36:30-38:00). For now, most explorers who experience this as a problem, have resorted to the use of external battery packs to keep Glass running longer on a single charge(Poltrack, 2014).[29]

Apart from the hardware specifications and issues discussed so far, Google Glass also runs software. Basically, Glass relies on a modified version of Google's own Linux-based Android operating system. Before the XE16 update mentioned earlier in this section, Glass ran Android 4.0.4 (cf. Google, 2014s; Song & Laligand, 2013, t. 5:10-5:30). On April 15, 2014, with the release of the XE 16 update, this changed into Android 4.4(Google, 2014x; Google Glass, 2014d). Already, during a session at the Google I/O conference in 2013, Google[x] software developers Hyunyoung Song and Pierre-Yves Laligand suggested that such an update might be coming when they said that "this [i.e. the fact that Glass at the time ran Android 4.0.4, BvdH] does not mean that at the time of a consumer launch this is the operating system that we'll be based on"(cf. Song & Laligand, 2013, t. 5:20-5:30). In other words, it does not seem unlikely that Glass will run Android 4.4 when Google launches the consumer edition of Glass. On top of this operating system explorers can chose from a number of officially approved applications – i.e. glassware- and a number of unofficial applications available from online code repositories such as GitHub.[30] I will discuss the details of some of these applications in the next subsection (2.3.2). For these applications imply use practices too, and therefore belong to the domain of societal usability. In this subsection, though, I want to end with a brief discussion of the two main building blocks of these applications; namely, the Mirror API (i.e. Application Programming Interface), and the Glass Development Kit (GDK). The Glass team introduced the Mirror API on March 11, 2013 at the SXSW conference in Austin (TX, USA)(Jordan, 2013a). Basically, the Mirror API allows software developers to integrate web services

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[27] Explorers Community - Explorers Community, http://www.glass-community.com , visited: June 23, 2014.

[28] i.e. video recording is one of the more power-intensive applications of Google Glass (R. Hooijer and T.H. van de Belt, personal communication, February 20, 2014) (also cf. Google, 2014s).

[29] (R. Hooijer and T.H. Van de Belt, personal communication, February 20, 2014)

[30] For the officially apporved glassware see: https://glass.google.com/glassware , visited: June 23, 2014. For GitHub see: Github - Build software together, better, https://www.github.com/ , visited: June 23, 2014.

(e.g. news, recipes, and weather websites) with Google Glass. For example, the New York times has built glassware that shows the user three new news stories each hour.[31] However, the Mirror API is a cloud-based API (i.e. all information exchanged between a user's Glass device and the web-service has to go through a Google server), and thus requires a working Internet connection in order for it to work(cf. Google, 2014p; Song & Laligand, 2013, pp. 1:30-32:00). Furthermore, the Mirror API does not give access to the camera, microphone, and other sensors that are part of a Glass device(Jordan, 2013c, t. 16:25-17:30). Therefore, Google introduced the GDK on November 19, 2013, to enable developers to add "real-time user interaction," "offline functionality," and "access to hardware" to their glassware(Google, 2014p; Jordan, 2013b).

So in conclusion, I think it's fair to say that the Glass team has tackled some of the technical challenges for wearable computers that we encountered in our history of wearable computing(section 2.2). After all, Glass is no longer like the heavy, bulky, and obtrusive wearable computers that Steve Mann and Thad Starner used to wear (section 2.2.2 and 2.2.3, respectively). However, like these early wearable computing systems Glass does offer software developers a chance to develop context-aware applications through its GDK and sensors(cf. Section 2.2.4). Finally, the issues of power consumption, and heat generation described by Thad Starner (2001a) as some of the technical challenges for the field of wearable computing, remain a challenge for Google Glass up to this very day. With these technical details in mind, let's explore the societal usability of Google Glass.

2.3.2 Societal usability

As the societal usability of Google Glass has many dimensions, I have decided to focus on four topics. In the first subsection, I discuss the design and aesthetics of Google Glass, and I give a brief historical explanation as to why the design and aesthetics of Google Glass influence its societal usability (section 2.3.2.1). I then move on to a brief discussion of human-computer interaction (HCI) with Google Glass, which I discuss in greater detail in the third chapter of this thesis (section 2.3.2.2). Based on this latter HCI discussion, I discuss the broader use practices of Google Glass. More specifically, I discuss its out-of-the-box functions (e.g. taking photos, navigation etc.), several health care practices, health care applications, and augmented reality applications for Glass, that will be elaborated upon in chapters 3 to 5 (section 2.3.2.3). Finally, I end this section with a brief discussion of the way Google distributes Glass, how that might happen in the future, and the thorny question of when the consumer edition of Google Glass might be released (section 2.3.2.4).

2.3.2.1 The design and aesthetics of Google Glass

In a question and answer session with attendees of the Google I/O conference in 2013, the lead designer of Google Glass, Isabelle Olsson, summarised her design principles for Google Glass using three words: "lightness, simplicity, and scalability"(Mendis, et al., 2013, t. 3:30-3:40). Lightness does not only refer to the physical weight of Glass, as discussed in the previous subsection (2.3.1), but also to what Olsson calls "visual lightness." In other words, visual lightness means hiding the largest components within a single computing unit that appears simple, small, and

[31] See: Glass, https://glass.google.com/u/0/glassware/198437243762364197 , retrieved: May 26, 2014.

unobtrusive on the outside(t. 4:15-4:35). Simplicity means that they removed everything that was not strictly necessary for the device to function well, this included a number of "adjustment mechanisms" to make Glass fit well on a user's head(t. 3:05-3:25, 4:35-4:50). Finally, scalability, "at this stage," refers to the fact that the computing unit can easily be unscrewed from the bar-shaped titanium frame, so that it can be attached to other types of frames, such as prescription frames(t. 4:55-6:00). I mention these principles because the Glass design team so far has succeeded in creating a wearable computer that people actually want to own. Indeed, as Radboud Reshape Centre's Tom H. Van de Belt, PhD mentioned when he explained how people generally responded to their presentations on Google Glass and other health care related IT innovations:

> "Most of the time their first question tends to be: where can I buy such a thing [i.e. Google Glass, BvdH]? That is actually always the first question.[32]"

And as his colleague Robin Hooijer adds:

> "And can I be photographed with it?[33]

In other words, wearing Google Glass has a certain prestige to it. I think the claim that wearing Glass has a certain prestige, is not self-evident, but can be explained based on the history of wearable computing. As we saw in the history of wearable computing, the early wearable computers made by Steve Mann and Thad Starner did not always entice enthusiasm (see section 2.2.2-2.2.4). However, in those cases where the creators of wearable computers paid close attention to the design and aesthetics of their devices, such as Choudhury's sociometer, Steve Mann's necklace-based wearable, and Smailagic and Sieworek's MoCCA platform, there users and bystanders adopted a more positive stance towards these wearable computers (see section 2.2.1, 2.2.5 and cf. Mann (2004); Smailagic et al. (1999)). Note that I do not argue that the design and aesthetics of Glass are the sole cause for the prestige and popularity of Google Glass. Undoubtedly, the Google brand, the marketing campaign, and the exclusivity of the explorer program have all contributed their part to the current prestige and popularity of Glass. Nonetheless, I think it is fair to say, that based on the history of wearable computing, the design and aesthetics of Glass have also played their role here, including the principles formulated by Olsson mentioned above.

2.3.2.2 Human-computer interaction of Google Glass

Next to its outward appearance, Google Glass also has a number of ways to interact with its user. The two main ways the user interacts with Glass are swiping gestures detected through the touchpad on the side, and voice commands preceded by the phrase "OK, Glass"(Google, 2014l, 2014u). Furthermore, users can interact with Glass in two additional ways to perform specific actions. First, there are two buttons on the device, of which one is used to turn the device on, off, or in standby mode, while the other button can be used to take pictures and record videos(Google, 2014f; cf. Karamanos, 2014). Second, Glass offers a head up gesture to activate the screen briefly, and a wink gesture to take pictures(Google, 2013b, 2014w). Apart from these officially supported ways of interacting with Glass, several explorers have also

[32] (R. Hooijer and T.H. Van de Belt, personal communication, February 20, 2014)
[33] Ibid , see previous footnote

experimented with other ways to interact with Glass. First, Glass explorer Brandyn White has 3d-printed a cheap eye-tracker for Glass, that allows the user to operate Glass with eye-gestures(White, 2013b). This should not be confused with the "infrared light sensor" that Glass uses for wink detection. For that sensor only tracks what happens in front of it, and does not track the movements of the pupil itself(, t. 1:50-2:10). Additionally White also developed a web page with various buttons that acts as a keyboard for Glass(, t. 3:05-4:15). Second, the Canadian start-up company Whirlscape Inc. Recently introduced its Minuum one-line keyboard for Google Glass (Walmsley, 2014a). Basically it shows a one-line keyboard with three-lettered keys on the Glass display, and through a clever algorithm the software is able to figure out which word you meant to type and shows word suggestions above the keys. The keyboard is operated either through the Glass touchpad alone, or through head-movements towards left or right combined with taps on the touchpad to select the keys. Finally, Google Glass provides feedback on user input (i.e. output), through visual cues displayed on the head-mounted display, and through auditory cues that can be heard through the bone-conduction speaker or the optional ear piece(Google, 2014b).

2.3.2.3 Basic functions and applications of Google Glass

Now that it is roughly clear how Glass has been designed in terms of hardware, appearance, software, and interaction design, let's have a look at some of the use practices that Google Glass enables through its software. Note that I will not discuss every piece of software that has been developed for Google Glass, but rather I will briefly focus on the basic functionality that comes with Google Glass out-of-the-box, some health care applications that I discuss in greater detail in the third and fifth chapter of this thesis, and some augmented reality applications that will be the topic of the fourth chapter of this thesis.

The basic functions Google Glass comes with out-of-the-box are the ability to take pictures and record videos using the camera, to perform Google searches, and to send e-mails to one of your contacts(Google, 2014u; cf. Google, 2014v). Furthermore, up to the XE 16 software update for Glass, explorers also had the possibility of making video calls using Google Hangouts (Google, 2013a). Unfortunately for some explorers, Google decided to remove this feature due to low usage, and the choppy and blurry quality of the images(Google, 2014x). When the user pairs Google Glass over Bluetooth with his or her phone, users also gain the ability to receive navigation instructions to particular locations, to call people, send SMS text messages (only available when paired with Android phones), show the Glass display on their phone, and gain Internet access through their phone subscription when a wireless local area network (WLAN) is out of reach(Google, 2014n).

Based on these basic functions, Glass explorers have developed a number of health care practices, and have extended the functionality of Glass by building their own health care and augmented reality software for Glass. Let's start with the health care practices. One of the health care practices where Glass has been tested several times is surgery(e.g. Engelen, 2013a; Grossmann, 2013; O'Connor, 2014). Glass turned out to be valuable for this practice in two ways. First, because it allowed medical students, and medical doctors in countries with less developed health care systems, to see how an expert surgeon performs surgery from that surgeon's point of view. So for this group

Glass has educational value(O'Connor, 2014).[34] Second, Glass allows the surgeons themselves to consult patient medical records (including scan results) through specialised glassware(Boulton, 2014; Gannes, 2014), or to consult colleagues through the video-calling feature(O'Connor, 2014). Furthermore, it allows them to do so hands free, thereby keeping the Glass device sterile(Boulton, 2014; O'Connor, 2014). Another health care practice for which medical centres are testing Glass is paramedicine(Engelen, 2013b; O'Connor, 2014; Pristine Inc., 2014). In other words, those emergency situations in which paramedics need to assess where a particular patient needs to go (e.g. a university hospital, local hospital, or specialised clinic). Being able to consult a specialist at the hospital using two-way video and audio communication while making this assessment, helps paramedics to make the right judgement and could save the life of the patient as no precious time is wasted on getting the patient from the wrong hospital to the right hospital(cf. O'Connor, 2014). Currently, the companies Wearable Intelligence, Inc. And Pristine, Inc.,[35] both offer secure video and audio communication systems based on Google Glass that comply with the American privacy regulations for medical information systems (i.e. they are HIPAA compliant)(Boulton, 2014; Gannes, 2014; O'Connor, 2014; Troutfetter, 2014). Additionally, Wearable Intelligence Inc., also provides Informant, a piece of glassware that allows the medical professional to access a patient's vitals, medical history, and other patient data(Wearable Intelligence Inc., 2014a).

Finally, there are three other pieces of health care oriented glassware that are aimed at a more general audience. First, there is CPR Glass which aims to assist a Google Glass user in performing cardiopulmonary resuscitation (CPR) on someone with a sudden cardiac arrest(Assad-Kottner, 2013a, 2013b; Vukin, 2014, t. 8:15-14:08). CPR Glass also provides feedback on a user's pushes to get the heart beating regularly again, by showing whether the user administers pushes too fast, or too slow(ibid). Second, the Radboud Reshape & Innovation Centre has developed a mockup version[36] of Glassist, a Google Glass application that aids people with various handicaps in making use of public transport by offering navigation instructions and the ability to contact someone through a video call for remote assistance(Engelen, et al., 2013). The Reshape Centre also performed some user testing using the navigation and video calling feature of Glass(pp. 25-28). On the current status of the Glassist project, their director said in a semi-structured interview:

> "We have made a mockup, we have finished the [interface] screens, the [necessary] technology is part of the device, and we only have to knit these together. We have only said: we are not going to do this at this moment, because we currently wait until we have some more glasses available, so that we can see in practice what people really desire. We currently have an expectation from these people, we have tried several things, and now we really want to test that with these people.[37]"

[34] (R. Hooijer and T.H. Van de Belt, personal communication, February 20, 2014)

[35] A third company, Augmedix, Inc., says it has been working on a similar communcation system, but so far has mainly focussed on removing the paper work during patient-doctor consults. They do so by live video streaming these consults to Augmedix, who then ensure that the necessary notes, and possibly video material, are added to the electronic patient record. However, Augmedix has so far declined to comment on how they translate these video recordings into notes(i.e. whether they do so through an algorithm, or through a person viewing the material).They have only stated that they do so in a way compliant with the medical privacy laws(S. M. Lee, 2014). Due to the unclarity about the workings of their technology, I have decided to limit my discussion to this footnote.

[36] (L. Engelen, personal communication, March 11, 2014)

[37] (L. Engelen, personal communication, March 11, 2014)

And on ‘knitting’ the interface screens and basic functions of Glass (i.e. navigation and video calling) together, he says:

“But that means you have to link those in that SDK; only now that is just going to be very hard, because you have to program at Android level and then port that [to Glass], while you cannot really [directly] call on the basic functionality of those glasses. Soon that will be possible.[38]”

In other words, back in 400n’t40ber 2013 when Reshape performed the user tests(Engelen, et al., 2013, p. 13), the software developers still lacked documentation on how to make use of the Glass camera, microphone, and GPS functionality of Google Glass for their own applications. For Google did not release this documentation until November 2013 (see section 2.3.1). So before that time they had to rely on their own technical ingenuity and Android expertise to do this. Therefore, I think it is likely that a version of Glassist running on Glass might be expected for the consumer edition of Glass, now that the GDK is in place, and now that it has become easier to obtain multiple Glass devices(cf. Google Glass, 2014e). Third and finally, Glass explorer Lance Nanek, did indeed rely on his own technical ingenuity to develop a medical augmented reality application for Google Glass. He calls his application MedView, and it allows medical personnel to see an enhanced image of a patient’s skin on which the veins are more visible, so that it becomes easier to puncture a needle *into* a vein, rather than next to it(Nanek, 2013d). Note, though, that the code of this application has not been updated for at least a year(cf. Nanek, 2013b), and therefore might need an update to work with the new Android 4.4 version, and the new GDK API.

Apart from Nanek’s medical augmented reality (AR) application, Glass has some other AR applications as well. Here’s just a brief overview of the more interesting ones for the discussion in chapter 4. When Google’s developer advocate for Google Glass Timothy Jordan introduced the GDK, he also demonstrated the Word Lens application, as a way to show what the GDK could be used for. Word Lens is an application that asks the user to aim the Google Glass camera at a piece of text in a foreign language, translates it, and then overlays the translated text over the original text, creating the visual illusion that the the text was always displayed in the user’s own language(Jordan, 2013b, t. 4:50-4:55). Another AR application that is currently able to run on Glass for about 15 minutes(Alt, et al., 2013, t. 14:50-16:00) is the Metaio Junaio augmented reality browser. Basically the Junaio browser allows developers to overlay what users see in front them with a set of location-based labels to guide them to particular locations of interest such as museums or restaurants(cf. Misslinger, 2013). Thirdly, Glass Explorer Brandyn White has developed several AR applications to aid the visually impaired. One of these applications is Memento, an application that allows a user *without* a visual handicap to create audible annotations of visual scenes for someone *with* a visual handicap who hears these annotations to learn about a scene, when Glass has recognised that particular visual scene(White, 2013c, t. 0:57-3:31). Another useful AR application for visually impaired users of Glass arose at a workshop given at the MIT Media Lab. There, a group of four students developed glassware that could overlay the visual ID’s of AR tags (i.e. tags similar to QR codes) and estimate, and audibly mention the distance between the Glass user and a particular tag. This system could allow a visually impaired person to know how many steps they still have to take on a stairway, or how far away they are from a wall or

[38] Ibid, see previous footnote

object(White, 2014b, t. 7:06-9:30). Finally, Glass Explorer Jacob Funch has developed a piece of glassware called Reader which allows the user to highlight a word in a paper document using an ordinary highlighter, and then have Glass scan the text with optical character recognition (OCR) software, to lookup the definition and translation of the word(Funch, 2014).

2.3.2.4 Distribution of Google Glass

Now that we have an overview of what Google Glass is, and what it can be used for, how does Google actually distribute the hardware and software for Google Glass, and how might it plan to do that when the consumer edition of Google Glass comes out? Let's start with Google's current explorer program. Google first announced this program at its I/O conference in 2012 (minipcpro, 2012). At that conference Google announced that only citizens of the USA could buy Google Glass for $ 1500,-, and only at the conference itself(, t. 27:54-30:43). As time progressed Google expanded the program to diversify their group of explorers, and currently allows every US and UK citizen to buy Glass for those same $ 1500,-(Google Glass, 2013a, 2014e, 2014h). There seem to be three ways in which explorers actually received their Glass devices, once Google accepted them into the explorer program. Some explorers picked up their Glass devices in person at one of the special Google Glass basecamps in the United States(Torborg & Simpson, 2013; van der Haak, 2013, t. 23:30-25:00), while another explorer did not have the opportunity to visit a basecamp, and had Glass shipped to him(Ibarra, 2013).[39] The Google support pages confirm this latter way (shipping by mail) as the main way of distributing Glass, while Google currently reserves basecamp visits for those needing help with their device, or for those who want a demo of the device(Google, 2014r, 2014t).Recently, Google introduced a third way to obtain Google Glass. Namely, by selling it through a few retail eyewear stores in California and Illinois(Rodriguez, 2014; Yerak, 2014). Additionally, Google already refers explorers who bought Glass together with one of the titanium spectacle frames (see section 2.3.1) to so-called "preferred providers" for their prescription lenses(Google, 2014d). The task of these preferred providers is not just to cut lenses for the Glass titanium spectacle frames, but Google's special website for eyecare professionals states that these professionals are also trained on using and demonstrating Glass itself. For the consumer edition of Glass sales through this third distribution channel are likely to increase. For in a post discussing their recent deal with eye wear manufacturer The Luxottica Group, the Glass team wrote the following: "In addition, Luxottica's retail and wholesale distribution channels will serve us well when we make Glass available to more people down the road."(Google Glass, 2014f). Therefore, Google will likely start selling Glass devices more often in regular optician stores when the consumer edition is launched.

In terms of software distribution there is more certainty. Basically Google has one website on which all officially approved glassware resides,[40] and from that website, or from the MyGlass app for Android, users can simply enable or disable particular

[39] The Dutch Glass explorer Lucien Engelen confirmed that he also received his device through shipping, though it was more difficult for him to actually get into the Glass Explorer program as Google focusses primarily on the US market. Eventually, with some help from friends he did get Google to transfer the device to his Google account and have it shipped to the Netherlands(L. Engelen, personal communication, March 11, 2014).

[40] Glass, https://glass.google.com/glassware , retrieved on June 7, 2014.

glassware(Google, 2014a). For Glassware that's still in development, or that has not yet been approved by Google, explorers need to enable debug mode on the device, and connect their Glass device to the computer, so that the software package (i.e. the APK) can be transferred to the device(Google, 2014e).

Finally, there is still the thorny question of when the consumer edition of Google Glass will be released. Officially, Google has mostly declined to give a specific release date of a Google Glass consumer edition, or when Glass might be released in other countries than the USA(e.g. Mendis, et al., 2013, t. 14:25-16:25). Only in their list of frequently asked questions for journalists Google has stated once, as an answer to a question about prescription frames, that "we move towards a consumer launch later in 2014"(Dale & Richardson, 2013a). Furthermore, one tech blogger and Glass explorer has claimed that this same list once contained the following more specific answer on January 28, 2014: "Starting last fall, we've been slowly expanding the Explorer program and we'll continue to do that until our consumer launch towards the end of 2014"(McGee, 2014a). However, no more than 10 days later,[41] Google changed the wordings of the last part of this phrase to: "(…) and we'll continue to do that until our consumer launch *down the road*"(Dale & Richardson, 2014, emph. Mine). A recent comment by Google co-founder Sergey Brin seems to confirm Google's doubts on whether they will be able to launch a consumer edition by the end of 2014. In an interview at the Code conference he said:

> "Uhm, This year I uhm … it … plus or minus. Plus or minus. I can't tell you exactly, it's… I'd hoped we could by the end of the year, but I'm not sure. I mean we do want to incorporate the learnings we've gotten, and we've learned a lot, about how people actually use this, and what works for them, and what doesn't work for them, and it just takes time to incorporate those changes, and to be able to manufacture at scale"(Mossberg & Swisher, 2014, t. 21:58-22:30).

Finally, the Dutch Glass explorer Lucien Engelen estimated what a roll-out across various countries *might* look like, when I discussed the possibility of having different language editions of Glass with him:

> [First] "it will become available in America, and (…) not long afterwards, or maybe even simultaneously, they will do the same in England, because obviously, the only factor you need to take into account is language, and it is much easier to do a roll-out there too, so to speak. And subsequently they will look at other languages. I do not estimate that the Netherlands are at the forefront of the line. I think they will first look at Spanish, or French, or maybe even German…"[42]

In other words, the consumer edition of Google Glass is most likely launched sometime near the end of 2014 or in the first quarter of 2015. Furthermore, this launch likely happens in the USA first, followed by or simultaneously with the launch in several other English speaking countries.

To conclude this whole section on societal usability, I think a fair assessment of the current Google Glass explorer edition is that many of the Glass practices, glassware beyond the basic functions, and ways of interacting with the device are still developing. In contrast, the aesthetic design of Glass seems to be successful, stable, and does not seem to scare people away, as some of the early wearable computers did. Some of the practices that involve the Glass camera and display (e.g. sneaky photography, facial recognition, and eye-strain complaints because the display is

[41] Another article by McGee published about three weeks later pointed out this change(cf. McGee, 2014b). However, the 10 days claim is based on my own research through the Internet archive (http://www.archive.org).

[42] (L. Engelen, personal communication, March 11, 2014)

placed slightly *above* the right eye), do got an ethical discussion going about Google Glass, and that is what we will look at in the next section.

2.3.3 Ethical desirability

The most recent (good-life) ethical discussion that arose due to Google Glass had to do with eye-strain complaints caused by the unusual upward rightward movement that an explorer's eyes need to make, when he or she starts using Glass(Google Glass, 2014k; Smith IV, 2014a). For Google positioned the display in the upper right corner of the user's visual field. These complaints seem to have been known to Google since 2013, as they appeared a few times on Twitter(e.g. Bilodeau, 2013; Harned, 2013) and one ex-Glass explorer reported that similar complaints (i.e. 'headaches'), which he experienced himself as well, could also be found in the explorers-only part of the official Google Glass community website(Matyszczyk, 2014). Google's initial response to an article published on these complaints in February 2014, was that they greatly valued the safety of their device, that they advised users to "ease into Glass" (i.e. don't use it for several hours straight initially), and that they invited users to contact them when they experienced these complaints(ibid). However, when two editors from the technology website *Betabeat* experienced similar complaints when trying Glass for the first time, and asked the Glass guides in New York how Google "was managing the headache issue," "they [i.e. the Glass guides, BvdH] seemed baffled by the question"(Smith IV, 2014a). After more discussion with Google, the company eventually referred the editors to Harvard University optometrist Dr. Eli Peli, whom Google asked to research the complaints(ibid). Dr. Peli explained to the editors that our eyes are not used to looking sideways for longer than a second at most. Therefore when new users start using Glass enthusiastically in ways that involves looking at the display a lot, they will start to experience these pains(ibid). However, these pains should not be confused with headaches, but rather indicate "sort of a discomfort in the eye muscles"(ibid). The good news, though, is that the pain should disappear within several days, as the eye muscles get used to making these movements, and hopefully users start using Glass less and adopt the shorter interaction times Google designed it for(ibid). After *Betabeat* published their story, Google got into a discussion with the reporters, and expressed its dissatisfaction with the rhetorical style of the publication(Smith IV, 2014b). Additionally, six days after the *Betabeat* publication Google posted a brief statement on its own official Google Glass channel on Google+ that referred to a muffled statement by Dr. Peli, that did not contradict his earlier statements, but did frame them in such a way that the *number* of users who did experience these complaints, *appeared* smaller because they were contrasted with "the thousands" of people who own a Google Glass device(cf. Google Glass, 2014k; Smith IV, 2014b). Nonetheless, even though new explorers experience these complaints temporarily, Google has so far only advised its users to "ease into Glass," while not taking any technical measures to prevent these complaints from occurring.

A second ethical discussion that has been going on for somewhat longer, is the discussion on face recognition applications for Glass. The first party to try and prototype facial recognition software for Glass has been Google itself(Mendis, et al., 2013, t. 21:50-22:40). More specifically, Google Glass product manager Steve Lee said the following about it at the Google I/O conference in 2013:

> "That's something we've prototyped early on, we have definitely experimented with it. But

it's not something that is part of the product today. It's not currently in our product plans. I think at some point in the future, whether Google's developing it, or third-party developers, I can imagine that existing. I think me being a product person, the way I view it, I'm not scared of it, but I wanna make sure there is a clear user benefit. (...) That's one thing, and then secondly, let's be honest and genuine about the privacy issues, and what policy would surround that type of feature. But currently there is no plans for us to do that."(ibid)

And in a later post on myths about Google Glass, the Glass team wrote the following:

"As we've said before, regardless of technological feasibility, we made the decision based on feedback not to release or even distribute facial recognition Glassware unless we could properly address the many issues raised by that kind of feature. And just because a weird application is created, doesn't mean that it'll get distributed in our MyGlass store. We manually approve all the apps that appear there and have several measures in place (from developer policies and screenlocks to warning interstitials) to help protect people's security on the device."(Google Glass, 2014j)

However, so far there have been three attempts by Glass explorers to develop facial recognition software for Glass.[43] Furthermore, as I stated previously, next to the official MyGlass store mentioned in the above quote, explorers can also run their own software packages on Glass by putting the device in debug mode (see section 2.3.2.4). One of the first Glass explorers who experimented with facial recognition software on Glass was Lance Nanek. As part of a broader software package for health care professionals, he added a feature that allowed these professionals to look up their medical notes about a client, based on Glass recognising that client's face(Nanek, 2013a). This feature makes use of an open web API (i.e. closed source code, but without additional costs for non-commercial use) called Betaface[44]. Betaface allows users to build an album of their own to match faces against, or check them against a database of celebrities.[45] The software source is freely available through GitHub,[46] but has not been updated for a year. Two other explorers who founded their own companies to try and bring facial recognition to Glass, are Lambda Labs, owned by Glass explorer Stephen Balaban, and Facialnetwork.com's NameTag app, created and owned by Glass explorer Kevin Alan Tussy(cf. Greenberg, 2013; Singer, 2014). Balaban's approach towards face recognition is similar to that of the Betaface API, even though his use of this functionality is different from that of Nanek. For Balaban too allows users to create their own album of faces against which the Glass camera pictures are matched,[47] while he uses face recognition as a way to retrieve memories about people and previous conversations(cf. Greenberg, 2013). So far, however, I have not been able to find the FaceRec glassware Balaban demonstrates in a Youtube video, and that he claimed to release(cf. Balaban, 2013; Greenberg, 2013). His company only offers access to the cloud-based API that they likely used to build the software.[48] Finally,

[43] Recently, a fourth party decided to add a facial recognition feature to their Glass software. The hotel-checkin software firm iTesso has developed an application for Google Glass that recognizes a client's face as (s)he enters the hotel lobby for checkin. Face recognition happens based on the private records of the hotel, and through public sources like LinkedIn. So far, only a demonstration of the software has been announced. (Udell, 2014)

[44] See: Betafaceapi - Face Recognition webservice, http://www.betafaceapi.com, visited: June 11, 2014

[45] Ibid (see previous footnote)

[46] lnanek/MedRefGlass - GitHub, https://github.com/lnanek/MedRefGlass/ , visited: June 11, 2014

[47] Face Recognition API | Mashape API Marketplace, https://www.mashape.com/lambda/face-recognition/pricing#!pricing , visited: June 11, 2014

[48] Ibid (see previous footnote)

Facialnetwork.com's NameTag glassware caused most discussion about the facial recognition capabilities of the Google Glass platform(cf. Robertson, 2014; Singer, 2014). The main reasons for the controversy were that NameTag tried to use social media profiles and the US sex offenders database[49] to recognise faces, and adopted an opt-out approach that still required someone to provide a valid social media profile to opt-out of the system(ibid). The controversy went so far that US senator Al Franken, the chairman of "the Senate Subcommittee on Technology, Privacy, and the Law" wrote a letter to Kevin Alan Tussy that requested him to change the app to an opt-in system, and to delay publishing the app until the National Telecommunications and Information Administration (NTIA) had finished its study on best practices for facial recognition software that started on February 6, 2014.[50] So far the release of NameTag has indeed been delayed, even though Tussy has already demonstrated it on Youtube(Singer, 2014; Tussy, 2013). To conclude the discussion of this issue I would say that even though some facial recognition applications for Glass are beginning to emerge, parties like Google and the US government have kept their distribution within bounds. Furthermore, the quality of these face recognition systems, as opposed to the detections systems, still has not reached great accuracy for the normal lighting conditions context in which Glass is regularly used(cf. Robertson, 2014; Singer, 2014).

Third and finally, many journalists have written about the various privacy issues raised by Google Glass. Most of these discussions focus on the camera and microphone of Google Glass(e.g. Hickey, 2013; Lake, 2014; Topolsky, 2013; Tsukayama, 2014a; Verlaan, 2014). For example, The Verge's Joshua Topolsky (2013) argues that its mainly the "camera that doesn't need to be held up to take a photo, and often won't even be noticed by its owner's subjects" that is causing most of the privacy problems. While others, such as the Dutch technology journalist Daniel Verlaan, observed that it's mainly the "ever-present [camera, BvdH] lens" that "scares people", combined with the thoughts that the camera is always recording, that Glass has facial recognition capabilities, or that every time the screen lights up a Glass explorer takes a picture(Verlaan, 2014). Google has characterised these first two thoughts as myths(cf. Google Glass, 2014j), while interestingly it describes the third thought about the screen lighting up, as one of the three distinct ways in which people can know that an Explorer is taking a photograph or recording a video(cf. Dale & Richardson, 2013a). Furthermore, the Washington Post's Hayley Tsukayama, felt that her own privacy was being invaded mostly by her wearing Glass. For she noticed that when she wore Glass she became a constant topic of conversations, and attracted a lot of attention from people wanting to know about Google Glass, and being a shy person, she experienced that as "more or less" her "personal idea of hell"(Tsukayama, 2014b). In contrast, Glass explorer and Radboud Reshape Centre director Lucien Engelen greatly appreciated this aspect of entering into conversations with people because of Google Glass. For Google Glass makes it easier for him to get into places and talk to people that he would not ordinarily speak to, and when these conversations are flowing, it often

[49] The press release states: "App will allow users of Google Glass to capture images from their live video and scan them against photos from social media and dating sites, including more than 450,000 registered sex offenders." Source: NameTag APP | Your Photo Shares You | Powered by the FacialNetwork.com, http://www.nametag.ws/ , visited: June 11, 2014

[50] For the letter see: Sen. Franken Raises Concerns about Facial Recognition App that Lets Strangers Secretly Identify People | Al Franken | Senator for Minnesota, http://www.franken.senate.gov/?p=press_release&id=2699 , visited: June 11, 2014

allows him to speak about the Radboud Reshape Centre's mission to improve health care[51]. So basically these latter two examples illustrate the more fundamental points, also made by Engelen, that our sense of privacy is personal, and largely "situationally shaped."[52] Finally, the main way Glass explorers in health care, and Google's Glass team, are tackling the privacy issues raised by the camera and microphone, is by endorsing the principle of informed consent, be it formally or informally. In other words, when you want to record a video or take a picture of someone, you ask them for permission first(cf. Dale & Richardson, 2013b; Grossmann, 2013). Furthermore, the Glass team has published a list of do's and 46on't's for Glass explorers that include educating people unfamiliar with Glass when they ask questions, and not wearing it at places where camera phones are not allowed either(Dale & Richardson, 2013b).

To conclude this subsection, I would say that even though Google Glass still has a limited group of users mainly located within the United States, it has already raised a variety of ethical issues. Some of these issues, such as face recognition and a camera that always records, tend to be based on ideas of what Glass *might* be able to do in the future, but currently cannot do with great accuracy or due to battery life limitations. While others, such as privacy issues, differ greatly in their meaning per author, and depend on personal and contextual factors. So let's now turn to the next section and see what we can say that Google Glass realistically is at the moment, and might become in the near and far future.

2.4 Conclusion: A taxonomy of Google Glass claims

By now we have explored a lot of details about the technology, practices, and ethics of Google Glass and wearable computers in general. But how does it all fit together? How do these details help us to answer the main goal we started this chapter with: to provide a realistic overview of what the current Google Glass explorer edition is(section 2.4.1), what we can expect from the Google Glass consumer edition that's likely launched near the end of 2014, or at the beginning of 2015 (section 2.4.2), and from a possible distant future edition (~2019) of Google Glass (section 2.4.3). Let's now answer these questions based on what we have learned.

2.4.1. Google Glass explorer edition (now)

The Google Glass explorer edition is first and foremost a light and unobtrusive $ 1500,- "prototype"[53](Google Glass, 2014j) meant for those people who want to *explore* what Google's wearable computer can do, and where it could benefit them in their professional and personal lives. A prototype, because explorers still encounter technical issues such as short battery life, heat generation, and sudden reboots or shutdowns(for the last point cf. Engelen, et al., 2013, p. 25; Google, 2014y). An exploration, because most of the Glass use practices, its glassware beyond the basic functions, and the morality of these practices, are still developing in the lives and minds of these explorers and the societies they belong to. Even though, most of these developments happen in the USA and UK as Google has decided to focus on those markets first, there are already a number of explorers outside the USA and UK as well,

[51] (L. Engelen, personal communication, March 11, 2014). Clarification note: Lucien Engelen is the director of the Radboud REshape Center in Nijmegen, the Netherlands.

[52] Ibid (see previous footnote)

[53] (R. Hooijer & T. van de Belt, personal communication, Feburary 20, 2014)

who invested a lot in actually obtaining Glass[54](cf. Verlaan, 2014). Furthermore, an European continental release of Glass might still take several years, as Google works on improving the voice recognition software for other languages and accents, and collaborates with privacy agencies in the European Union(EU) to work out the legal matters regarding privacy and Google Glass(EurActiv, 2013; Steinhauser & Robinson, 2013). So far, though, the Explorer program continuous to expand in the USA and UK, as more distribution channels become available, and more people learn about the capabilities of Google's wearable computer.

2.4.2 Google Glass consumer edition (~end of 2014, Q1 2015)

The Google Glass consumer edition will likely be launched some time near the end of 2014, or in the first quarter of 2015. Sales will likely occur through Google's own online Glass store, through retail shops, and for a price above $ 400,- and "lower than $ 1500,-"(Google Glass, 2014b). As most users seem quite pleased with the current aesthetic design, I do not expect any radical changes in that area, though spectacle frames from Oakley or Ray-ban will likely appear for the Google Glass consumer edition. For human-computer interaction, I expect start-up companies and individual explorers might still come up with new ways to interact with Google Glass during the explorer phase which after some time appear in the official Google Glass software, and possibly hardware(cf. DiGiovanni, 2013; Google, 2013e). Furthermore, I expect that solutions will arise to lengthen the battery life of Glass. Google will likely attempt to fix these issues through software changes, but for the hardware changes and accessories I expect third parties will step in to fill the gap. For Google has always communicated that Glass is meant for micro-interactions, and that always on video recording is not possible *due to* the short battery life(cf. Dale & Richardson, 2013a). However, there will always be specific user groups, such as health care or emergency services, for whom a short battery life, or a failing battery, is not an option. Therefore battery packs or modified versions of Google Glass with a longer-lasting battery are likely to appear from third party vendors. Furthermore, the range of stable applications for Google Glass likely expands too, which might increase the appeal of Glass among consumers. Note though, that I'm not making claims here about the scale of the success or failure of Google Glass. I am just stating that, for example, a fully functional and stable version of the Breng application developed by the Radboud Reshape Centre in Nijmegen, might make Glass a more attractive device to have for those with a visual, auditory, or other disability. Finally, it seems likely that at least some moral, and possibly legal, principles have developed for Google Glass, by the time the consumer edition has been launched. Undoubtedly, new cases might pop up as the number of Glass users increases, and thereby the effects of using Glass at a larger scale become more evident. A more detailed analysis of these moral effects will be presented in chapter 5.

2.4.3 Google Glass far future edition (~2019)

I can't predict the future, but I can give one, hopefully plausible, sketch of what Google Glass might become in the far future, say 5 years from now. A first question raised by such a sketch, is whether we will still be using wearable computers in that

[54] (L. Engelen, personal communication, March 11, 2014)

year. Have we moved beyond that, or did wearable computers stop being used before that time?

To answer this question I rely on some insights from the academic field of innovation studies. More specifically, the strategic niche management (SNM) approach as it is presented by Schot and Geels (2008). Basically, early work on this approach contends that emerging technologies develop in technological niches which the authors define as "protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures"(p. 538). Examples of such protected spaces may be conference demonstrations, or trial projects in university hospitals with emerging health care technologies. Later work, refined this notion of a technological niche in two ways. Namely, by distinguishing technological niches from market niches – i.e. "niches in which technology design and user demands have become stabilised"(p. 539), and secondly by arguing that technological niches are strongly associated with "*local* projects" with " initially diffuse, broad, and unstable" designs, use practices, and de-alignment with existing laws and regulations(pp. 543, emph. Mine), while market niches are strongly associated with a more *global* level and "more stable shared rules" such as "dominant designs," alignment with existing laws, and specific use practices(ibid). After one or more market niches have emerged, these market niches may either overthrow, or partly "reconfigure" what the authors call a socio-technological regime (i.e. the dominant technology in a particular market, together with its use practices and regulations)(cf. , p. 547).

So how do these insights help us to say something about the possibility of a far-future edition of Google Glass? First of all, I think it is fair to say that the first few market niches for Google Glass have started to emerge. For both Wearable Intelligence Inc. and Augmedix Inc. (see section 2.3.2.3) deliver medical Glassware that underwent user tests, complies with the American medical privacy regulations, and have recently been "authorized" by Google to deliver enterprise Glassware through its 'Glass at Work' program(Google, 2014g). The question is now what will happen within this market niche, and which socio-technical regime they aim to overthrow or reconfigure. Within this market niche these startup companies compete, and the recent inclusion of Wearable Intelligence, Inc and Augmedix Inc. Into the Glass at Work program, might give them a competitive advantage over a company like Pristine, Inc. That has not been included in this program(see section 2.3.2.3). With regard to socio-technical regimes I expect that a wearable computer like Google Glass will mainly reconfigure existing regimes. For example, even though Wearable Intelligence's Informant is able to show CT scans and other patient data on the Glass display, CT scans and other types of medical images may still require the larger screen of a tablet or regular LCD monitor to be studied closely(cf. Wearable Intelligence Inc., 2014b, t. 2:05-2:20). Therefore, even though keyboards, desktop computers, mouses, and other hardware may disappear from a medical doctors examination room, tablets and monitors may still remain for at least the coming years. Additionally, at a more general level, consultancy firms Deloitte and IHS expect the wearable computing market to grow in the coming years, especially in the "smart glasses" segment(IHS, 2013; P. Lee & Stewart, 2014, pp. 10-12). They base these claims on a great number of interviews with market analysts, clients, and consumers(P. Lee & Stewart, 2014, p. 3), or on forecasted scenarios(IHS, 2013), respectively. Based on these observations, I conclude that it seems at least plausible that wearable computers are here to stay and plausibly have become an established technology in five years time for at least some medical professional practices(P. Lee & Stewart, 2014, pp. 12, 20-22; cf. Hoogma et. Al. (2002) as quoted by Schot & Geels, 2008, pp. 544-545).

Another question raised by this conclusion that wearables are here to stay is what Google Glass might look like by 2019. I do not expect that Google Glass in its current spectacles-like form-factor has been replaced entirely by a contact lens. As I stated previously (see section 2.3.1), such a lens still requires a lot of research, investments, and regulatory work, to reach the level of functionality that Google Glass currently has. Nonetheless, I would not be surprised if such a contact lens would be used as a medical sensor by that time, and possibly transmits its measurements wirelessly to the user's nearby smart glasses. Furthermore, I expect Glass to have been adopted by more Europeans in 2019, as its speech recognition features have improved, and laws regulating wearable computers have been established (see section 2.4.1). Finally, an eye tracker may be included[55] as a way to interact with Glass (see section 2.3.2.2), given Google's current experiments with the infrared light sensor that's able to pick up winks(ibid), and more recently eye glances at the screen(Google Glass, 2014c).

Even though I realise the above claims offer far from a complete picture of what Glass might look like in 2019, I hope they offer at least a glimpse, or a rough, but hopefully realistic, sketch of where Glass may be heading in the coming years. For now, I suggest we return to the current prototypical state of Google Glass, and start to explore some of its features from a philosophical point of view. More specifically, in the next and third chapter we will explore the implications of Glass' voice recognition and gesture recognition features for postphenomenology, while the fourth chapter will focus on the way augmented reality applications for Google Glass might influence the way we interpret our world. Let's now leave our fact-checking efforts, and start philosophising.

[55] Additionally I base this claim on the fact that Brandyn White's curriculum vitae states that he will be a hybrid software engineering (SWE), and user interface (UI) / user experience (UX) intern at Google [x] in the summer of 2014(White, 2014a). White is the PhD student who has been experimenting with eye-tracking on Google Glass (see section 2.3.2.2).

Chapter 3 – Human-Computer Interaction for Google Glass: A first challenge to postphenomenology

In the previous chapter, I described several ways in which Glass explorers interact with the Glass device (see section 2.3.2.2). In this chapter we will study two of these ways from a (post)phenomenological point of view. Namely, the voice commands that explorers use to operate Glass in general, and the various gestures explorers can use to perform specific actions with Glass (e.g. winks, head wakeup). However, these two ways to interact with Glass also pose a challenge to postphenomenology. For they do not really fit the typical visual metaphors and focus that several phenomenologists, postphenomenologists, and other ancient philosophers have adopted in their studies (cf. Ihde, 1976/2007, pp. 5-15; 2009). Therefore, I augment postphenomenology in several ways so that it is able to address this challenge raised by speech and gesture recognition technology.

More specifically, I will first introduce the basics of phenomenology and postphenomenology (section 3.1), and then show the exact limitations of postphenomenology by applying it to the speech and gesture recognition technology of Google Glass (section 3.2). I address these limitations by introducing a new concept in postphenomenology, namely mode of exploration. I operationalise this concept by connecting the auditory mode of exploration to Don Ihde's phenomenologies of sound, and by connecting the motile (i.e. pertaining to movement) mode of exploration to Maurice Merleau-Ponty's remarks on gestures. Additionally, I show how augmented postphenomenology helps to overcome the limitations of postphenomenology, and how they could prove useful for interaction design and technology assessment as well (section 3.3). Finally, I end this chapter with some concluding remarks (section 3.4).

3.1 An introduction to phenomenology and postphenomenology

To understand what postphenomenology is, it is first helpful to know what phenomenology is. According to Verbeek (2005), phenomenology is a school of thought in continental philosophy that arose in response to two other schools of thought(p. 109). Namely, the idealists, who believed that our consciousness produced all knowledge we have about the world, and that the world could only be known through that knowledge, and the realists, who believed that we gained all our knowledge about the world from the world, rather than from our consciousness (ibid). In other words, for the most radical idealist, the world only exists in our ideas, while for a realist the world exists independently of our ideas, and all our ideas about that world, only exist because of that world. In contrast to both positions, phenomenologists argue that consciousness is always directed towards the world, because we are not simply conscious, but we are always conscious of something (ibid). This directedness of consciousness towards the world is what phenomenologists call *intentionality* (ibid). Furthermore, phenomenologists argue that the world too, does not exist in itself, because the moment we start to explore that world, it becomes meaningful to us, it becomes *our* world(p. 110). In the terminology of Edmund Husserl, the father of phenomenology, we could thus say that our consciousness and the world are "correlated" to one another(cf. Ihde, 1976/2007, p. 35). Finally, when it comes to exploring the world, Husserl did not follow the deductive approaches of the idealists, nor did he follow the inductive approaches of the realists, but rather came up with his own two-step descriptive methodology. Basically, the first step in that methodology is to put many of the things we *know* about what we experience between brackets, as we should *describe* what we experience. According to Ihde(1986), the ideas we should put between brackets while describing our experience include *explanations* of what we experience, and assumptions about the *structure* of what is being experienced (pp. 32-38). In the second step, once the experience has been described, we try to discover the essence of what we experience, through a number of variations of the experience. To illustrate this step, have a look at Figure 3-1. What do you see? Do you see two faces in black? Do you see a goblet in white? Do you see both? Just seeing faces, *or* the goblet, could be termed descriptions from the first step, while saying you see both, is a more essential description of the picture(cf. , pp. 69-73).

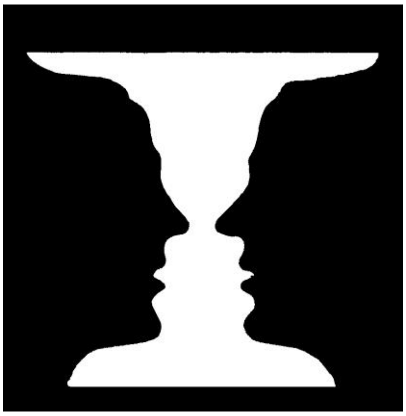

Figure 3-1 – A typical picture from Gestalt psychology. Picture taken from (Dewey, 2007).

In postphenomenology, in Verbeek's (2005) sense, the philosopher of technology Peter-Paul Verbeek radicalises and re-interprets these phenomenological ideas so that they fit better with the current postmodern emphasis on language and context(p. 112). For rather than following Husserl's argument that consciousness (or a human being) and the world are correlated, he argues that a human being and the world *constitute* one another. That is, a human being and the world (or a human being and its environment) actively "coshape" each other, and thus cannot be thought of as separate entities existing independently and passively by themselves (ibid). One important consequence of this premise is that human beings will always be studied within, and shaped by, a particular context, and that context is in turn shaped by that same human being. Within this context, however, technologies play an interesting role. For they are not simply parts of a context or an environment (e.g. cars, fridges), nor are some technologies simply part of a human being (e.g. pacemakers, prostheses). For technologies shape the way we act within the world, and/or shape the way we perceive the world. In the words of Verbeek: technologies "actively mediate this [human-world, BvdH] relation"(pp. 113-116). Furthermore, just like humans cannot be thought of without their environment in postphenomenology, so technologies cannot be thought of independently of their use practices(p. 117).

Both Don Ihde and Peter-Paul Verbeek have refined this idea of technologies mediating the human-world relation, by coming up with so-called human-technology relations. In his *Technology and the Lifeworld*(Ihde, 1990), Don Ihde came up with four human-technology relations. First, there is the embodiment relation, in which the technology itself withdraws from our attention, while it simultaneously shapes the way we experience the world(Verbeek, 2005, pp. 125-126). For example, binoculars do not draw attention to themselves, but rather they draw our attention to the distant objects in our environment they bring up close for us. Schematically the embodiment relation is represented as (I – technology) -> world, where the arrow represents what our intentionality is directed at. Second, there is the hermeneutic relation, in which the technology presents the user with an interpretation of an aspect of the world(p. 126). For example, a barometer tells its user something about the air pressure in its user's environment. Schematically, the hermeneutic relation is represented as I -> (technology-world). Third, there is the alterity relation, in which our attention is drawn to a particular technology, while the world itself fades from our attention (pp. 126-127). A typical contemporary example of this could be smartphone games which draw the attention of the gamer so much that they forget about what happens in their environment.[56] Schematically, the alterity relation is represented as I -> technology (-world). Fourth and finally, Ihde introduced the background relation, which denotes those technologies that have become a part of our environment that we only notice when these technologies break down, or when we move from an area where they were not present to one where they are present or vice versa(pp. 127-128). For example, when we enter a building with air conditioning on a hot summer's day, we at first notice that the building has a refreshingly cool climate, but after a short while we start to focus again on the task at hand, and forget that the air conditioning is there. Schematically, the background relation is represented as I – (technology/world).

In later work, Verbeek added two additional human-technology relations to analyse more contemporary technologies. The first of these is the cyborg relation, in which a technology and the human body merge together(Verbeek, 2008, pp. 390-391). For example, people wearing cochlear implants that make it possible for them to hear, or a pacemaker that helps to keep someone's heart beating regularly(p. 391). Schematically the cyborg relation is denoted as (human/technology) -> world. The second of these is the composite relation, in which Verbeek distinguishes between human and technological intentionality. He defines the latter as "the specific ways in which specific technologies can be directed at specific aspects of reality"(p. 392). In this relation a technology creates a particular interpretation of the world based on the specific ways in which it is directed at the world, in turn, a human directs his or her intentionality at the presentation of this particular interpretation that the technology created. For example, Google has equipped the car it uses to collect images for its Street View service with 15 cameras, a GPS sensor, a wheel encoder (i.e. a sensor that measures the exact speed of a rotating wheel), an inertial sensor, and three laser scanners that Google uses to develop the 3D models we see on Street View. After gathering all the data Google turns the photos into one big panorama picture, projects them on the 3D models, and combines them with existing road map data, in order to construct the Street View world(cf. Anguelov et al., 2010). In other words, the car and

[56] Note that I'm not claiming here that we always engage into an alterity relation with a smartphone. For we could use a smartphone to photograph a person, or navigate the world, as well. Nonetheless, most people will be familiar with those moments where a smartphone or mobile phone draws our attention so much, that we forget about the people physically nearby, or the traffic light that just turned green.

the algorithms are directed at the world in a specific way in order to construct the Street View world, while the user's attention is directed at the web-based Street View world produced by these sensors and algorithms. Schematically, the composite relation is represented by human -> (technology -> world). Finally, next to these human-technology relations Verbeek (2005) distinguishes between two dimensions of a technology which he respectively links to two invariant structures. First, many technologies shape our perception of the world (i.e. the hermeneutic dimension) by amplifying or reducing aspects of it (i.e. the invariant amplification/reduction structure). For example, binoculars amplify what we see before us, while they reduce what we would normally see beside us. Second, many technologies shape the way we act in the world (i.e. the existential dimension), by inviting or inhibiting certain actions (i.e. the invariant invitation/inhibition structure). For example, a green traffic light invites us to drive our car, while a red light inhibits us from driving our car.

By now, we have covered the basic ideas of phenomenology and postphenomenology that we need for a first discussion of the speech and gesture recognition features of Google Glass. So let's now move on to a postphenomenological analysis of these features.

3.2 A postphenomenological analysis of speech and gesture recognition

As the main ways to wake up Glass all rely on gestures, I will start my postphenomenological analysis of Google Glass with an analysis of these gestures (section 3.2.1). When Glass has woken up a user can start speaking voice commands to Google Glass in order to carry out various actions. Speech recognition will therefore be the second part of this analysis (section 3.2.2). Finally, in both sections (3.2.1 and 3.2.2) I present two challenges that highlight the exact limitations of postphenomenology. Let's now turn to the gesture recognition features of Google Glass.

3.2.1 Gesture recognition

Google Glass recognises a number gestures. First of all, the touchpad is able to detect backward, forward, and downward swiping gestures. Additionally, the Glass Development Kit allows a software developer to detect the number of fingers the user swipes along the touchpad(Song & Laligand, 2014, t. 5:17-5:49). Moreover, the touchpad also detects tapping gestures to select options or to wake up the device. Secondly, explorers can optionally wake up the device by moving their head upwards(Google, 2013b). Note that users need to enable this feature themselves in order to use it. Third and finally, Google recently introduced two experimental eye gestures: a winking gesture to take pictures, and a glancing gesture that allows the user to wake up the screen by glancing at it(Google, 2014w; Google Glass, 2014c).

From a postphenomenological perspective, two human-technology relations seem to offer promising starting points for a further analysis of these gestures. Namely, the alterity relation for those gestures that work as expected, while the composite relation allows for a more detailed analysis when gestures do not perform as expected. In the analysis that follows I will draw on my own experiences with Google Glass[57], and some

[57] Thanks to a Glass user at my university I was able to gain some experience with the device, and perform some phenomenological experiments using the device.

experiences of other Glass explorers who reviewed Glass for technology websites, or well-known newspapers. Let's start with the touchpad gestures. One way I can wake up Glass is by tapping the touchpad. When successfully tapped, the home screen appears and floats somewhat translucently in mid-air in the middle-top of my field of view. In the middle of that screen it shows me the time, and slightly below that, the salient phrase 'OK Glass,' nudging me to start speaking to the device. I refuse, and tap the touchpad again. Almost instantly I see a list of commands appear, and by swiping forward I scroll through the list until I reach the 'show a compass' option. I tap the touchpad again. After a few seconds a compass appears on the screen. As I move my head and body around, the compass shows me whether I'm facing the north, south, east, west. Sometimes an error appears, telling me that there is too much interference, but most of the time this error disappears after a few seconds. I decide that I have played around long enough with the compass and want to get back to the home screen. Now I get confused. As one female explorer noted:

> "The interface is simple to navigate, but does require a certain learning curve. If you're not used to using Glass, exiting apps can seem a bit jarring at first. For instance, a natural inclination for us was to swipe backward to navigate back to the Home screen, but Google Glass requires that you swipe down from the top of the touchpad. What's more, you need to make sure you swipe down on the right spot to navigate back. If you swipe too far up on the arm closer to your eye, it won't work."(Eadicicco, 2013)

So should I swipe down or swipe back? Actually both options help me to get back to the home screen. However, as I swipe back and forth through my timeline,[58] Glass still shows me the compass card. After giving it a few tries, tapping the compass card shows me the options menu, which allows me to close the compass application. As this description shows, I focused mostly on the screen, to gain feedback on my touchpad gestures. The world thereby fades from my focus. In other words, I engage in an alterity relation with Glass when I use the touchpad. Additionally, the touchpad gestures sometimes confuse users, as the Glass team added a gesture (i.e. swiping down) that is not familiar to most users as a gesture showing the home screen. The learning effects that occur because of this new gesture seem hard to take into account in our current understanding of postphenomenology.[59] So this will be one of the challenges an augmented version of postphenomenology needs to address.

Secondly, Glass allows me to wake up the screen using a feature called head wake up. After I close the compass application, I think about what I want to try next. After 30 seconds of thinking, I slowly see the screen fade to black. I have decided what I want to do, so I tilt my head up 30 degrees (i.e. the configured angle for head wake up) and the screen wakes up. I move my head down and try a Google search: "Ok Glass, Google, how tall is the Eiffel tower?" I speak to the device. Apparently the device has some difficulties processing my query as the screen turns black and empty, after the progress bar and Google keyword have faded away. I try to wake up the screen again using my head, but it does not seem to work. Swipe down does work. I continue my

[58] The basic interface metaphor for Google Glass is that of a line of cards called the timeline (cf. section 2.2.6). Swiping backwards shows me what I did in the past (e.g. search queries, photo's I have taken), while swiping forward shows me running applications and upcoming events.

[59] It could be argued here that Verbeek's (2011) discussion of Foucauldian disciplining processes and rebound effects could be used as heuristic concepts to describe these learning effects(pp. 66-89,93-94). However, in my view such an analysis would remain fairly abstract - i.e. it would describe these learning effects in terms of abstract concepts such as 'subject', 'power', and 'freedom'- and thereby lose some of the rich details a phenomenological description would provide.

explorations of the Glass device, and suddenly, when working with a different application, I hear Glass speak the answer to me: "The Eiffel tower is 1 063 ft tall." As this description illustrates, most of the time I engage in alterity relation with Glass when I use head wake up. My eyes focus on the screen, while my head gesture wakes up the screen. Only when Glass has too many tasks to perform simultaneously, the composite relation seems more appropriate to describe its behaviour. For in that case, Glass apparently prioritises some inputs from the world (i.e. the swipe down gesture), over others (i.e. the head wake up gesture), without telling the user about these priorities (the black and empty screen). In postphenomenological terms, Glass thus *invites* certain gestures, while it *inhibits* others, without telling the user in advance which gestures gain priority over others.

Third and finally, the Glass team recently introduced two experimental eye gestures: a winking gesture to take pictures, and later a glancing gesture to wake up the display. In order to use the winking gesture, I first needed to go through a calibration procedure. A message on the display asked me to wink. So I did, not fully aware that I already had to wink. It asked me to wink a second time. So I did, this time more aware of what Glass asked me to do. I then returned to the home screen by swiping down. The Glass user who kindly allowed me to use her device, then suggested that I would test whether the winking feature worked. I winked, and a photo appeared briefly on the screen. I then moved on to test a variety of other features. However, when I finished testing the device, and handed it over to its owner, she remarked that I had been making a lot of photos, while testing the other features. That surprised me, as Glass had not given any auditory cues while taking these pictures, nor can I recall having noticed these pictures showing up on the screen. The Glass user told me this lack of feedback was also the main reason why she often disabled the winking feature. The composite relation might again explain part of this behaviour. For I think that due to me being unprepared for the first part of the calibration procedure, Glass interpreted some of my regular blinks, as winks.[60] However, Glass did not translate all its photography actions into accompanying cues that can be noticed by the user. Perhaps, Glass only shows an accompanying visual cue (i.e. showing the photo) when the user looks at the home screen. Next to the wink gesture, Glass also offers a glance gesture which basically wakes up the screen when you glance at it. During my experiments with Glass I have not been able to test this feature myself. I did, however, find one response that illustrates the social effect of glancing at the Glass screen during a conversation:

> "What struck me most, however, was what happened when I let others try on the device, giving me a glimpse of how I appeared when I was wearing Glass: a conversation partner who was like a dinner guest who keeps looking at the door, as if to check if there's another person in the room they'd rather be talking to. Think of every person wearing earbuds or a Bluetooth headset who has annoyed you for the same reason. Now multiply it by a factor of 10"(Tsukayama, 2014b).

Even though the latter part of the above quote overstates the case in my view, I do think that Glass could make a conversation partner lose eye contact with you, in a way similar to looking at the ceiling in order to think, makes you lose eye contact briefly. See Figure 3-2 for an illustration. This figure shows me wearing Google Glass, while

[60] Google Glass has only one infrared sensor aimed at the right eye. So it cannot check whether the left eye is closed simultaneously with the right eye, and therefore it is not able able to distinguish a wink from a blink.

looking at the Glass screen.

Figure 3-2 – The author wearing Google Glass, while he glances at the screen. The device was kindly lent to me by a Glass user at my university.

As you may notice, my eyes look slightly upward, and this could come across as me being slightly distracted when it happens often during a conversation, especially when the screen lights up as well. Even though an alterity relation might partially capture this social effect in the strict phenomenological sense that I focus more on the technology than I focus on the world, it does not really seem to capture the sociocultural meanings that a conversation partner (observing me when I use Glass) would ascribe to what he or she observes.[61] I speak about sociocultural meanings, rather than social meanings here, as the meanings of particular eye gestures differ per culture(cf. Tidwell, 2013). This sociocultural effect too, will be addressed by my augmented version of postphenomenology (see section 3.3).

In summary, two human-technology relations I discussed earlier (section 3.1), the alterity and composite relation, turned out to be particularly useful to analyse the various gestures Glass explorers use to operate Google Glass. Additionally, two challenges for postphenomenology arose in the above analysis. First, the learning effects that arose because of an unfamiliar gesture (i.e. swiping down) were hard to take into account in postphenomenology. Steven Dorrestijn attributes these effects to the following assumption: "(…) fusions between humans and technology are not just given, but have to be fused by training"(Dorrestijn, 2012, p. 51). In other words, it takes some practice to understand the swiping down gesture, and thereby *develop* an alterity relation with Google Glass. Secondly, many gestures have sociocultural meanings, and as Google Glass invites users to use particularly well-known gestures to operate the device (e.g. glancing at the screen whereby the user momentarily loses eye contact), this could cause ambiguous or undesirable non-verbal communication, or add an additional meaning to these gestures. Both challenges will need to be addressed by my

[61] It could be argued here that Don Ihde's concepts 'macroperception' and 'multistability' attempt to capture this cultural dimension. For he uses both terms to describe the cultural dimensions of artifacts that go beyond what we strictly perceive with our senses(cf. Ihde, 1990, pp. 29,144-149). However, Ihde mainly uses multistability to describe the cultural meanings we attach to *the artifacts themselves*, rather than to *particular actions* these artifacts invite us to perform. Macroperception comes closer as it derives from Maurice Merleau-Ponty's work (cf. , p. 147) which I use in section 3.3.1, but Ihde restricts his use of macroperception to the interpretation of non-living objects, whereas for Merleau-Ponty it is also possible to perceive cultural meanings in gestures, and utterances from people and other living creatures(Merleau-Ponty, 1962/2002, p. 216). I adopt this broader perspective on macroperception in section 3.3.1.

augmented version of postphenomenology. Before we turn to this augmented version of postphenomenology, though, let's first explore which additional challenges the Google Glass speech recognition system raises for postphenomenology.

3.2.2 Speech recognition

One of the primary ways to operate Google Glass is by speaking voice commands to the device that are always preceded by the 'OK Glass' phrase. Preceding each voice command with this phrase has two advantages. First, it prevents the device from performing various actions when certain phrases are used in a conversation (cf. Section 2.2.3). Secondly, it is meant to make clear to bystanders that the Glass explorer is speaking to Glass, rather than to them(ibid). Apart from these preliminary remarks, what can I say about the Google Glass speech recognition system from a (post)phenomenological point of view? Before I tested Google Glass I came up with a number of phenomenological variations on the 'OK Glass' phrase to discover how Google Glass would respond to these variations. If Google Glass successfully recognises the 'OK Glass' phrase its main menu with voice commands appears on the screen. In contrast, if it does not recognise the phrase successfully, nothing happens and the Glass home screen keeps showing for about 30 seconds. See Table 3.1 for an overview of these phenomenological variations and how Google Glass responded to them.

Table 3.1 – *Phenomenological variations of 'OK Glass' phrase and Google Glass response*

Category	**Variations**	**Google Glass response**
Pronunciation	US English (Gl*a*ss as in b*a*t)	Voice command menu
	British English (Gl*a*ss as in b*a*r)	Voice command menu
Pitch	High pitch	Voice command menu
	Low pitch	Voice command menu
Pace	Fast pace (several times, increasing pace)	Voice command menu (every variation)
	Slow pace (same slow pace, several times)	Glass home screen (no response)
Incomplete phrase	Without 'OK' in 'OK Glass'	Glass home screen (no response)
	'Take a picture' without preceding 'OK Glass'	Glass home screen (no response)
Other person not wearing Glass (~ 1 meter distance)	Loud 'OK Glass'	Voice command menu
	Normal volume 'OK Glass'	Voice command menu
Loudness	Softly spoken 'OK Glass'	Voice command menu
	Whispering 'OK Glass'	Glass home screen

Note : For every category of variations other factors are kept constant. That is, except for a category's variations, I pronounced the 'OK Glass' phrase in US English, at a regular pace and volume, using my own baritone voice.

As you may notice the Google Glass speech recognition system shows a reasonable invariance with regard to pronunciation,[62] pitch, and the person speaking(also cf. Stevens & Armisen, 2013, t. 3:14-3:40). Furthermore, it correctly refuses to respond to commands not preceded by the full 'OK Glass' phrase. So with regard to these features the speech recognition system works well(cf. Angelini, 2013; Hattersley, 2014). Interestingly though, Google Glass is not able to recognise slowly spoken commands, or whispered commands. Rabiner and Juang (1993) explain[63] why this may be the case for slowly spoken commands (i.e. oookaaay Glaaaaass). They state that "most practical speech-recognition systems rely heavily on vowel recognition to achieve high performance" as "(...) vowels are generally long in duration (as compared to consonant sounds) and are spectrally well-defined"(pp. 21-22,24). In other words, when I lengthened my vowel pronunciation to make the command sound as if I spoke it slowly, I made it more difficult for the speech recogniser to recognise the command. With regard to the whispered 'OK Glass' phrase it has more to with the fact that I do not use my voice[64] when whispering, and thereby cause certain frequencies to remain absent in my speech, while the speech recogniser has likely been trained using samples that only contain voiced speech, and thus looks for different frequency spectra for particular speech sounds (i.e. phonemes), than those present in my whispered speech(cf. Passos, 2011, pp. 13-14).

What do these phenomenological observations tell us about the human-technology relation we engage in when we speak voice commands to Google Glass? Verbeek's composite relation seems the most adequate relation for this analysis. For I am not the only person that can speak to Glass to operate it. As the above variations showed, people in my vicinity can also speak voice commands to the Glass device I'm wearing and thereby operate it – i.e. I referred to this above as a reasonable invariance toward the person speaking to Glass. Consequently, the world or my environment do not entirely fade from my attention, as others in my environment may speak to Glass too, and therefore a hermeneutic or alterity relation seem less adequate for this analysis. If we apply the composite relation to this case, my intentionality is mainly directed at the screen, to check whether Glass 'understood' my voice command successfully, and towards the commands I speak into the world, so that I can speak differently when Glass does not respond to my voice command.

The technological intentionality of Google Glass is more complicated to analyse. For Google has not published specific details on the specific approach they have adopted for the Google Glass speech recognition software. Based on several recent Google research publications, though, it seems likely that Google makes use of Deep Neural Networks (DNN's) as part of their approach for speech recognition on Google Glass(e.g. Lei, Senior, Gruenstein, & Sorensen, 2013; Senior & Lei, 2014). In order to

[62] Lucien Engelen partly confirmed this invariance with regard to English pronunciation in my interview with him. He said: "I am pleasantly surprised, so to speak, by the quality of the voice recognition. If you speak English a bit decently, then it [i.e. Google Glass, BvdH] can really follow what you say."(personal communication, March 11, 2014)

[63] Attentive readers may object here that I do not follow Husserl's maxim to describe rather than explain. They are right. However, these explanations give more insight in the engineering problem and thus serve a practical purpose. This practical focus aligns well with Verbeek's implicit aim to make philosophy of technology useful to designers and policy makers as well (cf. Verbeek, 2005, pp. 203-234; 2011, pp. 90-119)

[64] More specifically, the vocal cords are only used to create a turbulent flow of air, but do not vibrate themselves. This turbulent flow of air is modified mainly by other parts of the human vocal system, such as the teeth, tongue, velum, and epiglottis(cf. Rabiner & Juang, 1993, pp. 16,31-32).

gain a high-level understanding of how these deep neural networks and the Google Glass speech recognition system work, we will need to make brief detour into the field of machine learning. In the field of machine learning, computer scientists try to develop software that is either able to discover a continuous structure in a data set (i.e. regression problems), or classify a dataset into a discrete number of categories (i.e. classification problems). Speech recognition is one of these classification problems, as words could be imagined as our categories, and the task for the software program is the following: Given a spoken input, which words are being spoken? In general terms, contemporary speech recognition systems roughly consist of three primary components: an acoustic model, a pronunciation model, and a language model. Basically, when a voice command enters the microphone, the speech recognition software first processes the raw audio signal using the acoustic model. The acoustic model, likely used by Glass and described by Lei, et al. (2013), first carves up the signal in a number of frames with a duration of 25ms every 10ms – so the frames indeed have some overlap. Next the speech signal in each frame is described in terms of a 40 dimensional vector representing the acoustic energies for 40 frequency bands(Lei, et al., 2013, p. 662 ; cf. Rabiner & Juang, 1993, p. 70). So here some information about specific frequencies is lost. In turn the first 16 frames serve as input to the deep neural network that has already been trained using a large number of audio fragments of which the speech has already been transcribed (Lei, et al., 2013, p. 663). Basically, a deep neural network consists of an input layer, a number of hidden layers (i.e. that is why they are called *deep* neural networks, a regular neural network has one or no hidden layers), and an output layer.[65] In our case, 16 vectors with 40 dimensions that describe speech segments, serve as input, of which one vector is the vector to be analysed, while the other vectors provide the auditory context for the analysis (10 past frames, 5 future frames). This context is necessary, as we tend to pronounce the same letter differently, depending on the location in a word and the letters that precede it. For example, the s's at the end of the plural nouns 'dogs' and 'cats' are pronounced as a 'z' and an 's' sound, respectively. Throughout the hidden layers, the trained artificial 'neurons' further transform the input vectors in order to discover which phoneme or phonemes the input vector under analysis describes, and this process eventually results in the activation of one or more output neurons that represent(s) the most likely phoneme(s) described by the analysed vector. After the acoustic analysis, the language and pronunciation models further analyse groups of phonemes to discover which words and sentences these phonemes represent. Researchers base these language and pronunciation models on statistical findings in large corpora of texts, and spoken information. For example, a word pronunciation model for the word 'Glass' could be modelled as a path with a starting point (first phoneme: G), several intermediate points, which could remain on the same path (second phoneme: L), or split up in two branches (a as in the verb to bark for British pronunciation; and a as in bat, for US English pronunciation), and finally arrive at the single endpoint where both a branches merge and reach the s phoneme(cf. Mohri, Pereira, & Riley, 2008, pp. 560-563). For the transition between each point there is a certain probability that the

[65] My understanding of neural networks, and to a lesser extent speech recognition, is mainly based on a free web-based course on neural networks taught by Geoffrey Hinton. Hinton is one of the leading experts on neural networks. The course can be found on Coursera: Neural Networks for Machine Learning | Coursera, https://class.coursera.org/neuralnets-2012-001 , viewed: July 27, 2014 [free login and subscription required].

transition from one point to the next occurs (ibid). These probabilities become especially evident at those points where there are multiple branches (e.g. pronunciation of the 'a' in the above example), and thereby certain probabilities that one or the other path is taken, depending on how often these different pronunciations occur. Finally, language models can work in a similar way, and can be integrated with the pronunciation models(cf. , p. 561). However, the language model tends to work with three-word sentences called trigrams, which make it more efficient to process a set of words or phonemes, in comparison to a longer sentence. Furthermore, these trigrams could inform the pronunciation model that 'take a picture' is more likely to occur than 'take a picdure.'

So now that it is somewhat clearer how the Google Glass speech recognition system likely works, what does this mean for our analysis of the technological intentionality of the Google Glass speech recognition system? As I mentioned above, the acoustic processing of the raw speech signal removes some information of that signal in order to process it more efficiently (i.e. the 40-dimensional input vectors). Furthermore, in later steps, the acoustic model transforms these input vectors further into the most likely phoneme or phonemes represented by that vector, and in turn these phonemes could again be changed by the language and pronunciation models based on the most likely word and sentence they are part of. Therefore, I would say that Don Ihde's amplification/reduction structure does not fully provide an adequate description of the Google Glass speech recognition system. For Ihde's amplification/reduction structure does not help to explain why particular phenomenological variations end up as successfully recognised voice commands (e.g. commands spoken with a high or low pitch), while other variations are not successfully recognised (e.g. whispering, slow speaking). Furthermore, the speech recogniser *removes*, rather than reduces part of my speech (i.e. the loudness of specific frequencies), and *transforms*, rather than amplifies, my auditory speech into the most probable written form, which might or might not trigger particular actions on the Google Glass device. So this will be yet another challenge that has to be addressed by an augmented version of postphenomenology.

Additionally, there is another small challenge raised by the Google Glass speech recognition system. Even though Google has added the 'OK Glass' phrase to each voice command in order to declare to whom or what a Glass user speaks, not everyone seems to have gotten fully used to the idea that Glass users talk to the wearable computer on their head. As one of my interviewees recalled when I asked him about his experiences with my observation that some of the gestures (back then: head wake up and winking) that Glass uses for its operation also have a sociocultural meaning, he responded:

> "Not with the movements [i.e. gestures, BvdH], but I did with the speech. I did encounter that: that I was just walking here in the hospital, and was just testing a bit, and that you suddenly start talking, and then people do look surprised at you as if [they think]: "Are you talking to me?[66]"

From a postphenomenological perspective, we could say that Glass invites me to say "OK Glass" by displaying this phrase on the home screen, and subsequently draws my attention to the voice command menu appearing on the screen, which in turn

[66] (Tom H. Van de Belt, personal communication, February 20, 2014)

invites me to speak one of the commands appearing in the menu. Thereby I engage in an alterity relation with Glass, and tend to forget the people in my vicinity that can hear me speak as well, and might not be aware that I speak to Google Glass. However, as we noticed in the more elaborate analysis above, I could just as well engage in a composite relation, and be aware that people in my vicinity can also speak voice commands to Google Glass (if they know about them, and Glass displays the home screen or voice command menu), and thereby I *might* be more aware that some other people might misunderstand my own voice commands that I spoke to Glass as well. So here the shift in human-technology relations, could take into account these social effects to the extent that people in my vicinity could speak voice commands to Glass as well. However, this analysis feels somewhat forced. For it does not take into account those people not familiar with Glass, looking surprised when a Glass user speaks to his or her device. Therefore, an augmented version of postphenomenology might attempt to alleviate this tension.

In summary, the Google Glass speech recognition system raises two challenges for postphenomenology. First and foremost, the Google Glass speech recognition software, due to its complexity, does not adequately fit Ihde's amplification and reduction structure. Second, the social effects of the Google Glass speech recognition system can only be analysed to a certain extent in postphenomenological theory. Let's now turn to the next section to explore how an augmented version of postphenomenology can address the four challenges raised in this section, and the previous section (3.2.1).

3.3 Augmenting postphenomenology: modes of exploration

In this section I will present my augmentations to postphenomenology, so that it will be able to address the challenges presented in the previous section. However, before we address these specific challenges raised by the Google Glass gesture and speech recognition features, I first want to draw your attention to two more general conceptual issues that came forward implicitly in the analyses in the previous section. First, that the human-technology relations (see section 3.1), and especially the conceptions of both human and technological intentionality used in these relations, have been formulated so generally, that it does not seem to matter which human senses (e.g. visual, auditory etc.), or technological 'senses,' or: sensors (e.g. accelerometers, cameras, microphones), have actually shaped a human's, or technology's directedness towards the world. For example, in both the gesture recognition and speech recognition analysis, I made use of the composite relation. In both cases, however, the technological intentionality of Google Glass took on a radically different shape. Whereas in the head wake up case Google Glass detected the motion of my head using its gyroscope (i.e. a sensor that measures rotation) and its accelerometer (i.e. a sensor that measures linear motion), there Google Glass focused on my speaking using its microphone in the speech recognition case. Why would these differences matter? Because for a large part they shape how we will interact with the technology. For instance, it would not make much sense to speak voice commands to a device without a microphone and speech recognition software. Furthermore, Don Ihde (1976/2007) makes a similar case for differences in human intentionality. In his *Listening and Voice* he recalls how one of his former students, who was blind, moved from an omnidirectional spatial focus (during her blindness), towards a more forward-oriented focus after she got treatment for her blindness and thereby gained some sight (i.e. sight tends to be forward-oriented due to the location of our eyes)(p. 65). So to translate this point about human intentionality to the above speech recognition example, I would say that it also does make much sense for a deaf speech-impaired person, to use a device with only a speech-controlled interface. To conclude, there are intentional differences, in the sense of intentionality, between different modes of human and technological perception. Furthermore, these intentional differences, and thereby a human's or technology's perceptual abilities, largely shape *which* technologies we use, and *how* we use these technologies.

A second and slightly related conceptual point has to do with the relationship between action and perception. Verbeek (2005) first analyses action and perception in separate chapters (pp. 99-146, 147-199, respectively), and later combines the vocabularies developed in these chapters in an analysis of a personal digital assistant (PDA)(pp. 197-199). However, the exact relationship between action and perception remains fairly implicit. As we noticed in the previous analyses of gesture and speech recognition (see section 3.2), action and perception often alternate rapidly. For example, we first speak the "OK Glass" phrase (action), then we see a menu of voice commands appear (perception), we speak one of these voice commands (action), and we see the application appear on the screen (perception). One way to explain this rapid alternation between action and perception, is to follow the British phenomenologist and cognitive scientist Alva Noë in claiming that "perceiving is a kind of skilful bodily activity"(Noë, 2004, p. 2). What does he mean by this claim? He means that I will need to move my whole body, rather than just the relevant sense organs such as hands or eyes, in order to perceive. For example, in order to hear the soft speech of the small person standing next to me, I turn my ear towards her speech and bend over a little bit to hear what she is saying. Furthermore, my bodily movements are not random movements. Rather they are skilful, and based on what Noë calls sensorimotor knowledge. That is, our implicit knowledge of "the effects of movements on sensory stimulation"(p. 1). To illustrate, I have implicitly learned that moving my ear towards the person I'm speaking with, helps me to hear their speech more clearly. How then, do these ideas help us to understand Google Glass better? Admittedly, Noë is not a philosopher of technology, as most of his work is focused on the philosophy of mind, philosophy of perception, and phenomenology. Nonetheless, as I have argued in earlier work (cf. van der Harg, 2013, pp. 11-12) we can rephrase Noë's claim in terms of Martin Heidegger's early tool analysis, by stating that we act with a technology *in order to* perceive(Ihde, 1990, p. 32 ; Verbeek, 2005, pp. 78-79). Verbeek's three modes of focal engagement best describe What I perceive: "the product the artefact makes available", "its environment", and "the artefact itself" (Verbeek, 2005, p. 192). In most cases, users will perceive the product Glass makes available after those users have given Glass a voice command, or have operated it through its touchpad. Such products may be photos the user has taken and Glass shows on its screen or news updates to which a user has subscribed in the past. In other cases, Glass may stimulate users to focus on their environment instead. For example, when a user asks Glass to give directions to a particular location, and Glass provides that user with subtle visual and auditory cues to guide the user to the requested location. Finally, in some cases where users still need to learn how to operate Glass, or where Glass malfunctions, there Glass may direct a user's attention to the Glass device itself. For example, when a user unknowingly whispers a voice command to Glass, the device refuses to respond, and the user gets frustrated *with the device* after several attempts.

We can also invert the above *in order to* statement, by stating that the technology provides us with various perceivable cues *in order to* invite or inhibit particular actions. Tromp, Hekkert, and Verbeek (2011) discuss four general ways in which these invitations and inhibitions take place: coercion, persuasion, seduction, and decision. Coercive design exerts a noticeable and strong influence on the user's actions. For example, when a user notices Google Glass simply does not respond to slow or whispered speech, he or she is coerced[67] to interact with Glass in different ways(cf. , p. 14). Second, persuasive design too exerts a noticeable influence on the user's actions, but its effect is weaker than coercive design. For example, after a user has taken a picture with Glass, and I tap the touchpad while viewing the result, Glass suggests sharing that photo on Google+. Third, seductive design unnoticeably exerts a weak influence on the user's behaviour. For example, the Glass designers have added double quotes around the "ok glass" phrase displayed on the home screen in order to seduce people to speak to Google Glass. Fourth and finally, decisive design exerts a strong, but unnoticeable or implicit influence on the user's actions. For example, after Glass seduced me to speak the 'OK Glass' phrase, it swiftly showed me a number of succinct sentences, that I could speak to it again. Hereby Glass keeps me speaking at a regular pace, and in a natural way, and triggers my tendency to complete my sentence (cf. , p. 16), while simultaneously *deciding* what I will say by offering a limited number of options. As a final remark, note that these four ways of inviting and inhibiting user actions are analytically distinct, and can therefore easily be combined, or be experienced differently by different people(pp. 12-13).

By now it may be clear that there is a mutual relationship between action and perception. But as the historian Carl Mitcham once wrote: "Mutual relationship is not some one thing; mutual relationships take many different forms"(Mitcham, 1994, p. 275). As much learning takes place on both sides of this relation (i.e. acting with a technology *in order to* perceive, and perceiving cues from the technology *in order to* act), and this learning process tends to be circular (e.g. we try something, the device acts and gives feedback, we perceive feedback and try some more, and so forth), I think what hermeneutic philosophers such as Martin Heidegger and Hans-Georg Gadamer, have called the hermeneutic circle best describes the form of this mutual relationship between action and perception. I will discuss the hermeneutic circle in more detail in the next chapter, but for now it is just important to know that the hermeneutic circle here, is just a way to say that our Google Glass skills continuously grow as we put them into practice and Google Glass corrects and refines them.

Based on the above two conceptual points, that intentional differences matter, and that action and perception have a mutual *in order to* relationship for many technologies, I now want to introduce a new concept to postphenomenology that takes into account both of these points: modes of exploration. Basically a mode of exploration is a way in which both humans and technologies, explore one another, or

[67] I speak about coercion here, because in their paper Tromp, Hekkert, and Verbeek classify the principle "Make the behaviour a necessary activity to perform to make use of the product function" as a mild form of coercion. As the authors explain: "When interacting with a product, the user has a specific goal related to the product function. This strategy is about including a design element that requires the user to perform a specific behaviour to reach his or her goal" (2011, p. 14).

explore the world. I have deliberately called this mode of exploration, rather than mode of perception, mode of interaction, or sensory modality(cf. Noë, 2004, pp. 106-107), as these terms tend to emphasise either perception or inter*action,* while exploration puts action and perception on an equal footing. Examples of modes of exploration that apply to both humans and technologies are the visual and auditory modes of exploration. An example of a mode of exploration that applies mainly to technology is motion, or the motile mode of exploration. For most human beings indirectly perceive motion visually (i.e. they see something move), aurally (i.e. through the Doppler effect or a whooshing sound), or tactually (i.e. pertaining to touch; when something or someone caresses our skin, or moves air along our skin). In contrast, an accelerometer or gyroscope perceives motion more directly, as it translates motion directly into an electrical signal, which in turn might be translated into a number or vector that indicates motion. Finally, as these examples illustrate, modes of exploration can only be distinguished analytically. For when I would stand still next to a highway where cars pass me by at 100 km/h, I would see these cars move, experience the Doppler effect, and feel the air these cars move gushing past my body. Focusing solely on one dimension would, according to Ihde, be an unphenomenological move to make, as these other dimensions of the experience are there, and each contribute their part to what it means to stand next to that highway. In other words, every new dimension of the experience should lead to a re-evaluation of the experience as a whole(cf. Ihde, 1976/2007, p. 21).

Now that I have generally introduced the new concept 'mode of exploration' in postphenomenological theory, let's explore how we can operationalise this concept in the next three sections, to address the specific challenges formulated in the previous section. In the next section, I will start to address the challenges raised in the analysis of the Google Glass gesture recognition features, by drawing on the work of the French phenomenologist Maurice Merleau-Ponty, and of the British phenomenologist and cognitive scientist Alva Noë (section 3.3.1). After that, I address the challenges raised by the Google Glass speech recognition system by drawing on Don Ihde's work on the phenomenology of auditory phenomena (section 3.3.2). Finally, we revisit our earlier case study of the Google Glass speech and gesture recognition features to see how these augmentations to postphenomenology work in practice (section 3.3.3). Let's now turn to the work of Maurice Merleau-Ponty and Alva Noë.

3.3.1 Merleau-Ponty and Noë on gestures and learning

In Maurice Merleau-Ponty's magnum opus, *Phenomenology of Perception*, he devotes one chapter to the analysis of the human body's role in speaking and expressing oneself. More specifically, he primarily focuses on gestures. According to Merleau-Ponty there are two types of gestures. First, we have non-verbal gestures; the gestures we ordinarily view as gestures in the sense of bodily movements that convey a particular meaning or message. Second, we have verbal gestures in the sense that Merleau-Ponty views spoken words as gestures too. In his own words: "The spoken word is a genuine gesture and it contains its meaning in the same way as the gesture contains its"(Merleau-Ponty, 1962/2002, p. 213). Like most phenomenologists, though, Merleau-Ponty does not endorse representationalism, and therefore does not claim that these gestures *represent* particular ideas or mental states. Rather, on the meaning of an angry gesture he comments: "The gesture does not make me think of anger, it is anger itself"(p. 214). But how then do other people know or learn that my gesture is anger? Merleau-Ponty writes: "The communication or comprehension of gestures comes about through the reciprocity of my intentions and the gestures of others, of my gestures and intentions discernible in the conduct of other people."(p. 215). Here Merleau-Ponty does not simply speak about empathy(cf. Zahavi, 2001), but rather goes beyond empathy to argue that we possess a self-awareness of our own body, and as we see others act out a certain gesture, we experience that acting out as "an echo of" our "own bodily constitution"(cf. Merleau-Ponty, 1962/2002, p. 216; Zahavi, 2001, p. 163). However, this bodily self-awareness does not guarantee that we always understand each other correctly, especially when it comes to verbal gestures or speech. Therefore, Merleau-Ponty characterises this problem of understanding each other in speech as "indeterminate,"(p. 208) and writes in a later passage:

> "Strictly speaking, therefore, there are no conventional signs, standing as the simple notation of a though: pure and clear in itself, there are only words into which the history of a whole language is compressed and which effect communication with no absolute guarantee, dogged as they are by incredible linguistic hazards."(p. 218)

In other words, understanding each other's speech, and I think to a certain degree each other's non-verbal gestures as well, requires effort, perseverance, and learning. This brings us to our second challenge: How can we (post)phenomenologically describe the learning effects that occurred when learning about the swipe down gesture (section 3.2.1)? To answer this question I will rely on Noë's (2012) discussion on understanding and perception.[68] Basically, Noë beautifully illustrates perceptual learning using the example of encountering unfamiliar works of art:

> "Every song on the new record (for example) may sound more or less the same, each comes across flat, or unengaging. Every painting in the gallery presents its face to you, but only as a face in a crowd, with no discernible features. Sometimes we encounter the work, but it is as if we don't see it, or can't see it, or don't see any meaning in what we see. But suppose you don't give up. You listen to the record again and again; you begin to notice different qualities in the different songs. As you familiarise yourself with them, they begin to engage your attention, and offer you comfort, or excitement, or stimulation, or pleasure. Perhaps you discuss the music, or the paintings in the gallery, with a friend, and she draws your attention to patterns or devices or lyrics. Whereas before the works – the songs, the paintings – were flat opaque, undifferentiated, now they reveal themselves to you as structured and meaningful, as deep and involving. Each song, or each painting, now shows you its very own distinctive face"(Noë, 2012, p. 115).

As the above example illustrates, perceptual learning is not a very formal way of learning, but rather involves perseverance, actively exploring the works of art with your senses, and sometimes having others aid you in that exploration. In short, and here Noë follows Wittgenstein: "understanding is akin to an ability" and "understanding a concept is having a skill"(p. 117). He further elaborates on this latter claim when discussing the relation between concepts and criticism. Basically, learning concepts means learning "to grasp something"(p. 127). Here Noë does not only refer to grasping in the sense of comprehending something, but also in the sense of "seizing

[68] I could attempt to describe this using Merleau-Ponty's work as well. However, Merleau-Ponty describes understanding in terms of worlds that we acquire(cf. Merleau-Ponty, 1962/2002, pp. 149-150, 160, 167). This is unfortunate as in this thesis I try to limit my definition of world to the world we live in daily. Culture, in that sense, is not so much part of a different world (as Merleau-Ponty would argue), but rather part of our own skilful understanding of that one world (as Noë would argue).

and holding" something "firmly."[69] His discussion of (art) criticism continues to rely on this double meaning of grasping. He writes: "What criticism affords is the cultivation of the understanding, the development and so the procurement of the conceptual tools that enable us to *pick up* what is there before us. Concepts are ways of achieving access to the world around us"(ibid, emph. Mine). In other words, our skills (be they sensorimotor, conceptual, or otherwise) develop through correction and refinement (i.e. criticism), and thereby we start to really perceive and understand the world around us (i.e. we gain access to the world).[70]

So what can we conclude and learn from the above discussion about the sociocultural confusion about the glancing eye gesture, and my endeavours to learn about the swipe down gesture? In the first part we saw that non-verbal gestures, the ones used for the Google Glass gesture recognition, act out certain attitudes and feelings in a fairly direct way, according to Merleau-Ponty (i.e. an angry gesture is anger itself). Other people around a Glass user, may pick up the social meanings of these gestures due to the self-awareness of their own bodies. Or they may not pick up these gestures, due to the indeterminacy of language. Furthermore, Google Glass does not have such self-awareness of its 'body' in the same sense that human beings do. It just runs software that translates the motions it detects through its touchpad, its accelerometer, its gyroscope, and its infrared sensor, into numbers, which at certain values and for particular applications, trigger particular actions. The social confusion about the glancing eye gesture (i.e. is Glass more interesting than the person sitting opposite the Glass user?) thus arises from two distinct modes of exploration. Whereas Glass simply detects eye motion, let's call this the motile mode-of-exploration, there people may grasp the sociocultural meaning of this gesture as well, which we could call the gesticulate mode-of-exploration. What can we say about my endeavours to learn about the swipe down gesture? As you may recall from the previous section (3.3), a continuous circular process is at work when I try to use Glass (i.e. referred to as the hermeneutic circle). I swipe forwards and backwards, and Glass shows me the unintended consequences of these actions. For example, I was not expecting to see the photo bump against the side of the screen, or see the next picture[71]. These actions tell me something about the meaning of swiping forwards and backwards, just like Alva Noë slowly grasped the different qualities in different songs. However, these gestures did not bring me back to the home screen. Luckily, like Noë's friend, who taught him about the patterns in the artwork, I too received help from the person teaching me how to use Glass, as she told me about the swipe down gesture. This helped, and further refined and corrected my skills to use Google Glass. Let's now turn to the next section to see how we can augment postphenomenology to address the challenge raised by the Google Glass speech recognition feature.

[69] English meaning from http://oxforddictionaries.com (British and World English Dictionary, viewed: July 25, 2014). Also note that this sense of seizing and holding something firmly is more evident in the German noun Begriff (containing griff which is an object that is either meant to be grabbed (e.g. a knob) or can grab other things (e.g. a claw)) , and the Dutch expression "ergens *grip* op krijgen" conveys a similar thought.

[70] Don Ihde makes a similar point, though he frames it in a slightly different way: "It is often this learning itself that offers itself as suspicious to the 'sensory atomist' whose notion of a built-up or constructed knowledge also infects his understanding of learning. Phenomenologically there is a great distinction between *constructing* something and its *constitution*. In constitution the learning that occurs is a learning that becomes aware of what there is to be seen or heard"(Ihde, 1976/2007, pp. 62-63, orig. emph).

[71] This happens when you tap the card with your most recent photos.

3.3.2 Ihde's phenomenologies of sound

In his *Listening and Voice*, the American phenomenologist and philosopher of technology Don Ihde develops a phenomenology of auditory phenomena. As most of Ihde's book focuses on the wide variety of auditory phenomena that humans are able to perceive, my main focus here will be on the relevant phenomenological terminology Ihde uses to describe these auditory phenomena. Nonetheless, I will first introduce the terminology for the human case, I then use this terminology to describe the speech recognition case, and finally address the challenges raised in section 3.2.2.

Basically, Ihde starts his analysis by stating that the shape of intentionality for an auditory phenomenology is that we do not simply listen, but that we always listen to something or someone(Ihde, 1976/2007, p. 23). He then slowly moves on to the description of the auditory field, hereby he draws an analogy with the visual field. Figure 3-3 shows what phenomenologists call the visual field. In this field the focal core is the area of my field of view where I see everything clearly and sharply. For example, right now the letters of this text are part of my focal core. However, as I keep my fixed on these letters, I notice that more text surrounds it (e.g. the other words on this page), and that even though I am able to distinguish it as text, I am not able to read it, because it looks too blurry. This blurry but visible area is what phenomenologists call the background, and the border between this background area and the focal core area is called the fringe. Finally, as I still keep my fixed on this text, and move my hand upwards, I notice that at some point my hand will disappear from the background into an area that I can only see when I direct my head or eyes upwards. The border that delimits my visual field in its entirety is called the horizon. Thus the moment my hand disappeared from my visual field, it crossed the horizon of my visual field.

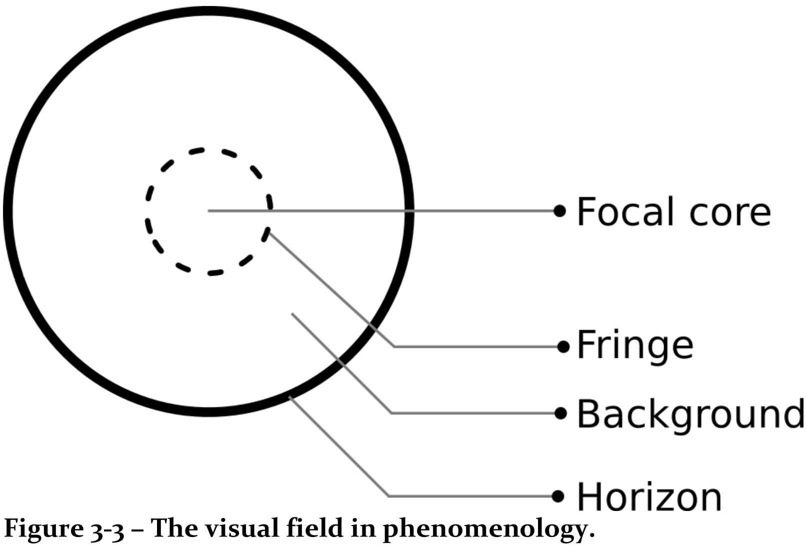

Figure 3-3 – The visual field in phenomenology.

When we apply these terms to auditory phenomena, we find that we can discover a horizon, background, fringe and focal core too. When we start to look for a horizon for auditory phenomena, we find that there are places where we are no longer able to listen to things, because they have grown mute and are too far away for us to hear them(cf. , p. 50). Hence, Ihde speaks of a horizon of silence(ibid). As we cross the horizon of silence we can notice a number of features of the auditory field. First, that we can indeed speak of a background, fringe, and focal core. For example, in a room full of people I have the ability to hear clearly what the people I talk to say (the focal core), while the talk of other people surrounding me reduces to mere mumbling (fringe and background)(cf. , p. 50). Second, in contrast to the forward-oriented visual field (i.e. I mostly see what is before me and beside me), the auditory field has an omni-directional shape(p. 65). Third, in order to bring someone or something into auditory focus from the auditory background, I usually do not have to move my body or parts of my body to do so, in contrast to vision where I do have to move my eyes, head, or body in order bring something into focus(cf. , p. 75). Fourth, I can also imagine aurally that I am listening to a song, or engaging in a dialogue with myself – Ihde calls this auditory imagination or the imaginative mode(cf. , pp. 117,124-125). In that case, other people may perceive me as "attending to nothing-in-particular"(cf. , p. 40). Fifth and finally, in contrast to the visual perception of say, an iron pipe, which will remain in its place as long as no one removes it, most auditory phenomena are intrinsically temporal and fleeting(cf. , pp. 85-94). That is, when I hit the iron pipe with a hammer once, its sounding will fade into my auditory focus, or background if I'm listening to someone speaking, and after a short while crosses the horizon of silence again. In other words, the iron pipe's auditory presence is not as constant as its visual presence. Now that we have described the "soundful" dimension of auditory phenomena, let's briefly move on to their meaningful dimension (p. 4). After all, spoken words and silence also have a meaning. With regard to spoken words, Ihde radicalises Merleau-Ponty's fundamental claim that "*the word has a meaning*" (Merleau-Ponty, 1962/2002, p. 206 orig. Emph.) by stating that "the word *is a* meaning"(Ihde, 1976/2007, p. 150, orig. Emph.), but he broadens the scope of this claim in his further explorations[72]. For according to Ihde, *what* is being said is not the only way in which a spoken word is a meaning. Additionally, *how* someone speaks a word, also tells a lot about its meaning. For example, whether I speak with a joyous voice or an angry voice, tells a lot about how I experienced a particular event(cf. , p. 152). Next to speech, there is silence. Even though silence forms the horizon of the auditory field, this does not mean it is insignificant. Ihde describes two kinds of silence that are relevant for our discussion here. First, there is the usual silence after speaking a word or sentence. Ihde writes: "In speech silence often indicates either the stopping of a line of thought or a transition(…)"(cf. , p. 110). Second and finally, we can also view silence as the unsaid. That is, whenever I speak with someone about a particular topic, many things about that topic may remain unsaid, as we both understand what the words we use to discuss the topic mean. In contrast, this silence about the unsaid may not be helpful when a person knows very little about the topic he is trying to discuss with an expert in that field. For example, when I discuss this thesis with my supervisors, we do not elaborately discuss basic philosophical concepts, even though we use these concepts regularly in our conversations. Only when one of us feels we do not share the same understanding of a concept, then we start to speak

[72] In a footnote at the start of his chapter on language, Merleau-Ponty explains how he prefers to use the terms having and being: "We prefer to take account of the usage which gives to the term 'being' the weak sense of existence as a thing, or that of predication (the table is, or is big), and which reserves 'having' for which the relation the subject bears to the term into which it projects itself (I have an idea, I have a desire, I have fears)"(1962/2002, p. 202). This remark, in my view, explains why Merleau-Ponty would not say that a word is a meaning, as Ihde does. For often Merleau-Ponty relates the significance of words to contextual factors such as "accent, intonation, gesture and facial expression," and the sentence to which the word belongs(pp. 174,452,469).

about what remained previously unsaid.

Let's now remain 'silent' about Ihde's analysis of auditory phenomena, and see what we can say with his concepts about the Google Glass speech recognition system. Let's start with the auditory field of the Google Glass microphone. Based on the technical specifications of Google Glass it seems most likely that the shape of its auditory field is not entirely omnidirectional.[73] Basically, Google Glass has two Wolfson WM7231 digital microphones, which are omnidirectional according to the specifications listed on its official data sheet(Wolfson Microelectronics, 2014, p. 5). Google has placed one of these microphones near the camera, while they have placed the other microphone close to the ear, behind the end of the touchpad(cf. Torborg & Simpson, 2013). Torborg and Simpson (2013) suggest that Google uses two microphones, instead of one, in order to cancel noise.[74] So that at least allows Glass to pick up sound from the front and the right of the user (the other directions could be blocked by the user's head). However, as the oral historian Juliana Nykolaiszyn wrote in a blog post on testing Google Glass to record oral history using the camera and microphone:

> "Another major downfall of Google Glass is the built-in microphone. The mic can easily and clearly record the person wearing the unit, but struggles to pick up other voices, such as narrators stationed at a comfortable distance. Furthermore, the mic is not omnidirectional, lessening the overall quality of recordings"(Nykolaiszyn, 2014)

Even though her statement on the omnidirectionality of the microphone is not entirely correct, I think her claim that the microphone "struggles to pick up other voices" is justified, as she also demonstrates this claim in a video accompanying the blog post(ibid). In this video she demonstrates how her own voice is recorded loudly and clearly by Glass, while the voice of her interviewee (sitting at a considerable distance at her front right) is only softly and clearly captured by the microphones. Nonetheless, I could not hear any background noise on the recordings, so the noise filtering feature seems to be working well. In Ihde's terminology we could thus say that due to this noise filter, Google Glass has an auditory focus too, even though the background remains desirably silent from a user perspective.

But how then, do these observations help us to describe the speech recognition system of Google Glass, and address the challenges raised in section 3.2.2? First of all, I think the above analysis reinforces the first challenge I raised in section 3.2.2: that the Google Glass speech recognition system, and now more fundamentally the Google Glass microphone, cannot adequately be described by Don Ihde's amplification / reduction structure. For not only is loudness information about specific frequencies removed from the auditory signal by the acoustic model of the speech recognition software, but Google Glass removes noise as well, using its dual microphone noise

[73] Unfortunately, I forgot to test this, as my main focus in the experiments was on the speech recognition system, rather than on the microphone. However, a simple experiment could have verified this. Simply have the person wearing Google Glass stand about 1 meter from a person not wearing Google Glass in a wide open space to prevent auditory reflection from walls, while both face opposite directions (i.e. their backs are directed at one another). Then have the person not wearing Glass say the 'OK Glass' phrase, and check whether Google Glass shows the home screen.

[74] i.e. by placing one microphone directed to the front, which captures the source you want to record together with some noise, and by placing a second microphone on the side to capture more of the noise and less of the source you want to record, you can filter out a large part of the noise by subtracting the signal from the microphone on the side from the signal captured by the front microphone.

filtering system. But how then do we address this first challenge raised in 3.2.2? I think this can be done in two steps. First, instead of speaking about amplification and reduction, I think a more apt description of what Google Glass does is to speak about a construction/deconstruction structure. Note that I am not using these terms in the same literary and intellectual sense that the French postmodernist Jacques Derrida used them to lay bare and undermine the implicit assumptions and distinctions of "dominant ways of thinking"(cf. Reynolds, 2010). Rather I use them in a more heuristic technological sense. More specifically, I use *deconstruction* to describe my observation that the algorithms sometimes remove parts of, or divide into parts, the electronic representation of speech they receive through the microphone. For example, the algorithms remove noise and loudness information for specific frequencies, and carve up the speech signal into short frames to perform an efficient analysis thereof. I use *construction* to describe my observation that these algorithms also construct new entities based on the input they receive. For example, to replace the electronic representation of the raw speech signal, the acoustic model constructs a 40 dimensional vector with loudness information over ranges of frequencies, ultimately leading to a technological action resulting from what Glass constructed to be my voice command (e.g. taking a picture), a (re)constructed text on the display (not necessarily correct) which shows what I said, or no response at all. Second, note that the Google Glass software developers who selected the training set for the acoustic model and pronunciation model (see section 3.2.2), did not include auditory samples of people who whisperingly or slowly spoke their voice commands. Consequently, the algorithms are not able to carefully and correctly 'listen to' these voice commands. For these algorithms need such explicit examples in order to perceptually 'learn' how to bring these whispered or slowly spoken voice commands into auditory focus from beyond the horizon of silence, in the sense of silence as the unsaid.

Finally, how does Ihde's analysis help us to address the second challenge raised in section 3.2.2? Namely, that people unfamiliar with Google Glass look surprised when I suddenly say: 'OK Glass, translate this', and wonder whom I was talking to. My response to this challenge starts by observing that even though *my* auditory and visual attention are directed towards Google Glass, bystanders perceiving me wearing Google Glass can only subtly notice that my visual attention is directed towards the Google Glass on my face, because my eyes look slightly upwards to see the Google Glass screen. For as Ihde remarked, auditory attention does not require my body to move. Furthermore, as Ihde remarked as well: all "listening is a listening to ___"(Ihde, 1976/2007, p. 23). So when I suddenly start speaking a voice command to Glass in a relatively silent environment, it is not strange for someone nearby to aurally imagine whether he or she should be the one listening. After all, the small device on my face with no visible microphones does not make it very clear to bystanders that it is the one listening to and responding to my voice commands. Additionally, the Glass user's eyes looking slightly upward may only add to the ambiguity of the situation, as from a bystander's perspective it may seem as if the Glass user is visually attending to no person-in-particular.

In conclusion, I think it is fair to say that Don Ihde's phenomenological reflections on auditory phenomena offered a new and fruitful perspective on the Google Glass microphone and speech recognition system. Furthermore, his auditory re-interpretation of classical phenomenological concepts such as focal core (or focus), fringe, and horizon, helped to neatly highlight the differences and similarities between visual and auditory perception. Therefore, I conclude that these concepts offer an adequate analysis of both the human and the technological auditory mode-of-exploration. That is, even though these concepts highlight phenomenological differences between how Google Glass 'listens' and how I listen (e.g. the shape of our auditory fields, the way we learn to bring auditory phenomena into focus), the concepts themselves apply to both cases, and thus do not warrant two different modes-of-exploration (i.e. one mode-of-exploration for the way Google Glass listens to the world, and another for how I listen to the world). Let's now briefly reflect on how the fairly specific analysis presented in this section may be generalised so that they can be fruitfully applied to other cases as well, and explore the practical uses of augmented postphenomenology.

3.3.3 Augmented postphenomenology in practice

In this section I have presented an augmented version of postphenomenology that arose from my phenomenological reflections on two features of Google Glass: its speech recognition system with its accompanying voice commands, and its gesture detection system that helps the user to perform a variety of specific actions. Most of these reflections went into considerable detail to make a number of (post)phenomenological points. However, this may have made it hard to see the bigger picture, and discover what we have achieved so far. Therefore, allow me to illustrate the bigger picture visually and to discuss its practical relevance.

We started our analysis of these features with the two human-technology relations depicted in Figure 3-4. Figure 3-4A shows the alterity relation, while Figure 3-4b shows the composite relation. The arrows surrounding these human-technology relations (i.e. the outer perception and action arrows) depict the human-world relationship (see section 3.1).

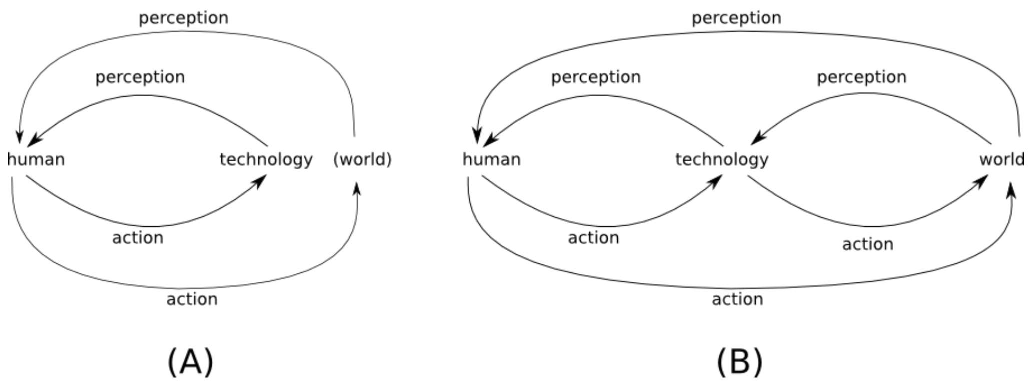

Figure 3-4 - The two human-technology relations used in the analyses in section 3.2. Picture A shows the alterity relation, while picture B shows the composite relation. In picture B, the arrows between human and technology depict human intentionality, while those between technology and world depict technological intentionality. The perception and action arrows surrounding these human-technology relations (in picture A and B), depict the human-world relationship.

In this figure you may notice that the ways in which a human, or the technology being studied, perceives and acts have not been specified. However, we do perceive and act in specific ways. We see, we hear, we gesture, and a technology may perceive motion or air pressure in a fairly direct way. Therefore in section 3.3 I introduced the concept mode of exploration to address these specific ways of perceiving and acting, and operationalised this concept in its two subsections. Figure 3-5, for example, summarises the gesture recognition analysis for the eye glancing gesture. When I glance at the Google Glass screen to wake it up (action(g)), then glass perceives eye motion (perception(m), and in turn that particular eye motion triggers Glass to activate the screen (action(v)), which I finally perceive as an activated screen and a confirmation that Glass detected my eye gesture properly (perception(v)). Furthermore, other people nearby may perceive (perception (all)) my gesture (action(g)) aimed at Google Glass, as me being distracted by Glass when it happens often. For they perceive my eye gesture as a gesture (perception(g), not shown), and not simply as motion (perception (m)).

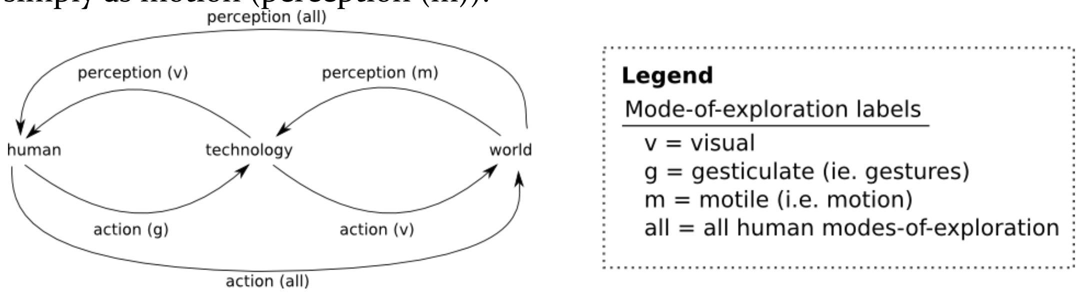

Figure 3-5 - An augmented postphenomenological analysis of the glancing eye gesture that Google Glass uses to wake up the screen.

Figure 3-6 depicts the same type of analysis, but applies it to the 'OK Glass, take a picture" voice command. Here I first speak the command (action (a)), Google Glass perceives this command (perception (a)), and takes a picture using its camera while it plays a sound to let the user know it took the picture and shows the picture on the screen (action (v,a)), which the user in turn perceives as a confirmation that the picture has been taken(perception (v,a)). Note that in this analysis I use multiple modes-of-exploration to fully analyse the situation (e.g. the (v,a) label), rather than the single labels in Figure 3-5. I do so to illustrate that the various modes-of-exploration are only analytically distinct.

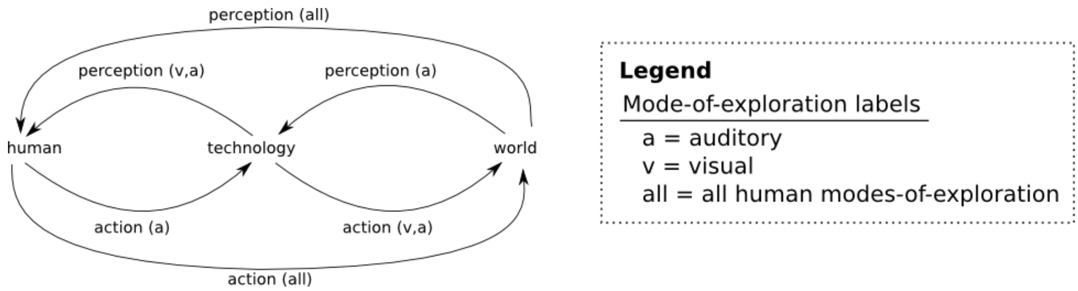

Figure 3-6 - An augmented postphenomenological analysis of the 'OK Glass, take a picture' voice command.

Even though, these pictures may offer a neat way to capture the various ways in which people and technologies explore one another, and explore the world, I would highly recommend complementing these pictures with a (post)phenomenological analysis when a deeper understanding of the situation illustrated by the picture is required. For these pictures only provide a quick high-level overview of the more detailed analyses described in section 3.3.1 and 3.3.2.

Finally, in which practices could augmented postphenomenology be of any practical use? I think there are two main areas where augmented postphenomenology could contribute useful insights. The first of these two areas is interaction design for users with disabilities. More specifically, when designing applications such as Glassist (i.e. a Dutch piece of glassware that helps people with a disability to make use of public transport, see section 2.3.2.3), schemes like those in figure 3-5 and 3-6, could provide a quick overview to describe which modes of exploration will be addressed by particular functions of that application, and thereby prevent mismatches between a person's disability and the design of the technology. For example, subtle auditory cues may not work very well for people with a severe hearing disability, while such cues may work very well for a person with a visual handicap. In order to emphasise peoples abilities, rather than their disabilities, the perception(all) and action (all) labels may be replaced with a more specific list of a person's abilities, such as vision, touch, or gesturing. A second area where augmented postphenomenology may turn out to be useful is in technology assessment, and in the evaluation of technological designs. In such cases postphenomenology, and the augmented version thereof I have presented here, could help to anticipate how technologies will influence our attention (i.e. what we attend to), and the way we perceive, and act within the world(cf. Verbeek, 2005, pp. 203-234, also see section 3.3 of this thesis). Furthermore, as I showed in section 3.3.1 and 3.3.2, these analyses are not limited to the relations between users and their technologies, but could include the social phenomena that these technologies give rise to as well (e.g. is Glass more interesting than the person sitting opposite me? who is that Glass user speaking to when she says 'OK, Glass'?). Such analyses could in turn inform ethical reflections (and later policy considerations) on the technology and its mediating role as I will show in chapter 5. But before we go to that chapter, let's first conclude this chapter and see what is in store in chapter 4.

3.4 Conclusion

In this chapter, I have presented my augmentations to postphenomenology. In the previous section, I have also presented some brief thoughts on how augmented postphenomenology could be used in practice by designers, and by researchers involved in technology assessment. Most of the reflections here, however, focused on the way technologies shaped our explorations of the world, and the way others could socially experience someone exploring the world with Google Glass. Furthermore, the discussion in this chapter also touched upon the way we learn how to use Google Glass, and the way Google Glass 'learned' to comprehend some of the ways we speak. However, could Google Glass teach us something as well? Or at least shape the way we understand the world? We will now explore these questions in chapter 4, which philosophically discusses augmented reality applications for Google Glass.

Chapter 4 - Augmented Reality: A second challenge to postphenomenology

As I discussed in chapter 2, several Google Glass Explorers have developed augmented reality applications for Google Glass (see section 2.3.2.3). Google itself, though, has stated that Google Glass does not offer an augmented reality experience (cf. Dale & Richardson, 2013a). Furthermore, if Google Glass indeed augments reality, or more specifically, changes the way we perceive reality (i.e. the world), then that might influence the way we interpret and know that reality as well. In this chapter we will explore the following questions: Does Google Glass offer an augmented reality experience? If that is so, can postphenomenology be used to analyse that augmented reality experience adequately? If not, how does the augmented reality experience offered by Google Glass challenge postphenomenology, and how can we further augment postphenomenology to address this challenge, or these challenges?

In order to answer these questions I will first explore what is meant by augmented reality (AR). Because when we have a clear definition of augmented reality, it becomes much easier to assess whether or not Google Glass offers an augmented reality experience. I argue that according to existing definitions of augmented reality, it is indeed hard to see how Google Glass would provide an augmented reality experience. However, if we interpret augmented reality in a hermeneutic/epistemological way, then several applications for Google Glass do provide augmented reality for particular groups of users (section 4.1). I then explore whether postphenomenology, and augmented postphenomenology as presented in chapter 3, can fully address the challenges raised by these Google Glass augmented reality applications. Even though the remarks on perceptual learning in the previous chapter come close (see section 3.3.1), I argue that they do not explain *why* we accept the alternative interpretations presented by these Google Glass augmented reality applications (section 4.2). Therefore, I re-interpret five concepts from the German hermeneutic philosopher Hans-Georg Gadamer, and combine those with my earlier augmentations discussed in chapter 3, in order to show how augmented reality applications help certain users to productively re-interpret the world (section 4.3). Let's now start our inquiry, and explore what augmented reality is.

4.1 Definitions of Augmented Reality

We will start our explanation with two commonly used definitions of augmented reality. As I will show, these definitions have two main limitations (section 4.1.1). I first discuss and resolve the first limitation (section 4.1.2). I then discuss and resolve the second limitation, and thereby arrive at a hermeneutic/epistemological definition of augmented reality software as well (section 4.1.3).

4.1.1 Ontological AR definitions

Two often cited definitions of augmented reality are those of Azuma (1997) and Milgram and Kishino (1994). Ronald Azuma (1997) first contrasts Augmented reality (AR) technologies with Virtual Environment (VE) technologies:

"VE technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it."(1997, p. 356)

In other words, AR technologies augment the world with virtual objects, but do so in a way that the world we daily live in (i.e. what Azuma calls the real world) remains visible. He then defines AR technologies in terms of three "characteristics"": such technologies combine "real and virtual", are "interactive in real time", and are "registered in 3-D"(p. 356). This third characteristic ("registered in 3-D") seems to suggest that only vision can be augmented by augmented reality technologies. However, even though Azuma primarily focuses on visual augmented reality technologies, he does acknowledge that our sense of hearing and touch can be augmented as well(pp. 363-364). Milgram and Kishino (1994) define augmented reality as "any case an otherwise real environment is 'augmented' by means of virtual (computer graphic) objects," and thus share Azuma's characteristic that augmented reality combines the virtual and real. However, their definition also tends to be less explicitly clear-cut than that of Azuma. For Milgram and Kishino define augmented reality in terms of what they call the virtuality continuum (see Figure 4-1), which, as Milgram suggests in a later paper(cf. Milgram & Colquhoun, 1999, pp. 5-8), does not make it necessarily clear when a combination of virtual and real constitutes augmented reality, mixed reality, or augmented virtuality. Finally, like Azuma, Milgram and Kishino (1994) mainly focus on visual augmented reality technologies, but acknowledge that auditory, haptic (i.e. pertaining to our sense of touch), and vestibular (i.e. pertaining to our anatomical sense of balance) augmented reality technologies exist as well.

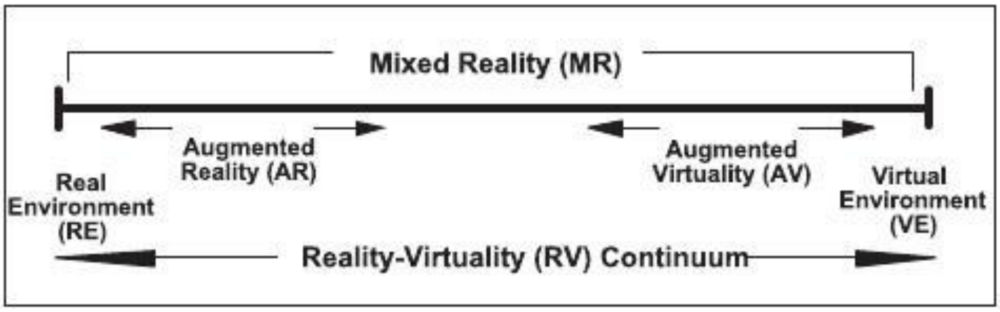

Figure 4-1 - The virtuality continuum. Picture from Milgram and Colquhoun (1999)

Even though the above definitions are commonly[75] used to define augmented reality, they do not work well for the augmented (post)phenomenological inquiry I pursue in this thesis. First, because both definitions rely on a distinction between a virtual and real world, and thereby suggest that the virtual world is somehow not real, and that the world can be carved up into a virtual and real world. Second and more

[75] Google Scholar indicates that Ronald Azuma's (1997) paper has been cited 4076 times, while the paper by Milgram and Kishino has been cited 1807 times. Even though both papers had more than 15 years each to generate such scores, and Azuma's paper does not solely aim to define augmented reality (as the paper by Milgram and Kishino does), I think these scores at least indicate that these papers are not read by a minority of researchers within a specialised field, but have built up some credibility. Furthermore, both the Oxford Dictionary and Collins Dictionary website, provide very similar definitions to the ones desribed by the papers under discussion(cf. Collins, 2014; Oxford University Press, 2014a), and thereby in my view indicate that these definitions are shared by a broader audience as well, at least in the English-speaking world, and at this time.

profoundly, because these definitions focus solely on the ontology of augmented reality (i.e. the way augmented reality is structured), and thereby exclude its hermeneutic and epistemological implications (i.e. the way the added virtual entities influence our interpretation or knowledge of the world, respectively). Let's now consider these two points in more detail.

4.1.2. Limitations of ontological AR definitions

Johnny Søraker (2010) has remarked that "the 'ultimate reality' of a virtual entity is rooted in the physical world, but only in a form that is not directly accessible (i.e. as strings of binary digits)"(p. 34). This remark has two implications. First, if 'real world' in the definitions of Azuma (1997) and Milgram & Kishino (1994) refers to the physical world, and Søraker rightfully remarks that virtual entities find their roots in that same physical world, then physical reality cannot be considered a relevant ground to distinguish between virtual and *real* entities (at least if we follow Aristotle's principle of formal equality). Søraker, following Albert Borgmann, also provides an alternative: rather than distinguishing between virtual and real entities, he distinguishes between *actual* and virtual entities instead(p. 20).

Second, to achieve access to a virtual entity, say a movie on a DVD, or a text document on a USB drive, I will always need some sort of "computational underpinning" such as a DVD player or laptop to achieve access to that virtual entity (ibid). I deliberately speak about "achieving access" here, rather than gaining access, as Alva Noë has argued that "we achieve access to the world around us through skilful engagement; we acquire and deploy the skills needed to bring the world into focus"(Noë, 2012, p. 2). More specifically, to achieve access to the movie on the DVD I need my technological skills to operate a DVD player or laptop in order to watch and hear the movie. Based on these two observations, that distinguishing between actual and virtual entities is a more apt description, and that we achieve access to such virtual entities through technologies and our technological skills, I see no need to carve up the world into a virtual and actual world. For an investigation concerned with virtual worlds such as *second life* and *World of Warcraft*(e.g. Søraker, 2010), or virtual reality technologies such as the Occulus Rift (i.e. technologies that cover the whole field of view) I would see the benefits of making such a distinction. However, Google Glass differs considerably from such technologies. For Google Glass does not cover my full field of view (it only covers the the middle-upper part of that field translucently), nor does it overwhelm my field of hearing with sounds generated by its bone-conduction speaker or ear buds (cf. section 3.3.2). Moreover, Google Glass is not meant do so either, as that would focus users too much on the device itself or the product it generates, rather than on their environment (section 3.3). In the words of Google Glass developer advocate Timothy Jordan: it would take users "out of the moment"(Jordan, 2013a t. 1:49-1:51)

Finally, the Google Glass applications I discuss in this chapter at most concern what Søraker refers to as *virtual x* 's (e.g. virtual text, images, sounds etc.), that he defines as "interactive computer-simulated x (or x made possible by computer simulation)"(2010, p. 55), in contrast to virtual environments, worlds, or realities which have more complex characteristics(cf. 2010, pp. 55-57). Such *virtual x* 's, from now on referred to as virtual entities, can be sufficiently described using the conceptual tools developed in the previous chapter, and the two observations stated above. For example, the Google Word Lens application allows a user to scan a piece of text by aiming the Glass camera at the text, then translates the text, and overlays the virtual translated text in such a way that it looks as if you are reading the translated text from the original document (see Figure 4-2). Word Lens does change the font of the text, though, and in my own tests with Word Lens a few glitches did appear, especially when moving my head to read a document. In contrast, moving the document as I kept my head still gave a more stable image. In other words, it does require some sensorimotor and technological skills to achieve stable access to these virtually translated words.

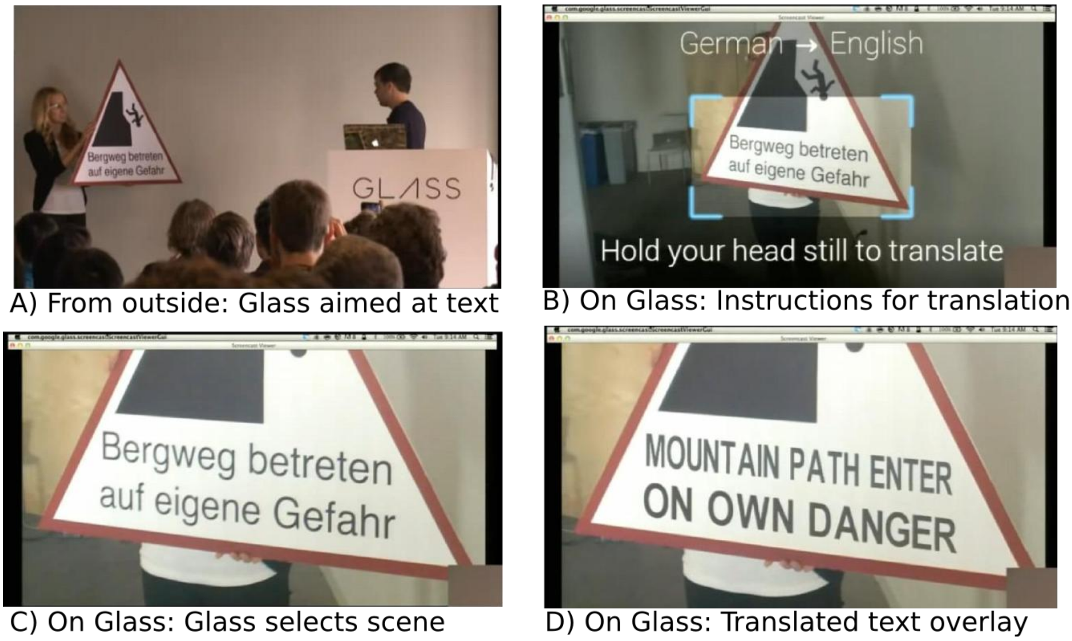

Figure 4-2 - Google Glass Word Lens application. Picture A shows the situation from an outside perspective with the Glass user on the right and the text to-be-translated on the left. Picture B shows the instructions on the user's Google Glass display. Picture C shows the visual scene selected by the Word Lens application. Picture D shows how Glass displays the translated text over the original sign, while someone not wearing Glass would still see the original text on pictures A to C. All pictures are derived from Jordan (2013 t. 4:50-4:55).

The Word Lens example also highlights a second and more profound reason as to why the commonly used definitions by Azuma (1997) and Milgram and Kishino (1994) do not fit well within this postphenomenological inquiry: they focus solely on the ontology of augmented reality (i.e. the way augmented reality is structured) without taking into account the epistemological and hermeneutic implications of *augmenting* reality (i.e. how AR affects my knowledge and interpretation of reality, respectively). For example, Word Lens changes the language of the words in the document in front of me (ontology), and that will also affect my knowledge and interpretation of that document (epistemology and hermeneutics). Thereby they overlook that the appearance of words, their meanings, and knowledge about words are intrinsically connected to one another (see section 3.3.1 and 3.3.2). For as Ihde radicalised Merleau-Ponty's fundamental claim: "the word *is a* meaning"(Ihde, 1976/2007, p. 150). How then can we broaden our definition of augmented reality so that it includes the epistemological and hermeneutic dimensions of augmented reality as well? Let's now turn to the next section to answer this question.

4.1.3 A hermeneutic/epistemological AR definition

Again Søraker provides an interesting point of departure.[76] In a brief analysis of Alan Turing's conception of intelligent machines he provides a clue on how to make the shift from ontology to epistemology. He writes:

> "What is important here is that Turing turns the question of intelligence from an ontological to an epistemological one. That is Turing does not ask which properties a computer must possess in order to be deemed intelligent (its ontological mode of existence), but rather how an intelligent observer judges its behaviour"(Søraker, 2014, p. 34)

In other words, to develop an epistemological/hermeneutic definition of augmented reality software we should not so much focus on the exact technological specifications of the software and/or hardware, but rather on whether the user judges that he or she has achieved a new interpretation or knowledge of the world, or him- or herself, through the virtual entities that Google Glass makes available. 'New' here refers to the significant difference between the interpretation made available through Google Glass, and the interpretation the user holds through the human-world relation. For example, the WatchMeTalk application for Google Glass provides its hearing-impaired user with a virtual textual representation of what people say in their environment(Rioja, Guerin, Vega, & Upadhyaya, 2014). For the hearing-impaired user the virtual textual representation offers new knowledge about what people in their environment say, in comparison to the muffled speech sounds and moving lips they would otherwise have to rely on through a human-world relationship, or better: a human relationship. However, for a user who is perfectly able to hear and understand the language of the people around them, this textual representation does not offer new knowledge about the world or themselves, and therefore does not augment reality in the epistemological/hermeneutic sense for this user. Thus an augmented reality definition in the hermeneutic/epistemological sense does not offer an absolute criterion to decide whether an application running on a particular device offers augmented reality. Rather it offers a criterion relative to particular user groups. At this point it may be objected that this sole criterion is not sufficient to define augmented reality epistemologically and hermeneutically. For under this sole criterion a news message from CNN, an e-mail from a friend, or the Google Glass compass, may also change my understanding or knowledge of myself, the world, a particular social event, or my relationship to the world. In short, this criterion may define augmented reality epistemologically and hermeneutically, but it does not sufficiently define augmented reality *software*. Therefore, I add another criterion: a computer system algorithmically interprets the actual world in near real time based on data gathered through one or more sensors. Two terms in this second criterion may require some explanation: 'near real time' and 'algorithmically interprets'. First, the Alliance for Telecommunications

[76] The archaeologist Stuart Eve provides another point of departure(Eve, 2012). He supplements Milgram and Kishino's virtuality continuum with archeological phenomenology and Gibsonian affordances, to explore how augmented reality through a smartphone could bridge the gap between visting an archaeological site and recording our experiences (archaeological phenomenology), and investigating archaeological sites using 3D computer models (Geographic information systems (GIS) approach). Even though his paper provides a fascinating case study, and rightly observes *that,* and concretely describes *how*, augmented reality could change our understanding of an archaeological site, it does not explain *why* it would change our understanding of the archaeological site. This latter remark is not meant as a criticism of Eve's study, but rather to say that his study has been carried out at a different level of explanation than the one I am pursuing in this chapter(cf. Floridi, 2008, p. 319).

Industry Solutions (ATIS) Telecom Glossary defines 'near real time' in the following way: "Pertaining to the timeliness of data or information which has been delayed by the time required for electronic communication and automatic data processing."(ATIS PRQC Committee, 2011). In other words, whenever Google Glass generates a virtual entity, there is always a certain delay involved as Google Glass itself, or a server, has to process the sensor data, and therefore we cannot really speak of 'real time,' but rather we speak about 'near real time' which takes into account this delay. Second, even though I will say more about algorithmic interpretation in section 4.3, for now algorithmic interpretation refers to those algorithms that ascribe a specific coherent, and possibly alternative, semantic content to the dataset gathered through one or more sensors. These interpreting algorithms should be contrasted with algorithms that directly repeat or slightly reformat the semantic content of the data gathered through one or more sensors (e.g. change the number of digits behind the comma from 6 to 2, or show an average of five sensor readings). In conclusion, a piece of software should only be called augmented reality software in the hermeneutic / epistemological sense when:

1. a computer system algorithmically interprets the actual world in near real time based on data gathered through one or more sensors, and
2. that interpretation is presented in near real time to the user *and* significantly differs from the interpretation the user would otherwise have had of the actual world[77] through the human-world relationship, so that the user obtains new knowledge about him- or herself, the actual world, or another person through the alternative interpretation presented by the computer system.

Only condition A and B *together* are sufficient to call software augmented reality software in the hermeneutic and epistemological sense. Let's now briefly look at a few examples to see how these criteria work in practice. Under these criteria news updates subscriptions through Google Glass no longer qualify as augmented reality software. Even though they meet criterion B (i.e. the user gains a new understanding of the world), they do not meet criterion A (i.e. news updates are not based on an algorithmic interpretation of a person, or the world through Google Glass sensors). Another example that does not qualify as augmented reality software for most users, is the Google Glass way of sending an e-mail. In that case a user speaks the e-mail recipient and content to Glass, while Glass selects the right recipient and transcribes the user's spoken message. In this case criterion A is met for every case (i.e. Glass algorithmically interprets the user's speech), but criterion B could only possibly be met by a deaf or hard-hearing person, as the transcribed message could serve as a way to check whether they pronounced certain words correctly, assuming that Glass transcribes them correctly (i.e. they gain a new understanding of their own speech). Apart from this possibility, criterion B will generally not be met by most users for the Google Glass e-mail case, as the transcribed message simply describes what they already thought and heard themselves saying to Google Glass. Finally, two other examples that meet both criteria, next to Word Lens and WatchMeTalk, are Memento and the Google Glass Directions application. Memento offers visually impaired users

[77] Here the actual world includes people. However, not to clutter the text too much I leave it out of this part, and mention it more explicitly near the end.

audible annotations of particular visual scenes, so that they can get some impression of the scene before them (White, 2013c t. 1:00-3:31). Even though the audible annotations are recorded beforehand, and thus do not rely on any algorithmic interpretations, playing these audible annotation does make use of computer vision algorithms that recognise the scene and play the accompanying annotation - so criterion A is met for the recognise-and-play-annotation part of Memento. Furthermore, if the user cannot see well, or cannot see at all, such audible annotations may at least offer some new understanding of a scene they could otherwise only explore by touch, hearing, with the help of another person, or with the help of a guide dog. More specifically, by hearing I mean those situations where users are looking for a particular device that makes noise such as a fridge or printer. Finally, the Google Glass Directions application provides users with navigation instructions to travel from A to B by car, bicycle, or walking. This application does not simply repeat the GPS coordinates Glass has received through the user's mobile phone via Bluetooth, but rather uses them to plot the user's location on a map and provides the user with a bird's-eye view of their own location relative to their destination B, and step-by-step instructions to follow the route towards B. This additional semantic content (i.e. the map, the bird's-eye view, the instructions, the route) turn the GPS coordinates into a coherent specific algorithmic interpretation (criterion A). Additionally, this interpretation provides those users unfamiliar or vaguely familiar with a geographic area with new knowledge about that area, which they did not have before they viewed these instructions on Google Glass (criterion B).

Now that we have developed a hermeneutic/epistemological definition of augmented reality software, and have seen that Google Glass provides at least some form of augmented reality in the hermeneutic/epistemological sense, depending on the application and the user of that application, let's now explore how to gain a better understanding of what these applications do from a postphenomenological, and an augmented postphenomenological point of view.

4.2 (Augmented) postphenomenology and Augmented reality

Postphenomenology (section 4.2.1) and Augmented postphenomenology (section 4.2.2) offers several concepts that could illuminate some of the hermeneutic (i.e. interpretive) processes that arise when users start to use Google Glass AR software. However, as I will argue below, even though some of these concepts offer insight into these hermeneutic processes, and some of them may even explain *why* particular new interpretations may come about, none of these concepts gives full insight into *why* new interpretations on the user's side arise for every example of augmented reality software I discussed in the previous section (4.1.3).

4.2.1 Don Ihde's material hermeneutics

Let's start with a brief explanation of why I do *not* intend to use Don Ihde's five concepts multistability, macroperception, pluriculturality, instrumental realism, and visual hermeneutics. This may surprise some readers, as these are some of the main concepts he uses to study material hermeneutics. More specifically, he uses macroperception and multistability to describe how specific technological artifacts gain one or more specific cultural meanings(cf. Ihde, 1990, pp. 29,144), and pluriculturality to describe how specific technologies bring us into contact with various cultures and thereby lead to new ways of interpreting artifacts(cf. Ihde, 1990, pp. 164-177). Additionally, instrumental realism denotes Ihde's position in the philosophy of science debate on realism (i.e. are entities that we cannot see with our bare eyes such as atoms and cells real?), and states that such entities can only be real if we take into account the interpretive scientific instruments that give access to them(cf. Verbeek, 2005, pp. 139-143). Finally, visual hermeneutics is related to instrumental realism in the sense that many scientific instruments produce images based on interpretations of various entities in the world (e.g. a foetus, bones, cells, microchips, stars)(cf. Ihde, 1998, pp. 151-183).

So why do I not want to use these concepts for an elaborate analysis of augmented reality? I have two main reasons for this. First, because the concepts cannot be used to understand the hermeneutic implications of all four examples - e.g. Word Lens, Google Glass Directions, WatchMeTalk, and Memento. Even though pluriculturality and macroperception may apply to Word Lens, as it brings us into contact with other languages from other cultures, or to Google Glass Directions, as it teaches us a different cultural way of looking at our environment(cf. van der Harg, 2011), and visual hermeneutics may apply to WatchMeTalk as it translates auditory speech into visual text(cf. Ihde, 1998, pp. 187-189), an application such as Memento, which translates the visual into the auditory, does not seem to fit any of these concepts. In other words, even if I would use all these concepts, and apply the appropriate concept(s) on a case-to-case basis, these concepts would still not cover every example. Second and more profound, even though these concepts may offer some general insights in the hermeneutic role of some of these augmented reality applications, they do not really address how and why specific computer-generated augmentations alter my specific interpretation of reality at a specific place and time. Near the end of his *Expanding hermeneutics* Don Ihde provides two clues why this may be the case for his scientific hermeneutic framework, and possibly his cultural hermeneutic framework as well. On the one hand, he acknowledges that computers, through their modelling capabilities, play an interesting philosophical role as "hermeneutic devices"(Ihde, 1998, p. 181). On the other hand, he writes: "For the purposes here, however, they [i.e. computers] will remain simply part of the 'black boxes' which produce images which mediate perceptions"(cf. Ihde, 1998, p. 182). In Floridi's terms, we could thus say that Ihde has adopted a higher level of abstraction for his study, than the one I pursue in this thesis(cf. Floridi, 2008). With this final observation in mind, let's now turn to augmented postphenomenology, and discuss three examples once more.

4.2.2 Augmented postphenomenology and hermeneutics

I will start this augmented postphenomenological inquiry with the World Lens application (Figure 4-3).

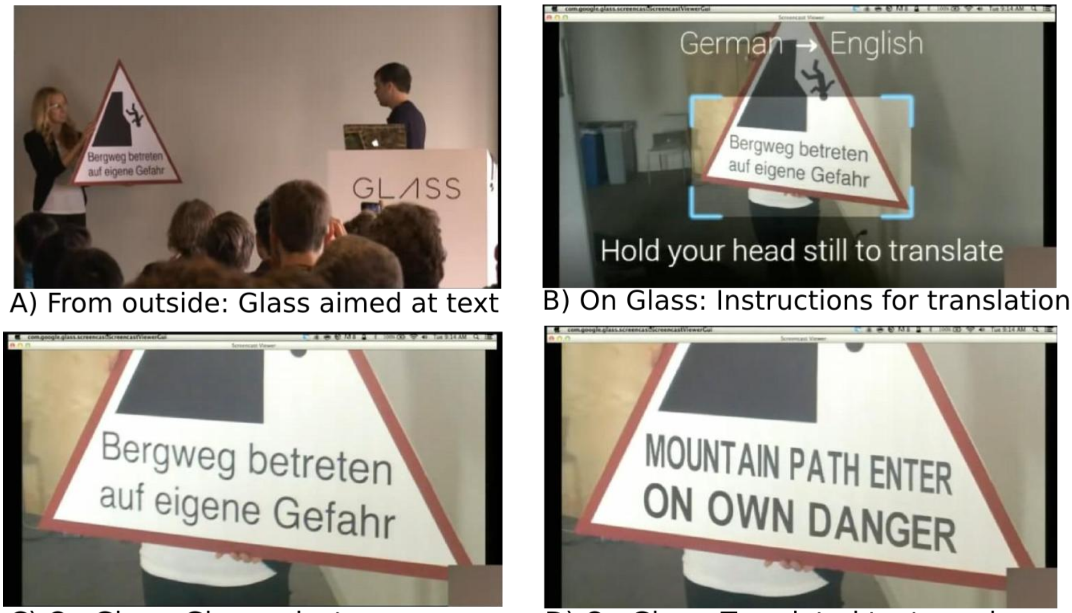

Figure 4-3 - Google Glass Word Lens application. Picture A shows the situation from an outside perspective with the Glass user on the right and the text to-be-translated on the left. Picture B shows the instructions on the user's Google Glass display. Picture C shows the visual scene selected by the Word Lens application. Picture D shows how Glass displays the translated text over the original sign, while someone not wearing Glass would still see the original text on pictures A to C. All pictures are derived from Jordan (2013 t. 4:50-4:55).

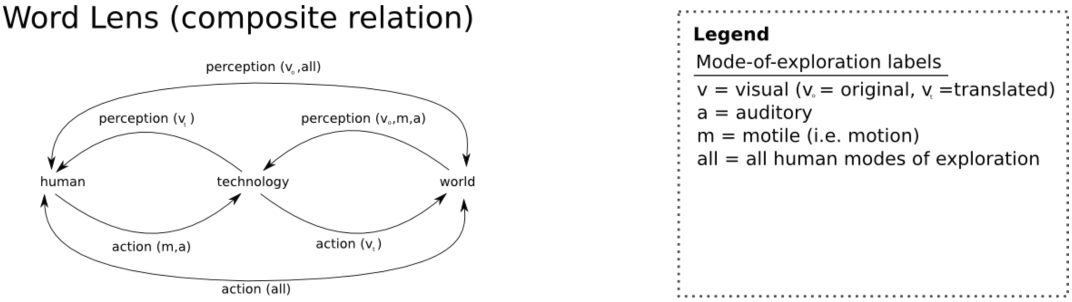

Figure 4-4 - Augmented postphenomenological analysis of Word Lens.

Additionally, Figure 4-4 shows a quick summary of the World Lens application in terms of a composite relation. Basically, users of Word Lens have a text in front of them they do not understand. This situation is shown in Figure 4-3A, and described in augmented postphenomenological terms by perception (v_o,all) in Figure 4-4. Here v_o refers to seeing the original text, while 'all' refers to all other human modes of exploration by which we perceive the world (e.g. hearing, touching, smelling etc.). Users then tap and swipe the touchpad, or use the voice command "Ok Glass, translate this," to start Word Lens – action (m,a), in Figure 4-4. Word Lens starts – perception (m,a), shown as perception (m,a,v_o) in Figure 4-4. It then asks the user to move his head and body in such a way that the rectangle displayed on the screen surrounds the text the user does not understand - more action (m), shown as (action (m,a) in Figure 4-4, also see Figure 4-3B. If we follow Andrew Ng's analysis of how optical character recognition (OCR) applied to photos works,[78] then the user has already helped Word Lens to perform its first phenomenological and hermeneutic step: locating where the characters in the image provided by the Google Glass camera are to be found. In phenomenological terms, we say that Word Lens brings these characters into focus, and presents this to the user as well (see Figure 4-3C). In turn, Word Lens then scans that particular area using one or more so-called sliding windows to determine the exact locations of characters. A sliding window is a square or rectangular area with a particular size that Word Lens first locates in the upper left-corner and then moves along the image until the bottom right corner has been reached, thereby asking for each incremental movement of the sliding window, say, by four pixels, whether the sliding window contains a character or not, using a classification algorithm with two classes (i.e. y=0 for no character, y=1 for window with character). In the next step, Word Lens segments the individual characters of the word, by placing lines between the individual characters, and then starts the actual character recognition task (i.e. which character is this?). In the final step, Word Lens likely uses a language model to correct small recognition mistakes (e.g. mistaking an l for an I), and performs the actual translation. In turn, Word Lens visually presents that translation to the user, who then reads it, and possibly compares it to the original text through the human-world relation - shown as action (v_t) in Figure 4-4, where v_t denotes that Word Lens visually presents the translated text. Finally, there is another way in which users have the ability to shape the Word Lens interpretation. Next to their involvement in showing Word Lens where to find the to-be-translated characters, users also choose the language in which they want to translate the text. They do so by tapping the touchpad while Word Lens is running. So what does this example teach us about the hermeneutic capabilities of augmented postphenomenology? Basically that augmented postphenomenology shows *that* Word Lens constructs an alternative interpretation of reality, and also indicates *how* Word Lens constructs that interpretation. Unfortunately, augmented postphenomenology, at least up to this point, does not clarify *how* and *why* that alternative interpretation may change *our own* interpretation of reality. So this is a first concrete point on which I will improve augmented postphenomenology in the next section (4.3).

Let's now turn to Google Glass Directions. Figure 4-5 shows a quick augmented postphenomenological analysis of this application.

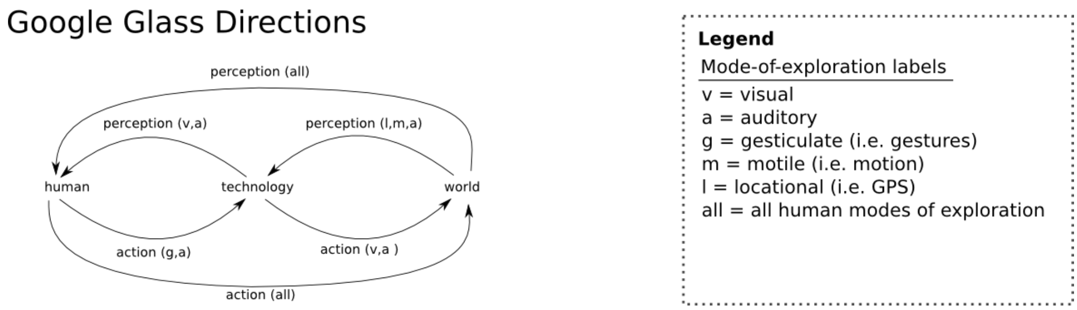

Figure 4-5 - Augmented postphenomenological analysis of Google Glass Directions.

[78] Andrew Ng is a professor at Stanford University, and well-known for his popular machine learning course on Coursera. I too gained a much better understanding of machine learning by following parts of this course. Near the end of that course he discusses OCR in photos(Lecture XVIII, Application Example: Photo OCR), and that is what I refer to here. You can find the course on Coursera: *Machine Learning | Coursera*, https://www.coursera.org/course/ml , visited: August 9, 2014 [free account and subscription required]

Basically, Google Glass Directions allows the user to find his or her way from A to B. The user starts the application by swiping and tapping the touchpad, or by speaking the voice command "Ok Glass, get directions to" followed by speaking the destination the user wants to reach (action (g,a)). Google Glass perceives these commands, retrieves my current location using GPS (perception (l,m,a)), and calculates the shortest route to the user's destination.[79] In turn, Google Glass presents the user with a map and travelling instructions (see Figure 4-6), accompanied by regular auditory cues(action (v,a)), to guide the user to his or her destination(perception (v,a)).

Figure 4-6 - Google Glass Directions interface. Picture used from Google (2014c).

As Figure 4-6 shows, the Google Glass Directions application shows the user his or her environment from a bird's-eye view, and offers information that the user does not immediately obtain through the human-world relation (e.g. a clearly indicated route, the time it takes to reach Belvedere Lane, and the distance towards it). In this case, Google Glass Directions thus provides the user with a presentation of his or her environment that stimulates perceptual learning (see 3.3.1). That is, through the alternative presentation of the user's environment provided by Google Glass Directions, the user learns to interpret his or her environment differently. For example, by noticing that the street some 300 metres down the road is Belvedere Lane. While the user learns in advance that the other two streets before that will turn out to be dead-ends. Nonetheless, the question *why* exactly I would adopt this alternative interpretation provided by Google Glass remains unanswered.

Finally, I want to discuss a few more philosophical points using the WatchMeTalk example, before we move on to the next section (see Figure 4-7).

[79] The attentive reader may notice that I skip a more detailed discussion of how exactly Google finds the shortest route from A to B here. This is mainly because Google has not been open about the algorithm they use to find the shortest route. They only offer a web-based Directions API that takes the starting point, possible points along the route the user wants to visit, the end point, and the type of transport you plan to use, as input, and delivers a description of the recommended route as output(Google, 2014j).

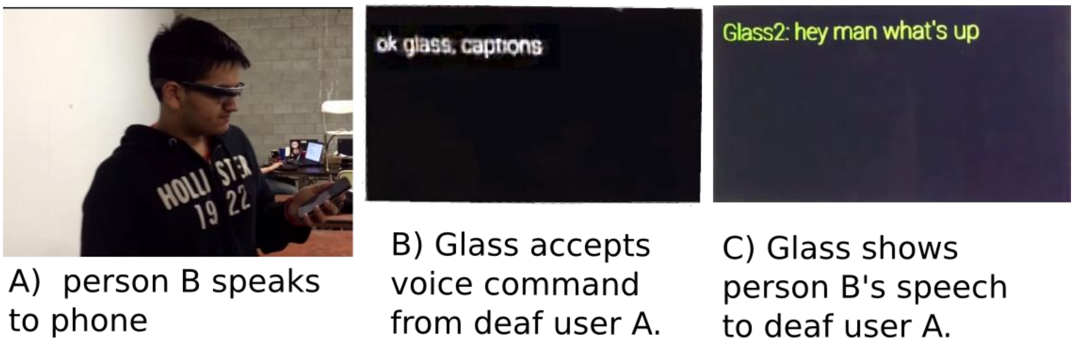

Figure 4-7 - The WatchMeTalk application. A person speaks a message into a smartphone that transcribes the speech (Picture A), and sends the transcribed message to Google Glass. Next, The deaf Google Glass user starts the WatchMeTalk application using the voice command 'OK Glass, start captioning'(Picture B, shown on the screen as: OK glass, captions). Finally, WatchMeTalk shows the transcription(Picture C). All pictures used from Rioja (2014)

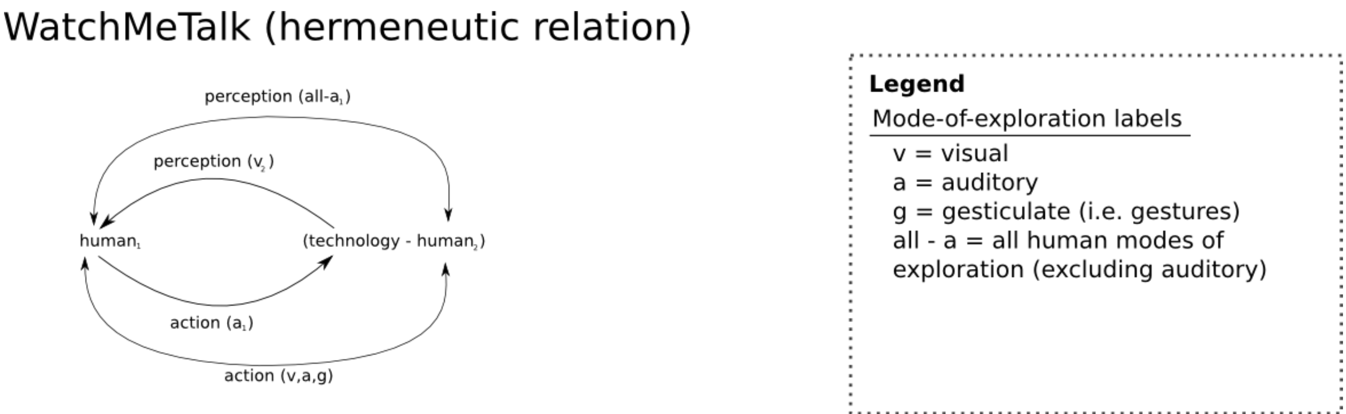

Figure 4-8 - Augmented postphenomenological analysis of WatchMeTalk

Figure 4-8 summarises the augmented postphenomenological analysis of WatchMeTalk. As you may notice Figure 4-8 has a few peculiar features that require some explanation. I used a hermeneutic relation to analyse WatchMeTalk, rather than a composite relation, I replaced world with human$_2$, and changed the arrows for the human relationship into two-way arrows. The main rationale behind the first change is that WatchMeTalk represents only a single aspect of the other person (human$_2$), namely, that person's speech. The rationale behind the second change is that WatchMeTalk mediates a face-to-face contact between two people, and when two people sincerely talk to one another, then their surroundings (i.e. the world) tend to be less important. Furthermore, and related to the third change, a good conversation is not a monologue, and when two people talk they both act and perceive each other visually (i.e. they look at one another), aurally (i.e. they speak and listen), and gesturally (i.e. they use non-verbal gestures). Moreover, I also use these two-way arrows to denote the typical phenomenological idea that we only get to know ourselves in relation to others, and to the world (cf. Zahavi, 2001, p. 166).

Apart from these remarks on notation, what can we say about the actual human relationship being mediated by Google Glass? When a male Google Glass user with a hearing disability wants to understand what a female says (perception (all-a_1)), he asks her to activate the WatchMeTalk app on her smartphone, and on his own Glass device starts the WatchMeTalk application by speaking the "OK Glass, start captioning"[80]

[80] See Rioja (2014)

voice command(action (a_1)). In turn, Google Glass displays the transcribed speech to the Google Glass user (perception (v_2)).What can we say then about the hermeneutic aspects of WatchMeTalk? I have already discussed speech recognition in section 3.2.2, and Merleau-Ponty's remarks (section 3.3.1) could be used to analyse the non-verbal aspects of the hearing-impaired user's communication with the hearing person. However, what is most interesting about WatchMeTalk in the description above is that two hermeneutic processes likely influence each other. For whenever person A listens to person B, he visually focuses on the transcription appearing on the Google Glass screen, and thereby does not notice the non-verbal gestures of person B while she speaks. He only notices her non-verbal gestures, when he speaks, and she listens. In contrast, person B does not necessarily have to focus on her smartphone, as it could be configured for hands-free calling, and thereby she is able to notice all person A's non-verbal gestures, including that person A does not make eye contact while she speaks. This type of argument does not always apply, though. For the Australian ICT company Telstra has developed a similar transcription application for Google Glass that differs in one relevant aspect. Rather than displaying the transcribed speech on a black background, the Telstra application displays the speech in overlay balloons above a person's head, and thereby makes it possible for person A to see person B's non-verbal gestures (cf. Figure 4-7c & Figure 4-9).

Figure 4-9 - The Telstra transcription application. The man on the left has a hearing disability, and sees the transcribed speech of the woman in the middle, in the balloon floating on the left of her head. Picture used from (Hall, 2014, t. 2:19).

Even though Figure 4-9 comes from a promotional video, and could thus be a mock-up, albeit a technically feasible one as Word Lens uses a similar technique, the phenomenological difference between these two approaches remains interesting nonetheless. Furthermore, these two transcription applications also highlight a second smaller challenge for augmented postphenomenology: to capture the dynamics of the various hermeneutic processes that occur when users start to use augmented reality applications that directly mediate human relationships.

To conclude, the main challenge is thus to understand *why* different interpretations come about through Google Glass, in comparison to the interpretation I hold of the world through the human-world relationship, or of another person through a human relationship. Additionally, it is important to gain a better understanding of how and why various interpretations do or do not influence one another. The hermeneutic circle discussed in section 3.3 already gave us a clue, but the time has now come to develop a better understanding of this concept and several other concepts used by the German hermeneutic philosopher Hans-Georg Gadamer.

4.3 A Gadamerian take on augmented reality

The German hermeneutic philosopher Hans-Georg Gadamer offers five concepts in his magnum opus *Truth and Method*, that I will use here to further develop the way in which augmented postphenomenology provides insight in the hermeneutic processes of Google Glass augmented reality applications. In short, these five concepts are the hermeneutic circle, prejudice, authority, horizon, and 'fusion of horizons.' Originally, Gadamer used these, and several other concepts, to clarify how we interpret historical texts. Here I will re-interpret these concepts to clarify how augmented reality applications shape our interpretations of the world. Let's now go through these concepts one by one, explore how they resolve the challenges discussed in the previous section (4.2.2), and finally how they reframe the discussions found there.

4.3.1 The hermeneutic circle

For Gadamer "understanding begins (…) when something addresses us."(Gadamer, 1960/2004, p. 310). In other words, a particular situation captures our attention. For example, someone starts talking to us, or we encounter a sign with words we do not understand. Here the interpretive process begins, and the hermeneutic circle starts to do its work. We already encountered this hermeneutic circle in section 3.3, where I used it to describe the mutual relationship between action and perception when using a technology. Now it is time to see how Gadamer defines this concept, and explore which role it plays in augmented postphenomenology. Gadamer introduces the hermeneutic circle as the first concept of his theory of hermeneutics, while the concept was originally introduced by Martin Heidegger. Gadamer describes the start of the interpretive process as follows:

> "A person who is trying to understand a text is always projecting. He projects a meaning for the text as a whole as soon as some initial meaning emerges in the text. Again, this initial meaning emerges only because he is reading the text with particular expectations in regard to a certain meaning. Working out this fore-projection, which is constantly revised in terms of what emerges as he penetrates into the meaning, is understanding what is there."(Gadamer, 1960/2004, p. 279).

And as the process continues, he writes:

> "The process that Heidegger describes is that every revision of the fore-projection is capable of projecting before itself a new projection of meaning; rival projects can emerge side by side until it becomes clearer what the unity of meaning is; interpretation begins with fore-conceptions that are replaced by more suitable ones. This constant process of new projection constitutes the movement of understanding and interpretation"(p. 280).

In other words, as we start to explore the unfamiliar words on the sign, or the situation that captured our attention, all sorts of meanings start to enter our thinking. For example, one of the words on the sign looks a lot like a French word I do know, or the shouts that captured my attention sound like angry shouts. But as I continue to explore the situation and the sign, new and possibly rival meanings pop up. For example, 'or are those people just fanatically supporting someone?' 'The symbols on that sign do seem to support the similarity with that French word.' And so this circular process, which Gadamer describes metaphorically by the hermeneutic circle, continues until we have ascribed a coherent and satisfactory meaning to the situation, and to the sign(cf. , p. 302).

So what does this hermeneutic circle have to do with Google Glass augmented reality applications? Let's reconsider the Word Lens example (recall Figure 4-3 in section 4.2.2). If we look closely at the composite relation, we discover that there are actually three hermeneutic circles at work (see Figure 4-10).

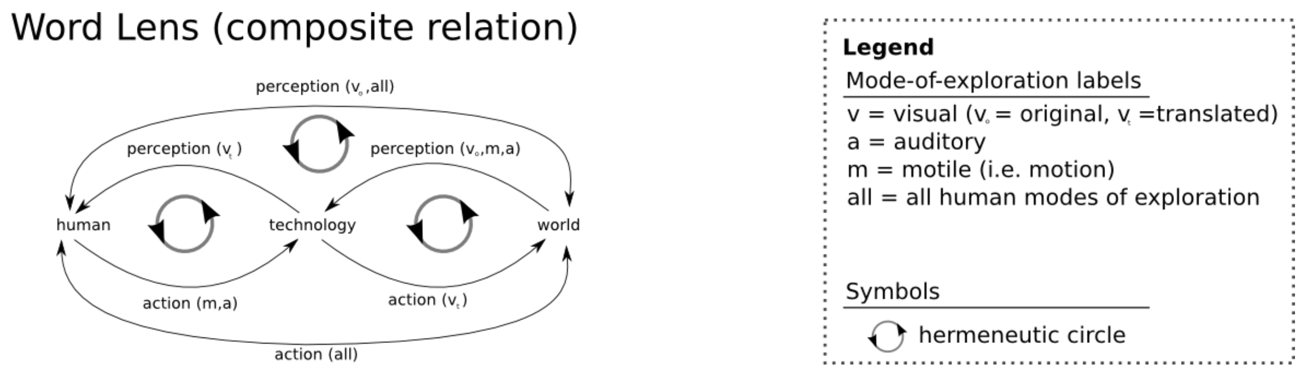

Figure 4-10 - Augmented postphenomenological analysis of Word Lens that includes three hermeneutic circles.

First, there is the hermeneutic circle for the human-world relation (upper middle circle in Figure 4-10). Let's call this the HW circle[81]. Through this hermeneutic circle my first puzzlement arose about the sign with words in an unfamiliar language, and through this interpretive process, metaphorically described by this hermeneutic circle, I decided to continue my exploration of these unfamiliar words through Word Lens.

Second, my head wake-up gesture, followed by an 'Ok Glass, translate this' voice command, give rise to a second hermeneutic circle; namely, the hermeneutic circle between Google Glass and the world (middle-right in Figure 4-10). Let's call this the technology-world circle (TW circle). Here Google Glass 'interprets' my head motion as a sign that it should activate the screen. In turn, Glass interprets my voice command as a cue to start Word Lens. This hermeneutic process thus includes multiple modes of exploration (i.e. auditory, motile, and later visual). This contrasts with the way Gadamer applies the hermeneutic circle, as he solely focuses on the interpretation of texts, and thereby restricts himself to the visual mode of exploration.

Third, the activated screen, the voice command menu appearing on that screen, and later Word Lens appearing on that same screen, all indicate the presence of a third hermeneutic circle working here; namely, the hermeneutic circle between the user and the technology which we already encountered in section 3.3 (middle-left in

[81] I have deliberately removed 'hermeneutic,' in order to prevent the creation of verbose terminology. Whenever it is important to emphasise hermeneutics as such, I will speak about hermeneutic circles, or hermeneutic processes.

Figure 4-10). Let's call this the HT circle. Through this circle we act *in order to* perceive (e.g. I move my head upwards (act), and see the screen light up (perceive)), and we perceive *in order to* act (e.g. I notice the lit up screen (perceive), and say 'Ok Glass, translate this' (act)). Even though most interpretive processes in this hermeneutic circle will be fairly short and straightforward, as Google Glass has been designed for short interactions(cf. Google, 2013d), it is still good to include this hermeneutic circle, as it presents the alternative interpretation by Google Glass of a thing or person, to the user. Let's now see how we can further explore these three hermeneutic processes described by these three hermeneutic circles.

4.3.2 Prejudice

The two block quotes above mentioned terms such as "fore-projection" and "fore-conceptions", and thereby indicated that when we read a text, we always bring along certain ideas and expectations about its meaning. In turn, these ideas and expectations shape our initial understanding of the text. Gadamer's second concept puts a name on these initial expectations and ideas: prejudice. Note that Gadamer does not mean to say that these initial prejudices are wrong or bad in any way(cf. 1960/2004, pp. 281-283). Such a contemporary understanding would be based on the negative conception of prejudice that developed during the Enlightenment(pp. 283-289). Rather, Gadamer defines a prejudice as "a judgement that is rendered before all the elements that determine a situation have been finally examined"(p. 283). For example, "in German legal terminology a 'prejudice' is a provisional legal verdict before the final verdict is reached"(ibid). Furthermore, it is "not necessarily (...) a false judgement, but part of the idea is it can have either a positive or negative value"(ibid). Finally, when we apply this concept to the interpretation of texts, then we find that it is important to maintain an open attitude towards the text, and "be aware of one's own bias, so that the text can present itself in all its otherness and thus assert its own truth against one's own fore-meanings"(pp. 281-282). This does not mean that a certain status quo arises, with me having my own prejudices, and the text having its own *other* set of meanings. But rather this open attitude towards the text involves "our situating the other meaning in relation to the whole of our own meanings or ourselves in relation to it"(p. 281). In other words, we try to bridge the gap between our own understanding of the text, which is grounded in our prejudices, by relating the ideas we find in the text to our own ideas, and in that way our own prejudices and ideas may change, as the hermeneutic circle above described. I will say more on this when we discuss fusion of horizons, but let's first explore the role of prejudices in augmented postphenomenology.

In the human-world relationship prejudices largely follow what Gadamer said about them above, with the one difference that they again apply to every mode of exploration. For example, we may have prejudices about the reasons why the people around the corner are being noisy, or the blind man may have guessed which object his cane is touching. For the TW circle, we can speak about prejudices in two senses. First, in the case of a supervised machine learning algorithm, it develops its very first prejudices during the training stage. In that stage the algorithm initially starts with all-zero values or a set of random values for its coefficients (depending on the type of algorithm). To make this intuitive, imagine a continent with no borders at all (i.e. zero values), or random borders (not necessarily correct), and given a position (x, y) the algorithm has to say in which country (z) I am. To train the algorithm, I give it a list of positions and tell it to which country those positions belong to - so the training dataset contains a list of correct (x,y,z) combinations. Based on this training set the algorithm changes its coefficients so that it draws borders that give an increasingly better approximation of the correct borders. Here two problems could arise: if we try to fit the borders with functions that do not fit the borders described by the training set (e.g. straight lines, while the training set borders are curve like), then the algorithm is said be underfitted and to have a high bias. In Gadamer's terms this would be someone that does not have an open attitude towards any text, and clings to his own prejudices. In contrast, if we try to develop functions that describe the borders in such a way that they exactly fit all samples in the training set (e.g. higher order polynomials), and because of that exactness the algorithm is not able to classify a new sample outside the training set correctly (without a given z), then the algorithm is said to be overfitted, and has a high variance. In Gadamer's terms this would be someone who endorses all prejudices from one text, and clings to them, but refuses to maintain an open attitude towards other texts. Usually software engineers develop machine learning algorithms in such a way that they classify most input well, and their algorithms could thus be said to hold reasonable prejudices.

Second, the inputs to a trained artificial neural-network (see 3.2.2), could also be seen as prejudices that change as they pass through the artificial neural network (i.e. the network interprets them).[82] Geoffrey Hinton describes this aptly in his Coursera course on artificial neural networks, when he briefly discusses speech recognition:

> "These [deep neural, BvdH] networks compute a series of transformations between their input and their output. So at each layer, you get a new representation of the input in which things that were similar in the previous layer may have become less similar, or things that were dissimilar in the previous layer may have become more similar. So in speech recognition, for example, we'd like the same thing said by different speakers to become more similar, and different things said by the same speaker to be less similar as we go up through the layers of the network."(Hinton, 2012, lecture 2.1 types of neural network architectures)

Another example of this latter type of prejudice occurs when Word Lens tries to locate the exact locations of characters in the image provided by the Google Glass camera (see 4.2.2). Because in its first classification step Word Lens develops a black-and-white map, on which white areas indicate the presence of characters, and black areas contain no characters. Finally, this latter prejudice in Word Lens also manifests itself at the user-interface level (i.e. the HT circle). For Word Lens shows a blue border around the area that contains the characters, while it darkens the surroundings that contain no characters (see Figure 4-3B). Let's now explore why people would adopt these prejudices offered by Google Glass, through Gadamer's concept of authority.

4.3.3 Authority

Rather than relating authority directly to power as some Enlightenment thinkers did(cf. Gadamer, 1960/2004, p. 291), Gadamer approaches the concept of authority epistemologically. He writes: "Indeed, authority has not to do with obedience, but

[82] I also characterise these inputs as prejudices as they fairly literally follow from Gadamer's definition: "a judgement rendered *before all elelements that determine a situation have been finally examined*"(emph. mine).

rather with knowledge. It is true that authority implies the capacity to command and be obeyed. But this proceeds only *from* the authority that a person has"(Gadamer, 1960/2004, pp. 291-292, emph. mine). In other words, power is a consequence of authority, rather than its condition of possibility. How then do you gain authority in Gadamer's sense? He provides a clue when he defines authority:

> "Admittedly, it is primarily persons that have authority; but the authority of persons is ultimately based not on the subjection and abdication of reason but on an act of acknowledgement and knowledge - the knowledge, namely, that the other is superior to oneself in judgement and insight and that for this reason his judgement takes precedence (...). This is connected with the fact that authority cannot actually be bestowed, but is earned, and must be earned if someone is to lay claim to it."(p. 291)

In other words, you earn authority by having "superior" judgement and insights. But what kinds of judgements and insight make your judgement and insights superior to those of someone else? Or more to the point, but in disagreement with the above quote (as Gadamer primarily attributes authority to people): What makes a Google Glass augmented reality software interpretation of reality superior to my own interpretation? The following quote provides one part of the story, in my view:

> "Thus acknowledging authority is always connected with the idea that what the authority says is not irrational and arbitrary but can, in principle, be discovered to be true. This is the essence of the authority claimed by the teacher, the superior, the expert."(p. 292)

Indeed, if I have some knowledge of a similar foreign language, I could verify whether the translation provided by Word Lens is correct, or I could compare it to the symbols on the sign. Additionally, I could observe how a person responds to my reply that I based on the transcription provided by WatchMeTalk, and in that way verify whether I, and WatchMeTalk as well, have interpreted the words of the other person correctly. In short, the human-world relationship, or a human relationship, allows me to discover the truthfulness of the prejudices Google Glass presents to me... in principle. However, as I argued in section 4.1.3, at least *two* conditions need to be fulfilled for a piece of software to be called augmented reality software in the hermeneutic/epistemological sense. The above criterion suggested by Gadamer only fulfils the second condition. Namely, that the interpretation provided by the augmented reality software differs considerably from the interpretation the user would otherwise have had through the human-world relationship, so that the user obtains new knowledge about him- or herself, the actual world, or another person through the alternative interpretation presented by the computer system. Unfortunately, it fails to meet the first (material) condition: a computer system algorithmically interprets the actual world in near real time based on data gathered through one or more sensors. So here we need to find an additional criterion in order to speak about the authority of augmented reality software interpretations. Therefore we will now turn to Alva Noë's discussion on models, as at one point in his discussion he too investigates the authority of a material object. I will first explain his take on models, and then show how Noë's discussion relates to the authority of augmented reality software interpretations.

Basically, Noë argues that models act as stand-ins, proxies, substitutes, and representatives of the world (Noë, 2012, pp. 97-99). He uses models in a broad sense here to denote lab animals, architectural models, human fashion models, mathematical models, and improvised models that make use of salt shakers, pepper mills, and knives to indicate the route from A to B(pp. 98-99). What all these models have in common is the following:

> "Models are tools for thinking about or investigating or perceiving something other than the model itself. We explore the model in the service of exploring something else. And so we are able to explore something remote and difficult by studying the model."(p. 99)

He then asks how we perform such investigative activities exactly. As a first step he argues that these models may indeed have similar "psychological (visual, kinaesthetic, emotional) effects on us" when compared to actual buildings, routes, and people wearing fashionable cloths. However, these psychological effects are *consequences* of these models being good models, rather than *constituting* them as good models (p. 99). He then leverages this point against a representationalist account of models:

> "The point is, the [architectural] model is not itself the effect of a building - as it were a reflection of or a projection from it. The model is not, in this sense, a representation of the building of which it is the model. Rather - and this is critical - the model is a substitute, or proxy, or stand-in, for the building. It is not a representation of it; it is, rather, its representative"(p. 99)

Having clarified this point, Noë then raises a question that brings us back to authority: "Our question then, the fruitful question, becomes this: what *licenses* or *authorises* a construction out of balsa wood or cardboard(...), to perform the role of serving as a representative or stand-in for a possible or actual building?"(pp. 100, emph. mine). He answers this question by arguing for two "factors" that authorise a thing "to serve as a model" (ibid). First, the *purpose* for which we use one thing to stand-in for another(ibid). For a model can only be a *good* model "relative to this or that purpose"(ibid). Second, the *material properties* of the things we use to stand in for other things, and the abilities of these stand-in objects to "mirror the relations of that which they model"(pp. 100-101). These two factors are not independent factors. For example, my USB keyboard could serve well as a stand-in to explain how a bridge opens and closes due to its rectangular shape and its mobility, but it would not work well to explain the aerodynamics of a parachute due to its weight and unchangeable shape. Nonetheless, Noë argues that in the end people decide whether something serves as a model for a specific purpose, and that the material properties in no way *determine* whether a specific thing serves as a substitute for another, even though we may *understandably prefer* one thing over another to serve as a model for a specific purpose due to its material properties(p. 101). Finally, a third factor that may influence whether a model is a good model, are the skills and knowledge we require to understand and use a model effectively(cf. Noë, 2012, pp. 102-106). Noë does not acknowledge this third factor as a condition for the authority of models, even though he does elaborately discuss this factor. For example, in order to use Google Glass Directions I need to be able to read and understand maps, and I need to understand how to use the application. For someone not familiar with Google Glass, or map reading, the model Google Glass Directions provides for navigational purposes, may simply not open up to that person, and thereby lose its authority.[83] This criterion works in two ways, though. It is not just about the skills and understanding I have, but just as well about the way a particular technological design meets my skills and understanding (pp. 103-104). For example, if we take photos to be models as well, which Noë does, then the only skills and understanding we need are our abilities "to see and think in normal ways"(p. 104).

In my view, these points also apply to augmented reality software interpretations, and shed new light on their authority. For such interpretations too function as models. But what makes these augmented reality models unique is that what they attempt to substitute is always "perceptually present" in one way or another (cf. , p. 22). For example, the relevant street Google Glass Directions shows is right there in front of me, the scene Memento describes audibly is visually and haptically present in front of me, the person whose speech WatchMeTalk transcribes is right there in front of me, and finally, the text Word Lens translates is right there in front of me. So here indeed Gadamer's epistemological criterion that what the authority says can in principle be "discovered to be true" again shows up. But as Noë argued, there are two more criteria that authorise these augmented reality models to act as good substitutes. First, that they are only good augmented reality models relative to a specific purpose.[84] That is, Google Glass Directions serves as a very good model to navigate from A to B, but does not serve as a good model to learn how to wash a car on the spot. For that latter purpose of washing a car, Google Glass Directions thus has no authority as an augmented reality model. Second, Google Glass Directions serves as a good model for navigation, because it provides several structural features that help me to navigate the world, which are not directly available through the human-world relation. See Figure 4-11 for an overview of these features.

Figure 4-11 - Google Glass Directions interface. Picture used from Google (2014c).

More specifically and most basically, Google Glass Directions provides me with a route from my current position to my destination (virtual blue line), it shows me my orientation towards that route (virtual arrow pointing in the direction of my

[83] This point also coincides with the point I made earlier, when I argued that augmented reality software always augments reality relative to particular user groups (see 4.1.3).

[84] At this point it might be objected that this could easily lead to an instrumental conception of technology (i.e. the view that a technology itself is neutral, and merely a means to an end). If I would solely focus on the purpose of these augmented reality models, that would indeed be the case. However, as I will show in the remaining part of this section on authority, the structural features of the virtual entities Google Glass makes available also play a large role in the authority of augmented reality software for Google Glass.

orientation towards the world), and it shows me the streets surrounding my route from a bird's-eye view (virtual grey thick lines surrounding the blue line). Such structural features all help me to see whether I am still travelling in the right direction, or whether I am wandering off from the route. Furthermore, another important structural feature of this augmented reality model is that its algorithms, based on the data they gathered through GPS and the motion sensors, regularly change the model so that it maintains its authority. To illustrate, say that the Google Glass screen would keep displaying Figure 4-11 continuously, even though I have already passed Belvedere Lane long ago. In that case, what Google Glass displays violates Gadamer's criterion for authority in the sense that the prejudices Google Glass Directions displays on the screen turn out to be wrong about my current environment. Moreover, these wrong prejudices could also go all the way down to the hardware level, where Google Glass lost its connection with the GPS sensor in my phone. Additionally, Google Glass Directions also stops meeting my purpose to navigate to a place far beyond Belvedere Lane.

In summary, I have argued that there are thus four criteria that influence the authority of Google Glass augmented reality software. First, the *verifiability* through the human-world relation of the visual and auditory prejudices that Google Glass makes available to its user. Second, the degree to which augmented reality software meets the *purpose* for which I intend to use it. Third and related to the second criterion, the degree to which the s*tructural features* of the virtual entities Google Glass augmented reality software provides, help me to gain a better understanding of, or purposefully explore, my environment. Fourth and finally, the degree to which I skilfully understand the alternative interpretation of the world provided by the augmented reality software, and thereby the degree to which this software meets my *skills and knowledge*.

Let's now explore how we actually integrate the prejudices provided by authoritative Google Glass augmented reality software, by discussing Gadamer's last two concepts: horizon and fusion of horizons.

4.3.4 Horizon & fusion of horizons

At the start of my discussion on prejudices I mentioned that we always bring along certain ideas and expectations about the meaning of a text (section 4.3.2). We called such ideas and expectations prejudices. I also briefly described how a tension can arise when a historical text is written from one of set of prejudices, while I hold another set of prejudices(cf. Gadamer, 1960/2004, p. 317). However, in that discussion we did not discover how to relieve this tension. The time has now come to discuss this matter by means of Gadamer's two concepts: 'horizon,' and 'fusion of horizons.' As especially the latter concept belongs to the more controversial and often misunderstood parts of Gadamer's hermeneutic theory, I will here rely on David Vessey's (2009) explanation of both concepts, and where necessary quote from Gadamer's original text.

Basically, Vessey starts his discussion by explaining that 'horizon' can be understood in two different ways. First, we have what Vessey calls the "everyday" meaning of horizon, where horizon indicates the *limit* between earth and sky, that I cannot see beyond from a particular point of view(cf. Oxford University Press, 2014b;

Vessey, 2009, pp. 532-533). Second, there is the phenomenological concept of horizon that Vessey explains in a slightly different way than we encountered it in section 3.3.2. He refers to this meaning of horizon as the "technical meaning." He writes:

> "Specifically, a horizon as a limit is downplayed in the technical meaning in favour of a a horizon as that which expands, that which we can see beyond with a little effort, and that which points toward something more. Although a horizon marks the limit of sight at any moment, it is not an insurmountable limit. Simply walking a short distance or going to the top floor of a building can help us see beyond our previous horizon. In fact, most of us know quite well what lies beyond the horizon simply from past experience."(Vessey, 2009, p. 533)

In other words, a horizon in the technical phenomenological meaning is not a fixed limit that cannot be overcome. Rather, by movement we overcome previous visual horizons. Moreover, as we saw in section 3.3.2, when I discussed the auditory horizon in terms of the unsaid (i.e. the implicit assumptions we make in conversations about the knowledge of our conversation partner), we overcome previous auditory horizons of the unsaid by speaking explicitly about those assumptions. Gadamer uses the concept horizon in its technical phenomenological meaning, and thus does not speak about horizons as limits, but rather as horizons that expand. Before we can fully grasp his account of horizons and 'fusion of horizons,' though, we need to make one more distinction. That is, the distinction between internal and external horizons. Vessey, following Husserl, defines internal horizons as "horizons that arise from the nature of the object either as an object, such as taking up space, or as the kind of object that it is"(p. 534). For example, when I see the back of a hand, the internal horizon of that hand suggests I will find fingernails on the fingers on the other side of that hand.[85] In other words, even though this internal horizon demarcates the hand from a particular perspective, it also points beyond that perspective towards the other side of the hand with the nails (cf. , pp. 534-535). In contrast, Vessey defines external horizons as "horizons established by the relation between the object and its surroundings"(p. 534). Surroundings should here be interpreted in a very broad sense. Vessey writes: "All relations get their character from the external horizon, including the relation of belonging to one spatio-temporal whole with everything else"(p. 535). For example, the monitor in front of me is demarcated by its internal horizon, but when I shift my focus to the external horizon, this external horizon could stretch as far as the whole world, or to my student room, depending on how far I want to see beyond the internal horizon of the monitor(also cf. Kwan, 2004, p. 311). Now that we have discussed this distinction, let's see how they help us to grasp Gadamer's two concepts 'horizon' and 'fusion of horizons.'

Vessey explains that Gadamer's first move is to apply these concepts to language. He writes:

> "Gadamer preserves those essential elements of Husserl's account, but transforms them in a simple, but significant, way: he applies Husserl's account of horizon to propositions. He writes, 'every proposition has its horizon of meaning in that it originates in a question situation.' Where Husserl spoke of horizons as making our perception of objects meaningful,

[85] Granted, Alva Noë would say that this does not have to do with the internal horizon of the object 'hand', but rather with our implicit sensorimotor knowledge about hands, that the hand's fingers have fingernails on the other side(cf. Noë, 2012, pp. 18-20). In other words, whereas Noë ascribes such present-as-absent features to the human side of the human-world relation, there Husserl ascribes these to world side of this relation. For the sake of grasping Vessey's argument, though, I will draw on Husserl's account in this section.

> Gadamer speaks of horizons as making propositions meaningful. His focus is linguistic rather than perceptual and thus is intimately connected with dialogue."(Vessey, 2009, p. 536)

When we apply these concepts to understanding a sentence, a 'horizon' is "the set of beliefs that make it possible to understand the sentence"(p. 536). Vessey then relates this 'set of beliefs' to Husserl's two horizons, to specify this single set of beliefs further. He argues that "Husserl's internal horizon" parallels "having background knowledge of the subject matter," while "Husserl's external horizon" parallels "having background knowledge of the context of the sentence"(p. 536).[86] For example, when I read in the Bible that the apostle Paul was suddenly released from his chains when he told the soldiers that the was a Roman citizen (Acts 22:25-29), then it does not only help to know what an apostle is, who Paul is, and what chains are (i.e. background knowledge on the subject matter), but it also helps to know what the Romans understood by the word citizen (i.e. background knowledge of the historical context). Here Vessey's interpretation starts to show its strength. For not only does it help us to make sense of Gadamer's concept 'horizon' in general, but it also helps us to understand the following remark made by Gadamer: "A person who has no horizon does not see far enough and hence over-values what is nearest to him"(Gadamer, 1960/2004, p. 313). If we keep thinking of horizons as limits, or horizons as a demarcation of the visual field, having no horizon, as Gadamer claims in the above quote, would not make much sense. However, within Vessey's interpretation it simply means we lack the historical background knowledge to make sense of a sentence (Vessey, 2009, p. 537). In the above example we would thus lack knowledge of Roman citizenship. Furthermore, acquiring a horizon means doing the work of obtaining such background knowledge (p. 539).

Finally, how does Vessey interpret Gadamer's concept 'fusion of horizons'? He first argues that we should not see acquiring a historical horizon, and the fusion with our own horizon, as two subsequent steps. He writes:

> "The relevant interpretive contexts, the historical horizons, are those that produce possibly true sentences. Notice that in practice determining the meaning of a sentence and determining how a sentence might be true are not two separate operations. This insight is necessary for understanding how the fusion of horizons is properly called a fusion."(p. 540)

He then sketches how such fusions take place:

> "Horizons fuse when an individual realises how the context of the subject matter can be weighted differently to lead to a different interpretation from the one initially arrived at. Either new information or a new sense of the relevant significance of available information leads, at the very least, to an understanding of the contingency of the initial interpretation, quite possibly to a new understanding of the subject matter, and ideally to a new agreement between two parties about the subject matter."(p. 540)

After which he directly defines 'fusion of horizons':

> "In any case, the original understanding is surpassed and integrated into a broader, more informed understanding. Our horizons are broadened; we have a new perspective on our old views, and maybe new views as well. This is the meaning of 'the fusion of horizons'. "(p. 540)

[86] Vessey emphasises that this distinction between two types of background knowledge (i.e. subject matter, and contextual) is an analytic distinction. For the external horizon "informs us of the appropriate inner horizons, of the possible subject matter of the sentence."(p. 539). That is, it shows us the specific (historical) meaning of a word in the sentence. Likewise, the internal horizons tell us something about the outer horizon as well(p. 539). Namely, the various ways in which people used particular words throughout the ages(p. 540).

Before we enter into a discussion of how these concepts apply to augmented reality applications for Google Glass, there are still two brief points that need to be made. First, according to Gadamer we have only one horizon (i.e. set of beliefs that shapes our understanding). However, in hermeneutics we "project" a second historical horizon to highlight the tension between our current set of beliefs, and the different "background beliefs" from which a person wrote or uttered his words(Gadamer, 1960/2004, p. 317; Vessey, 2009, p. 541). About the alleviation of this tension Gadamer writes that "the hermeneutic task consists in not covering up this tension by attempting a naive assimilation of the two [horizons] but in consciously bringing it out"(Gadamer, 1960/2004, p. 317). Second, acquiring a historical horizon does not necessarily mean agreeing with its subject matter, but rather having "a shared understanding about the subject matter"(Vessey, 2009, p. 541). We are now ready to apply these concepts to Google Glass augmented reality software.

A first step to apply these concepts to Google Glass augmented reality software is to redefine horizon slightly, so that it fits our augmented postphenomenological reflections on augmented reality. Like Gadamer, Vessey too, focuses solely on the interpretation of texts, and thereby only on the visual mode of exploration. For our purposes here, I therefore redefine horizon as *the set of prejudices that make it possible to understand the world*. Again, such prejudices are not restricted to the visual mode of exploration, but apply to the auditory mode of exploration and the haptic mode of exploration as well. For example, I hold prejudices about what particular words sound like, and what particular surfaces feel like when I touch them. Several of these prejudices remain implicit, though, as they concern sensorimotor knowledge (i.e. how a particular surface or sound changes as I move). All these prejudices together encompass the horizon we bring along as we explore the world.

Sometimes, though, we encounter situations in which our own prejudices, knowledge, or abilities are not sufficient to grasp those situations. For example, when someone encounters a menu in a language that is foreign to him, or when a person cannot see whether she is taking the right bus due to her visual impairment. In those cases augmented reality software could help them to grasp these situations by making additional prejudices available so that their horizon expands, but only if they accept the authority of the Google Glass augmented reality application. At this point I again re-interpret Vessey's point slightly. Whereas Vessey argued that the *historical* horizon always provides contextual information about a sentence (e.g. historical context, the setting in which it was uttered), this does not seem right for Google Glass. For applications such as Word Lens and WatchMeTalk do not provide contextual information, but rather provide information about the subject matter itself. So rather than ascribing Vessey's two types of background knowledge to different horizons -i.e. knowledge of the subject matter, and knowledge of the historical context- I will here simply view them as two different ways in which Google Glass tries to aid the user in expanding his or her horizon, by providing an alternative horizon of its own. This also aligns better with Vessey's own point that when a fusion of horizons occurs, the interpreter either obtains "new information" or "a new sense of the relevant significance of available information"(p. 540).

How does Google Glass augmented reality software acquire this alternative horizon? This differs per augmented reality application. Both Memento and WatchMeTalk rely on machine learning algorithms, and have thus developed their prejudices, and thereby their horizon, during the training stage of these algorithms (see section 4.3.2 and 3.2.2). WatchMeTalk has a relatively fixed horizon in the sense that its recognition abilities only improve when Google updates the underlying speech recognition algorithms. Even though Memento's visual scene comparison algorithms will likely stay the same (i.e. the algorithms that compare the picture from the Google Glass camera to a database), its horizon has more flexibility compared to WatchMeTalk. More specifically, it allows a user to add new annotations and visual scenes to the database. So in that sense Memento's horizon expands, even though I would not call it a fusion of horizons. For basically a user adds a record to a database, and the server "naively assimilates" that record into its horizon(cf. Gadamer, 1960/2004, p. 317).

Word Lens likely[87] uses a combination of machine learning and statistical machine translation algorithms. I have already discussed the machine learning algorithm of Word Lens in section 4.2.2, and these algorithms too seem to have a fairly fixed horizon, with one exception. For in the first step Word Lens asks the user to position a viewfinder around the text that is to be translated (see Figure 4-3B). In turn, Word Lens scans the rectangular area to locate the characters exactly. Here I think it is appropriate to speak of a fusion of horizons. For in this case the user points the Google Glass camera at a visual scene with characters, and thereby visually states the implicit prejudice: 'Word Lens, this is where you should look for characters,' whereas Word Lens responds by first scanning the area for characters, and then, if the prejudice turns out to be true, removes the viewfinder and shows the translation (see Figure 4-3C & D). Thereby Word Lens has come to share the prejudice shown by the user, which it first carefully examined.[88] Additionally, the statistical machine translation prejudices of Word Lens have developed during a training stage as well, only this time based on human-translated documents from a variety of organisations. Users do have some influence on which prejudices Word Lens uses to translate a text, though. For they can easily select into which language Word Lens translates a text. But again, I would not consider this a fusion of horizons as the computer simply accepts what the user selects.

Finally, Google Glass Directions is an interesting case as well for two reasons. First, Google Glass Directions provides contextual information about the user's environment, in contrast to Word Lens and WatchMeTalk which provide information about the subject matter. The road is no longer just a road in a particular city, but has become part of a route to a particular destination. Second, because we do not always accept the prejudices navigation applications such as Google Glass Directions provide. For example, most people who have used electronic navigation systems will likely have ignored the instructions of these systems at some point, either accidentally, because they missed an exit, or deliberately because they preferred a different route. In those cases these systems often recalculate the route, and provide the user with a new set of

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[87] I use 'likely' here as Google recently acquired Word Lens. Google uses statistical machine translation algorithms for Google Translate. However, such algorithms require access to large numbers of human-translated documents in order to be trained(Google, 2010). However, Word Lens was originally developed by a small startup company, and therefore it seems unlikely they had access to such large corpora of translated texts. In other words, Word Lens could have used a different translation algorithm before it was acquired by Google.

[88] I did not want to use Gadamer's exact phrasing here which spoke about 'consciously bringing it out.' For obviously Word Lens is not conscious in the human sense of the word.

prejudices they could chose to follow. With Vessey we could thus say that "horizons fuse when" Google Glass Directions "realises how the context of the subject matter [i.e. which route the user follows, BvdH] can be weighted differently to lead to a different interpretation from the one initially arrived at" (Vessey, 2009, p. 540).

To conclude, in this section I have shown how Gadamer's concepts 'horizon' and 'fusion of horizon' can be re-interpreted to describe the hermeneutic processes that take place when Google Glass users use WatchMeTalk, Memento, Word Lens, and Google Glass Directions. Each case had its unique features, but all in one way or another, aimed to expand the horizon of their users. Let's now see what we can conclude from all these hermeneutic and epistemological reflections on Google Glass augmented reality software.

4.4 Conclusion

In this chapter I have discussed four augmented reality applications for Google Glass. We saw that even though these applications might not be considered augmented reality applications in the ontological sense of the word, they did augment reality in the hermeneutic/epistemological sense of the word. We also considered whether Don Ihde's material hermeneutics and the augmented postphenomenology framework as I presented it in chapter 3, could be used to analyse the hermeneutic and epistemological aspects of these applications. Even though augmented postphenomenology came close, two challenges remained: it did not explain *why* we adopted the interpretations presented by these applications, nor did it describe well how various hermeneutic processes influenced each another. To address these challenges we used five concepts from Hans-Georg Gadamer to augment postphenomenology for a second time. In the discussion on authority four factors turned out to influence why we accept the interpretations provided by Google Glass augmented reality software: the ability to *verify* the prejudices provided by these applications through the human-world relationship, the degree to which the application meets the *purpose* for which users intend to use it, the degree to which the *structural features* of the virtual entities help users to explore and interpret his or her environment, and finally the degree to which the application meets users' *skills and knowledge*. Finally, by adding three hermeneutic circles, and the concepts prejudice, horizon, and 'fusion of horizons,' we can now *systematically* analyse and describe the hermeneutic processes raised by these augmented reality applications.

Now that I have discussed all the details, what more could we use these concepts for, apart from philosophical analyses? The hermeneutic/epistemological perspective presented in this chapter raises several interesting questions for the design of augmented reality applications. I will here briefly mention two of them. First, in the discussion on horizons we noticed that some of these applications involved users in their interpretive processes by interpreting prejudices offered by their users. For example, Word Lens involves users playfully by asking them to select an area with words. Thereby it saves computing resources, and involves the user in its interpretive process. My first design question is therefore: How can we involve users more often in the interpretive processes of augmented reality applications, and thereby make them more intelligent and efficient at what they do? Second, in the discussion on authority we noticed that the structural features of the virtual entities presented by these augmented reality applications, influenced the authority of the application as a whole.

How do we design these virtual entities in such a way that they actually help the user to explore the world?

With this second question we have reached the end of this chapter, and hopefully the beginning of a fruitful discussion on how augmented postphenomenology could develop even further. In the next chapter, though, I will not augment augmented postphenomenology for a third time. Rather, I will apply the framework we have discussed in chapters 3 and 4, to clarify some of the ethical issues raised by Google Glass.

Chapter 5 - The ethical debate on Google Glass

In chapter 2, we already encountered some of the ethical issues that Google Glass raised: eye-strain complaints due to the screen being located slightly above our line of sight, a discussion on face recognition, and privacy issues. In this chapter I will both broaden the ethical discussion by discussing some other social and/or ethical issues raised by Google Glass, and deepen the discussion by studying two of these issues in much more detail. Thereby I aim to show two things. First, how comical Youtube skits about Google Glass help to gain insight in the current ethical debate about Google Glass, and help to *broaden* the view of an ethicist on this debate by stimulating his or her moral imagination. Second, how augmented postphenomenology helps to *deepen* ethical reflection on privacy issues raised by Google Glass by generating alternative points of view, and by generating alternative designs that could help to resolve them.

In order to so, I will first explain why I intend to use comical YouTube skits to develop a broad overview of the current ethical debate on Google Glass. I argue that even though these skits stimulate the moral imagination of the ethicist, and thereby help him or her to explicate current positions in an ethical debate, they should only be seen as a first productive step towards a more elaborate critical reflection on this debate. Having made this point, I present an overview of the ethical issues raised by these skits (section 5.1). In the next section, I present a more elaborate critical reflection on the privacy issues raised by Google Glass. More specifically, I use augmented postphenomenology and some points from the history of wearable computing to show which points are currently missing in the debate on the privacy issues raised by Google Glass. Additionally, I synthesise these missing points with the existing points from the current discussion through a brief case study of taking pictures with Google Glass (section 5.2). Finally, I end this chapter with some concluding thoughts on the role of descriptive theories such as augmented postphenomenology in ethics (section 5.3).

Let's now broaden our view on the current ethical debate on Google Glass.

5.1 Current ethical debate on Google Glass

In this section we will explore the current ethical debate on Google Glass. I will do so by analysing several comical YouTube skits. From a theoretical stand point, I understand that such an approach may raise some eyebrows. Therefore, I will first clarify my approach, why I have adopted it, and discuss some of the possibilities and limitations of this approach (section 5.1.1). In turn, I present how this approach helps to gain a broader overview of the current ethical debate on Google Glass by analysing several comical YouTube skits (section 5.1.2). I will now clarify my approach.

5.1.1 Using comedy in ethical deliberation

The main inspiration to use comical Youtube skits to analyse the ethical debate on Google Glass came from New and Emerging Science and Technology (NEST) ethics, and Mark Coeckelbergh's (2007) book *Imagination and Principles: An Essay on the Role of Imagination in Moral Reasoning.* I will first discuss these two sources of inspiration, and then explain how they inspired the idea to use comical Youtube skits to explore the current ethical debate on Google Glass.

Let's start with NEST ethics. As we saw in section 2.1.3 when I discussed

Lucivero et. al's (2011) NEST ethics approach: technologies have a tendency to change and/or challenge our current moral practices. We called this phenomenon techno-moral change. One way to explore this phenomenon is by means of scenarios(cf. Boenink, Swierstra, & Stemmerding, 2010; Lucivero, et al., 2011, p. 140). Such scenarios do not just include any wild ethical fantasy, but rather attempt to provide an "historically informed" and "plausible" overview of where techno-moral developments might be heading (cf. Boenink, et al., 2010, pp. 9-10; Lucivero, et al., 2011, pp. 138-140). For example, Boenink, et al. (2010), base their framework to generate such techno-moral scenarios on four considerations. First, their framework allows an ethicist to develop scenarios that include a variety of arguments based on various ethical and meta-ethical theories (i.e. meta-ethics concerns the discussion of ethics and ethical theories as such). In other words, the framework does not favour one particular ethical and/or meta-ethical theory. Second, moral change occurs at a macro, meso, and micro-level, and thereby occurs at different paces. At the macro level we find "abstract moral principles that have proven their worth time and again"(p. 9). Moral-change at this level happens "only very slowly"(ibid). At the meso level we speak of "moral regimes" which consist "in specific institutional practices (…) regulated by procedures and rules"(ibid). Such regimes "will display some robustness, but (…) will change more often than the principles at the macro-level"(ibid). At the micro-level, "very specific moral issues are dealt with in local circumstances"(ibid). At this level moral change happens "relatively frequently"(ibid). Third, Boenink, et al. (2010) argue that the speculations in the techno-moral scenarios should be "historically informed," both in terms of the types of arguments used, and in terms of the contents of those arguments(pp. 9-10). Fourth, and finally, the scenarios should not only focus on specific ethical issues, but also include meta-ethical concerns such as "the status of technology and morality and their interaction, in general"(p. 10). More specifically, will technologies always *determine* the way we morally act, or can we influence the way technologies will shape our moral practices? These four considerations offer a fairly abstract overview of what such scenarios could look like. In sections 5.2 and 5.3 I will make these considerations more tangible. However, for now I will focus on a different, but related question: Why would you develop such techno-moral scenarios in the first place? Boenink et. al. answer this question by explaining that most policy makers focus on the "quantifiable impacts" of technologies; that is, their impact on "health, environment, and safety"(p. 0). These scenarios broaden this policy focus by including the potential impacts of technologies on, "for example, the distribution of social roles and responsibilities, moral norms and values, or identities"(ibid). Thereby these scenarios stimulate the moral imagination of policy makers, and may positively influence the "democratic quality" of their moral deliberations as well(cf. , pp. 0,33-34). Let's now discover what that term 'moral imagination' means by turning to the work of Mark Coeckelbergh.

In his book *Imagination and Principles* Marck Coeckelbergh argues that both imagination and moral principles are "equally necessary and dependent" on one another for moral reasoning (2007, p. 225). Coeckelbergh prefers not to speak about 'moral imagination' "since the term may falsely suggest that imagination is itself moral"(p. 33). Rather, he prefers to speak about the "*use* of imagination" that "can be morally right or morally wrong, or contribute to morally right or morally right or morally wrong decisions and actions"(ibid). What, then, is/are the role(s) of imagination in moral reasoning, according to Coeckelbergh? He argues that there are four roles for imagination in moral reasoning. Generally, he uses the metaphor of movement towards the future or towards the Other to describe these roles of imagination, on the one hand, and distinguishes the individual from a collective to describe the "user of imagination," on the other hand(p. 196). At the individual level we can imagine the consequences of our acts and thereby move towards the future (i.e. "projection"),[89] or we could imagine what its like to be in the shoes of another person that has to make a difficult ethical decision and thereby move towards the other(i.e. "empathy")(ibid). At the collective or societal level, we could imagine in what kind of society we would like to live and thereby move towards the future (i.e. "improvisation and tuning / visions of common life"), or we could imagine why particular principles or values are important for a community and thereby move towards the (generalised) Other (i.e. "Discourse and communication")(ibid). In addition to these definitions, Coeckelbergh makes one other point that is relevant for our discussion here. For he does not restrict the stimulation and development of our moral use of imagination to written media alone. He argues that "television news, Internet journals, (…) video games," and "objects of art" all have the capacity to stimulate and develop moral imagination as well(cf. , pp. 94-97,116-127). The written scenarios proposed by Boenink, et al. (2010), are therefore not the only format in which scenarios of techno-moral change could be presented. It is mainly this intuition about the format of these scenarios, based on the NEST ethics literature and the work of Coeckelbergh, that led me to explore the question whether these comical YouTube skits could be approached as scenarios of techno-moral change.

At first this may sound strange as these comical YouTube skits have not been based explicitly on the four considerations presented by Boenink, et al. (2010), that I have discussed above. Indeed, even though these comical YouTube skits may include various ethical and meta-ethical arguments (consideration 1 and 4), and display deviating norms and values with regard to technology use, and thereby illustrate techno-moral change (consideration 2), these skits do not seem to curtail "free floating" speculation by being based on historical case studies of "past ethical debates and the evolution of moral practices or regimes relevant to the new or emerging technology"(consideration 3)(pp. 9-10). I agree that these skits themselves have not been based on historical case studies. However, much of the work the work done in this thesis *has* been based on the history of wearable computing discussed in section 2.2, and to a certain extent section 2.3. Furthermore, in section 5.2 we will also encounter the work of Lynsey Dubbeld (2004) who wrote an elaborate techno-moral history on the concept of 'privacy.' Additionally, as Boenink et. al. suggest themselves as well, Swierstra and Rip (2007) offer a rich historically informed inventory of existing ethical and meta-ethical arguments that I will use here to classify the various arguments implicitly or explicitly stated in these comical YouTube skits. So in that sense we should be able to historically "judge the plausibility of imagined developments" proposed in these skits, and thereby curtail the most excessive ethical speculations(Boenink, et al., 2010, p. 10). Finally and again, the purpose of these skits in this thesis is to use them to gain an overview of the current ethical debate on

[89] The terms in parentheses provide the names Coeckelbergh ascribes to these roles of imagination in moral reasoning.

Google Glass, rather than to help policy makers decide on these ethical issues. So in this thesis having fully historically informed speculations tends to be less important, than in the case of actual nation-wide political deliberations being based on them.

Another question raised by this plea to approach *comical* YouTube skits as techno-moral scenarios is: Why comedy? Why not just any YouTube video about Google Glass (cf. Coeckelbergh, 2007, pp. 95-96,127)? Christine James (2005) offers several reasons in her fascinating essay on how she uses comedy to teach ethics. First and foremost, James argues that comedy makes her students feel comfortable to talk about delicate topics such as racism and homophobia. She writes:

> "Rather than merely saying that racism, sexism, homophobia, and cultural misunderstandings exist, we can explain it and illustrate it as reflected in entertainment. Comedy works best for this project, because the students feel comfortable with it. Were I to use drama, many students might feel bored, or they might find the approach to the issues too aggressive. (...) But by asking students to view comedy critically, they have more of a chance to read the theory and then have new specific insights of their own, and they can begin to pick their own examples from their favourite comedies"(James, 2005, p. 7).

Later on she restates this point, by summarising Michael Gelven's (2000) profound philosophical reflections on comedy as follows: "comedy allows us to express truth clearly, concisely, vivaciously, and perhaps with less offence and more grace than direct statements"(p. 11). In other words, comedy breaks the metaphorical ice to start conversations on delicate moral topics. Second and related, James distinguishes between three roles that comedy plays in her ethics classes: aid students in understanding ethical theories, challenge a student's assumptions, and provoking discussion and activism among her students. Comedy helps those students "who might not feel an affinity for the primary text by (...) seeing the behaviour, recommended by an ethical theory, acted out on television or film"(p. 4). Additionally, comedy makes students aware of their own assumptions on societal issues, challenges them, and through critical reflection on them, helps them to develop "a new and more accurate understanding of those [societal] issues"(p. 4). Finally, James uses comedy to inspire activism in the sense that she uses a skit by Chris Rock to illustrate how comedy and humour help to engage in a dialogue and resolve a racial issue, which she sees as a useful social skill her students should have(p. 9). More specifically, Rock speaks with people from South Carolina on the issue of the confederate flag flying on top of its capital dome, experienced by some as a symbol of racism, and resolves the issue by showing comical alternative designs of the flag of which some symbolise unity among black and white(Rock, 1998/2012).

Especially this two-sided ability of comedy to both challenge and illustrate our background assumptions graciously, in my view, makes comical YouTube skits suitable to gain an overview of the current ethical discussion about Google Glass. Not any comical skit on Google Glass will do, but as I argued above, the considerations by Boenink et. al. will help to select the right skits for this purpose. Let's now explore the current ethical debate on Google Glass through a selection of these skits.

5.1.2 Current ethical debate about Google Glass on YouTube

In this section I will discuss five comical Youtube skits that I have selected based on the considerations offered by Boenink, et al. (2010), and the diversity of the arguments they offer. After this discussion I will also evaluate the approach I have adopted in this section. I will start with the oldest skit, and end with the most recent skit.

The first skit has the title “how Google Glass ruins relationships” and illustrates how a fake Google Glass influences the loving relationship of the two main characters Rick and Tammy(Huzieran, 2013). Rick wakes up next to Tammy, says good morning to his Google Glass, and asks for the time. Only afterwards, does he greet Tammy, and asks how she is doing. She responds reluctantly and continues reading her book. Google Glass shows Rick that Tammy is mad at him, and Rick responds to Glass by telling it to order flowers for Tammy on Wednesday. He smiles sheepishly at Tammy, and then it becomes too much for her. She hits him with her book, and makes it very clear he’s acting ridiculously, as he can’t take off his Glass, and even wears it while he is sleeping. The irritated conversation continues, and Rick regularly has to check his Glass to understand Tammy. Eventually she seductively makes him chose between her, and the Glass device. Rick chooses Tammy, even though Glass warns him that it is a trap. The moment he has taken off his Glass, great fear of the ‘real’ world, not being filtered by Google Glass grabs his heart, Tammy walks away angrily, and leaves him alone. Rick sadly lies down on his bed and slowly puts his Glass back on, asks it to play him some music, and show pictures of his pleasant times with Tammy.

The main point of this skit is to explore how Google Glass affects relationships. Tammy gives the main answer to this question when she says: “there is no connecting with you when you have those on (…) you *know* what you have to do… it’s either me… or, the glasses?”(t. 1:07-1:27). But how did it get this far? The skit suggests several reasons for Rick’s distracted behaviour. First, he got so used to these Glasses that he even wears them while sleeping. Even though, from my own experience I could imagine that this would not be very comfortable or practical with Google Glass. Because the titanium frame already started to feel somewhat uncomfortable after half an hour or so, and the battery would simply get in the way when lying down. Apart from these observations, I did find one example in the history of wearable computing where a friend of Richard DeVaul (see section 2.2.4) wore the Mithril 2000 system at night to check e-mail while he could not sleep in “a shared sleeping environment”(DeVaul, 2004, p. 64). Second, Rick relies a lot on the capabilities of Google Glass to help him make sense of the world. In a way, this turns the argument on naturalness we typically find in discussions about technology on its head(cf. Swierstra & Rip, 2007, p. 16). In other words, whereas critics usually characterise a technology as artificial and unnatural, in this skit Rick has grown so accustomed to Glass that his encounter with the ‘real’ world unmediated by Glass starts to feel unnatural, and is experienced as such by Tammy. I doubt the plausibility of this second reason, though. Even though Google Glass indeed offers some context-aware features through Google Now, and several of its augmented reality applications partly provide an alternative understanding of the user’s environment, these features have not yet reached the level to support all the things that Rick uses Google Glass for. As long-time Google Glass Explorer Robert Scoble[90] pointed out in December 2013:

> “No contextual filtering. When I'm standing on stage, why does Glass give me Tweets?

[90] Even though media have reported that Scoble “publically disowned” Google Glass, and thereby suggest he has stopped using it entirely(e.g. Munford, 2014; Warzel, 2014), this is not true. In a recent post on Google Plus he did wear Google Glass and referred to it as “My Google Glass” (Scoble, 2014).

Why can't it recognise that I'm at a conference at least and show me only tweets about that conference? Hashtag style. But it can't because Google's contextual OS isn't done and probably won't be done until 2015"(Scoble, 2013c).

The second skit comes from *Saturday Night Live,* where their 'tech correspondent' Randall Meeks provides his views on Glass (Meyers & Armisen, 2013). Again the Glass device in this skit is fake, and Meeks' device emphasises this by hanging *in front of* his *left* eye. The main point of the skit is to undermine the main promise of Google Glass that you no longer have to look downwards to your phone and thereby come across as rude or distracted. As Meeks says at the beginning of his review:

"They're amazing. I had to spent so much time in my life looking down on my phone, and now, thanks to Google Glass, the phone is up here, and I can use it without being rude or distracting"(Meyers & Armisen, 2013 t. 01:17-0:26).

Meeks then shows how easy it is to use Google Glass by making a number of awkward gestures, by repeating the same voice commands over and over again, including a Wi-Fi password, and claims that nobody noticed that he was doing so. Furthermore, between these repeated voice commands he mentions quickly that we wouldn't be able to talk to each other if phones would work the same way. Suddenly we hear groaning woman sounding through the studio, and Seth Meyers, the host of the show, asks Randall what he is watching on Glass. Randall embarrassingly tries to mute the volume quickly using more voice commands, and has to reboot the device by making a gesture that makes his neck hurt. In my view, the main theme of this skit is to show how private ways of operating a device suddenly become more apparent through voice commands and gestures, and thereby they undermine the main promise of Google Glass that you no longer come across as "rude or distracting." Even though Meeks exaggerates these gestures and voice commands, and adds a few gestures and commands that do not currently exist for Google Glass, we did observe similar claims on the awkwardness of the eye gestures, and the noticeability of the voice commands (see section 3.2). So this leads me to ask whether Google Glass actually meets its own design principle: "Design interfaces that use imagery, colloquial voice interactions, and natural gestures"(Google, 2013d). More specifically, what does Google mean when they speak about "natural gestures"? Another related point raised by this skit has to do with privacy. For these voice commands and the bone conduction speaker make it quite noticeable what you are doing on Google Glass. As Minuum founder Will Walmsley remarks on the speech recognition features of smart watches:

"As useful as voice recognition might be for some situations, it will always remain insufficient when it comes to noisy environments and private message replies. (...) and I'm sure your boss/teacher wouldn't be too pleased with you talking to your watch. And don't get us started on URL/password entry."(Walmsley, 2014b)

In other words, does speech recognition make some information about our actions and messages too public?

In the third skit by technology website *Mashable* published in May 2013, this theme of public action gains a somewhat different meaning. The key deontological principle this skit illustrates is: "Don't be a Glasshole"(Silverman, 2013 t. 0:16). What does Mashable mean by 'Glasshole"? Basically the skit follows a user with a real Google Glass device, who models the behaviours of a Glasshole perfectly. He is "smarter than everyone" due the information searching capabilities of Google Glass, and he is not afraid to interrupt a social conversation between two people in a hallway to show off his smartness by correcting a small factual mistake. He believes Glass makes him attractive to women, and at first Glass indeed seems to help him to start a conversation, but he actually scares them off with a remark about Glass not yet having X-ray vision. Other characteristics include his inability to know that it is inappropriate to wear Glass in a toilet and film, his inability to maintain eye contact, cheating at Trivia, abusing the camera to secretly photograph women, and showing contempt for his colleagues due to the coolness of his Google Glass. The narrator then repeats the key principle positively: "Nobody likes a Glasshole. Avoid these behaviours and you'll be on your way to Google Glass greatness" which is then virtuously modelled in a toilet by the Google Glass user.

In my view this skit raises the question of what appropriate Google Glass use practices would look like. In fact, Google actually repeated this principle in February 2014, when they published a list of "do's and dont's" for Glass Explorers to follow. In their list of don'ts they state:

> "Be creepy or rude (aka, a "Glasshole"). Respect others' privacy and if they have questions about Glass don't get snappy. Be polite and explain what Glass does and remember, a quick demo can go a long way. In places where cell phone cameras aren't allowed, the same rules will apply to Glass. If you're asked to turn your phone off, turn Glass off as well. Breaking the rules or being rude will not get businesses excited about Glass and will ruin it for other Explorers."(Dale & Richardson, 2013b)

It's interesting that Google itself has also chosen to combine deontology and virtue ethics by providing guidelines in terms of principles, while illustrating them in concrete situations by appealing to certain character traits (e.g. politeness, respect). For this is the exact same approach adopted in the Mashable skit.

In the fourth skit Glass explorer Teddy Miller (played by Michael Sullivan) introduces himself as the latest Glass explorer(DiNapoli, 2014). Sitting in an empty room with only one chair, he tells us the following about his purchase of Google Glass:

> "it was a little expensive, $ 1600,-, I don't have much food, any food really, I had to take out a loan and I sold some things as you can see, but the Google Glass has changed my life, even though I don't have bed, or furniture, except this chair, I kept the chair, I probably could have sold the chair."(DiNapoli, 2014 t. 0:19-0:30)

He then describes the features of Google Glass, constantly alternating between overstatements and understatements. For example, he explains Google Glass can take pictures, record videos, search online, and get directions, followed by the overstatement that Google Glass has a lot of features. Additionally, it allows him to record his whole life, including mundane activities such as making breakfast, and his daily route to work. Near the end of the skit he explains that he started his own photography business, and uses Google Glass to take pictures. He has to move his head sideways to create a portrait, and has to move his whole body forwards and backwards to zoom in and out, which "makes it easier" to do his job.

I would summarise the big theme in this skit as: you pay so much, but you gain so little. The normative utilitarian question raised by this theme is thus whether the price of Google Glass actually justifies the value or benefits we gain from it. The skit undermines the value of Google Glass by creating parodies on the big promises from Google's own Explorer Stories. That is, the skit shows parodies on promises from a series of videos by Google, that show the greatness of Glass by following explorers who pursue worthy causes such as fire fighting, overcoming disabilities, and protecting wildlife. Actually, the skit claims, the benefits are not that great. Furthermore, for a lot of people it is not even clear what they would want to use Google Glass for(cf. Hong, 2013), including Teddy Miller, who jokingly asked Glass to make him a sandwich, which it didn't do(DiNapoli, 2014 t. 2:40-2:50).

In the fifth and final skit by the Daily Show, Jason Jones interviews six real Glass explorers who have all been 'discriminated' in some way(Jones, Kahn, & Paone, 2014). Two were robbed of their Google Glass, one unfairly received a traffic fine for wearing, but not using, Google Glass while driving, and the others had been refused service at restaurants and bars, because they wore Google Glass. The interview then quickly moves on to privacy. One of the explorers says she films Jones while he is interviewing her, to which Jones responds that she should stop filming him. 'But,' she replies, 'you are filming me.' Jones partly agrees, he says: "yeah, except that our cameras have red lights on them, and big crew guys operating them, and you signed a release form for a national TV show, otherwise exact same thing yeah"(Jones, et al., 2014 t. 1:45-2:03). After repeating how people discriminated these explorers, the explorers try to convince Jones of the value of Glass. But every time, Jones wittingly rebukes them. Nick Starr argues that you keep looking at people, but his head wake up gesture shows he does not. Kyle Russell starts talking about how Glass "acts as an interface between you and the real world"(t. 3:00-3:13), but according to Jones we already have such an interface; namely, our eyes. Finally, Sarah Slocum answers that Glass gives us access to all information on our cell phone, but Jones replies we already have such access; namely, through our cell phone. Slocum says we now have such access right in front of our eyes, but apart from having faster access to that information, it doesn't become much clearer why that would be useful.

The main theme of the skit is discrimination, but if we look at the responses to Google Glass described in section 2.3.3 and provided by some journalists, it turns out that most Explorers actually receive positive attention, or no attention at all(cf. Eadicicco, 2013; Scoble, 2013c). Apart from that theme, the remarks on privacy are still interesting. If you turn them around, you arrive at a description of Google Glass. It has no red light, the Google Glass camera is fairly small, your operation of it is barely noticeable, and informed consent often arises informally (cf. Dickinson, 2014a t. 1:55-2:20). Finally, the discussion on the value of Google Glass, adds the dimension of human-computer interaction to this discussion, rather than focussing on specific features like Teddy Miller did in the fourth skit.

So what we can we conclude about the current ethical debate on Google Glass, and the methodology we used to study it? Let's start with the debate. The main questions running through most of these skits is: How does Google Glass actually contribute to our quality of life? A few more specific questions within this theme are: What are the appropriate or virtuous ways to use Google Glass? How do the features such as voice recognition, gesture recognition, and the screen being slightly above my line of sight, influence social interaction? Are those influences desirable? Most of these skits provided negative answers to these questions, even though the Mashable skit encouraged Glass explorers to behave appropriately, by demonstrating how not to behave. With regard to methodology, these skits did indeed raise a number of moral questions to think about. Furthermore, by giving names to Glass users ethics also became less abstract in the sense that you stop speaking about 'users' in general. Apart from these remarks, I would recommend studying these skits by combining it with written media in two ways. First, by using written media to check whether the claims made in these skits actually match the observations of other explorers. For sometimes comedy exaggerates or fantasises a bit too much, as we saw above. Second, even though the skits discussed here touched upon a wide variety of moral themes, they did not include all moral issues. For example, I could not find any skits that paid considerable attention to the issue of using Google Glass while driving, while written media and several non-comical YouTube videos did address this current moral issue (cf. Gershowitz, 2014; Scoble, 2013b). Let's now focus on the privacy issues raised by Google Glass, and see how augmented postphenomenology helps to clarify these issues.

5.2 Privacy Issues and Google Glass

As we saw in section 2.3.3, journalists and Glass explorers have discussed a number of privacy issues with regard to Google Glass. In this section I will first provide a brief summary of the privacy issues we encountered so far in this thesis. I will then use the history of wearable computing and augmented postphenomenology to explore which points are missing in the current discussion. Finally, I will provide some design suggestions based on augmented postphenomenology that address some of these privacy issues.

In section 2.3.3 we encountered three different ways in which Google Glass raised privacy issues. The first two ways pertain to the privacy of other people in the vicinity of a Google Glass explorer, while the third way pertains to the privacy of the Glass explorer him- or herself. With regard to the people in the vicinity of the Glass explorer we found that the explorer no longer needs to hold up the camera to take a picture, and that the "ever-present lens scares others away," in part because some people misunderstand how Google Glass works, and therefore assume that the camera is "always filming wherever you look," that it could be used for facial recognition, or that an explorer is always taking pictures whenever the screen lights up(Topolsky, 2013; Verlaan, 2014). With regard to Glass explorers themselves we found that the Washington Post's Hayley Tsukayama experienced the attention she drew by wearing Google Glass as a violation of her privacy, as she was quite a shy person(Tsukayama, 2014b). In contrast, other people such as Lucien Engelen did not experience this as a violation of their privacy, but rather as a great benefit to engage in conversations with people. In his view privacy is personal and "situationally shaped."[91] In the previous section (5.1.2) we also encountered two points about privacy. First, the Saturday Night Live skit illustrated how the bone-conduction speaker, voice commands, speech recognition, and bodily gestures made it much more noticeable which activities a user is carrying out on Google Glass. More specifically, the speech recognition feature makes it possible for people nearby to hear what (personal) messages you send to your contacts. Second, the Daily Show skit illustrated how filming with Google Glass differed from filming with a television camera. For Google Glass did not have a red light to show whether it is filming, its camera is fairly small, it is not very noticeable that you *operate* the camera, and most of the time we give informed consent for such

[91] (L. Engelen, personal communication, March 11, 2014)

filming informally or implicitly (cf. Dickinson, 2014a t. 1:55-2:20). With regard to resolving these issues health care professionals formally apply the informed consent principle (cf. Engelen, 2013a; Grossmann, 2013), while Google recommends the following informal version of the same principle in its list of do's and dont's for Glass explorers:

> "Ask for permission. Standing alone in the corner of a room staring at people while recording them through Glass is not going to win you any friends (...). The Glass camera function is no different from a cell phone so behave as you would with your phone and ask for permission before taking photos or videos of others."(Dale & Richardson, 2013b)

However, does the above overview mention all privacy issues, and does it offer a sufficient resolution for these issues? Let's now explore the privacy issues raised by Google Glass using augmented postphenomenology. I will start in a fairly abstract way by approaching Google Glass in terms of a composite relation, and then eventually discuss concrete applications. As I mentioned in section 2.3.1, Google Glass contains a number of sensors: two accelerometers, a gyroscope, a compass, a GPS sensor that only works when paired to a mobile phone with GPS, two microphones, a 5 megapixel camera, and a light sensor aimed at the user's right eye. In terms of the augmented postphenomenological composite relation these sensors describe the various modes of exploration of Google Glass. In principle, every sensor could collect a specific type of information about the user him- or herself, people in his or her vicinity, and/or objects in his or her vicinity. See Table 5.1 for an overview which sensors could collect information about which people or objects.

TABLE 5.1 Google Glass sensors and information collection

Sensor	Type of Information	Collects information from
Accelerometers	Linear Motion	User
Gyroscope	Rotational Motion	User
Compass	Direction relative to the world	User
GPS sensor (paired to phone)	Location	User
Microphones	Audio / speech	User and people & objects nearby
Camera	Photographic images	People & objects nearby
Light sensor	Device worn on head? Winks and Double Winks Does user look at screen?	User

Based on the survey by Klasnja, et al. (2009) we know that people classify data from different sensors differently when it comes to privacy. They perceived motion data as fairly general and harmless, while the collection of audio and GPS data tended to be more controversial, especially when gathered 24/7 (section 2.2.5). So based on the findings, data from the first three sensors will likely not provoke a lot of discussion (i.e. accelerometers, gyroscope, and compass), while data from the GPS and microphones will likely provoke more discussion. The photographic images shot by the camera have already provoked discussion as the sketches discussed above have shown. Cunningham, Masoodian, and Adams (2010) suggest that this might be caused by the revealing aspect of photos. That is, photos reveal much more than facts about a person, they also tell something about a person's "mood and activities" (p. 27). Finally, The light sensor by itself will not provoke a lot of discussion about privacy, as it only detects what happens in front of it, and does not track pupil motion(White, 2013b t. 1:50-2:10). Only when software would combine it with photos from the camera, it could provoke a discussion, as in that case it might suggest to whom a person winked. So here we find a first point that is currently missing in the discussion on privacy issues about Google Glass. Even though the microphone and camera are regularly mentioned as sensors that raise privacy issues, I have only found one source that suggested that the Google Glass GPS sensor raises privacy issues(cf. Gore & Lah, 2014).

If we move towards the HT-circle, Google Glass does not continuously alert the user that it is collecting information. That would contradict their design principles of getting in the way, keeping information relevant, and avoiding the unexpected(cf. Google, 2013d). However, in its terms of use for Glass, Google does state the following:

> "Google will determine and use your location, photos and videos taken on your Device will be added to your Google+ Auto Backup album, and your Device will display information sent to devices that are synced with it (such as text messages)"(Google, 2014i).

In other words, whenever Google Glass is paired to a phone, and connected to the Internet Google will know about the location of a particular Google Glass device, and will automatically store the photos and videos of that device on its servers. This locational information is accessible to the user through the MyGlass App (see Figure 5-1), and his or photo's through a private folder on Google+.

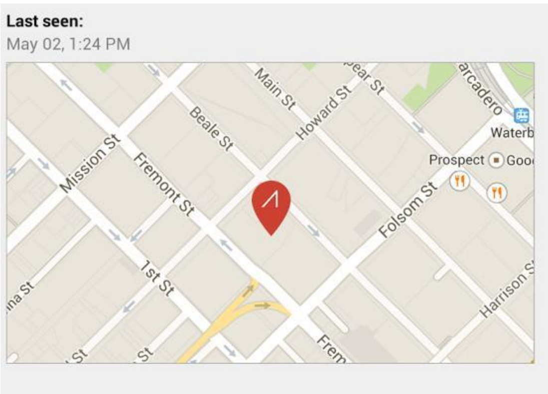

Figure 5-1 - Location Data available to Google through the MyGlass application[92]

Furthermore, whenever a user activates an application for Google Glass, they see which permissions that application asks, and can then decide to agree with all of these permissions, or disagree with all of these permissions. However, as we noticed in section 2.2.5, *what* type of data sensors collected played a considerable role in user deliberations on privacy. So here I would suggest to make these permissions modular, so that the application allows the user to manage his or her identity in a more refined way, based on what he or she deems appropriate within the context of using that application(Nissenbaum, 2004; van 't Hof, van Est, & Daemen, 2010).

Now that we have discussed privacy at a fairly general level, I want to look at a case study on taking pictures with Google Glass. One question that Glass Explorers have often been asked by people nearby is whether they are filming them at the

[92] Picture used from: MyGlass - Android-apps op Google Play, https://play.google.com/store/apps/details?id=com.google.glass.companion , visited: August 24, 2014.

moment(Scoble, 2013a; Verlaan, 2014). Often the answer is that they are not, but how can you actually tell that you are being photographed or recorded on video by Google Glass? According to Google there are three ways to know that a Glass user is filming or photographing you(Dale & Richardson, 2013a). First, you can tell by the lit up screen. Second, you can hear it when Glass is taking a picture by a brief high-pitched sound played through the bone-conduction speaker, and through the brief voice command 'ok glass, take a picture,' or when the user records a video 'ok glass, record a video.' Third, instead of speaking to Google Glass the user could also push a button, or wink to take picture, or record a video. In that case, the gesture communicates that the user takes a picture. However, the first two ways seem to become less noticeable as you stand farther away from a Glass explorer. Will I still be able to see and hear those gestures at a distance? Basically, I tested this when I tried out Google Glass. I varied the distance between me and someone wearing Google Glass systematically to explore how distance would influence the noticeability of these gestures[93]. We tested this in a quiet environment with the bone-conduction speaker volume at 50%, and with 1, 2, 4, 6, 8, and 10 meters distance between us (see figure 5-2 for the first 4 distances). At all distances I saw the screen lighten up brightly when the Glass user spoke his voice command. From 6 meters distance and further away, the voice command started to sound progressively softer, but remained clearly understandable up to 10 meters; the high-pitched sound sounded quite softly at 10 m distance. Furthermore, at 10 m distance, I could no longer recognise my face clearly on the photographs, due to the resolution of the camera. Therefore we stopped the experiment at this distance. So based on this experiment I conclude that Google rightfully mentions these features to indicate the use of Glass for taking pictures and videos of a person.

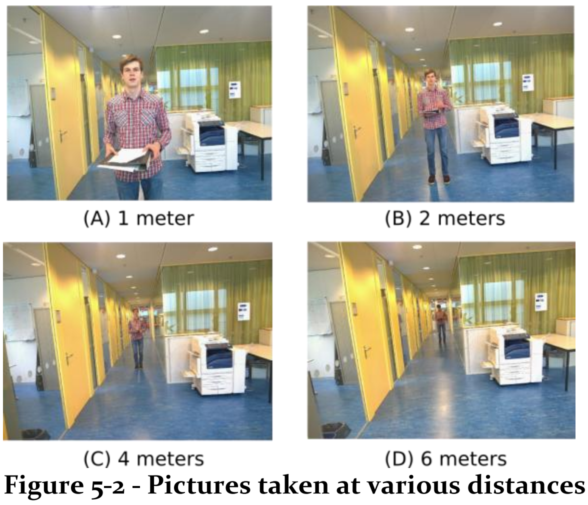

Figure 5-2 - Pictures taken at various distances with Google Glass.

However, the lit up screen alone offers no guarantee that a Glass user is photographing or recording me. For as Daniël Verlaan experienced: sometimes people can think you are filming them, because the screen lights up, but in fact you are doing something else such as looking at Twitter updates(Verlaan, 2014). In other words, the screen always lights up when the user works with Google Glass, and this might cause ambiguity for people nearby. So now we arrive at the more hermeneutic (i.e. interpretive) aspects of privacy. Why do some people respond so sharply to having their pictures taken, while others do not seem to mind? (cf. Dickinson, 2014b; Verlaan,

[93] I thank Jacky Chow for assisting me in this experiment.

2014). From a Gadamerian point of view this must have something to do with our prejudices and horizon. Recall that Gadamer said that all understanding begins when something addresses us. In this case, the fact that I notice that someone is pointing a camera at me that moves along wherever he looks, and is located at a height at which it is easy to take picture of my face, makes me curious to learn why that person is pointing a camera at my face, and move beyond my current horizon. However, exactly which prejudices are shaping my interpretation of this situation, and trigger me to investigate this further? In one of the few papers that has thoroughly investigated the phenomenon of privacy perception empirically *and* theoretically for the case of picture sharing, Cunningham, et al. (2010) describe one basic idea, and three main factors that influence our perception of privacy in this particular case[94]. Their basic idea comes from sociology. They write:

> "Privacy is closely interwoven with how others perceive us. We act not only as means to attain a purpose but also with the desire of creating the appropriate impression with others. Photographs can be an aid or an embarrassment in our social interactions since they give the impression of accuracy yet present a manipulated version of reality. We pose for photographs to give an impression. Pictures can show us in positive and negative lights with no basis in reality. (...) Understanding how we present ourselves is vital in maintaining an accurate appraisal of, and control of, our privacy."(p. 28)

In other words, a first prejudice that the camera being aimed at my head could tease out is whether I'm making the right impression if I am standing in front of the Google Glass camera of a friend, or whether that strange person will make me look bad if he puts my picture on his blog. Here we arrive at the three main factors Cunningham et al. distinguish in a user's perception of privacy. First, to what degree I *judge* the information being collected as *sensitive* or *confidential* (p. 29). In our Google Glass camera case I might not appreciate it when a deputy physician uses Google Glass to film every part of my consult with him, as I deem the physical examination to be considerably confidential. Second, the way I perceive "the person who receives and/or manipulates (...) [my] information" (ibid). More specifically, the authors state that *trust* "seems to be the most important" factor in how we perceive the person that receives and possibly manipulates our information (ibid). For example, I might trust a friend much more in taking a picture of me using Google Glass, than a complete stranger wearing Google Glass. I trust that friend to handle my picture in a way that ensures my privacy. This second factor shows some similarity with Gadamer's concept of authority, insofar that people earn both trust and authority, rather than bestow it on each other, and that as people earn trust and authority, that we come to acknowledge them as trustworthy and authorities in their respective fields. For example, as a friend and I get to know each other better, we learn to respect each other's privacy and as time passes we come to acknowledge each other as trustworthy enough to take a picture using Google Glass of one another(cf. Gadamer, 1960/2004, pp. 291-292). Third, Cunningham et al. argue that my understanding of "how and for what purpose (...) [my] information will be used at present as well as in the future" also influence the way I perceive my sense of privacy (ibid). Basically Google Glass

[94] More specifically, their qualitative study is based on auto-ethnographical and ethnographical research among 37 participants, and mentions many more factors that influenced a participant's picture sharing behaviour. However, I restrict my discussion above to main three factors in their empirically grounded theoretical model that the third author (Adams) developed in earlier work.

offers its user four options to use pictures: view them, share them on Google Plus, delete them, or store them on a computer by connecting a USB cable to Google Glass. In my own experiments with Google Glass I noticed how easy it was to share a picture. After the picture has been taken and shows up on the screen all you have to do is tap the touchpad, and then read aloud the words ‘share with’ and mention the name of a contact that appears on the screen. As all commands show up on the screen sharing happens fairly quickly. So here how a picture will be used is partly shaped by Google Glass itself, and how it will actually be used depends on its user as well. In my view, these three factors offer at least some insight in the prejudices that shape our considerations about a Google Glass user pointing a camera at us. As I noted at the start of this hermeneutic analysis, vagueness about some of these factors might stimulate us to expand our horizon. More specifically, vagueness about the trustworthiness of the Google Glass user, the way that user might use that picture, and/or how the possibility of that user taking a picture might influence the impression we make on other people, might all lead us to respond sharply to, or question Google Glass users pointing cameras at our faces. Adding a red light to Google Glass to show whether it actually took a picture might help to take away some ambiguity with regard to our expectations of whether a Google Glass user might be taking pictures of us. However, from a hermeneutic point of view developing a better understanding of how a Glass user behaves when he or she takes a picture (i.e. speaking to the device, or pressing the button on top of the device), and getting to know that Google Glass user might be much more effective ways to preserve our sense of privacy.

So what can we conclude about the privacy issues raised by Google Glass? First of all, that there is not one single solution that may resolve all these issues in one go. In other words, privacy is not merely a human affair that can be solved through social negotiations about informed consent. Yes, informed consent is important, but as we noticed above, the design of Google Glass, the way the user acts towards the device, and the way other people nearby perceive and understand that user’s voice commands and gestures, also influence our sense of privacy. Additionally, getting to know Google Glass users, and knowing more about the device help to preserve our sense of privacy as well. Secondly, even though the privacy discussions on the use of the camera, and to a lesser extent on microphones, have started, the real privacy discussion on locational data still needs to begin. Finally, the conceptual privacy metaphors of ‘contextual integrity,’ and ‘identity management’ may offer a good start for a more normative evaluation of the privacy issues raised by Google Glass(see Nissenbaum, 2004; van 't Hof, et al., 2010).

5.3 Conclusion

In this chapter I have shown how to use comical Youtube skits to gain insight in the ethical discussion of the new and emerging technology Google Glass. Additionally, I used augmented postphenomenology to structure the discussion on privacy issues raised by Google Glass, and have drawn on some insights from both the history of wearable computing, and ethical literature on privacy to make a few design recommendations for Google Glass. This chapter may have raised more questions than it answered, but hopefully they have shown a way to pursue this ethical inquiry further.

Chapter 6 - Conclusion

In this thesis we have studied Google Glass intensively. We started out in chapter 2 with the question of what Google Glass realistically is. Based on the history of wearable computing and a large variety of sources we sketched what Google Glass currently is, and might become in the near and far future. We then moved on to a postphenomenological inquiry to study the speech and gesture recognition features of Google Glass. Actually, this inquiry raised four challenges for postphenomenology. We addressed these challenges by augmenting postphenomenology through the newly introduced concept mode of exploration. We then shifted our focus to augmented reality, re-interpreted this concept in a hermeneutic / epistemological way, and encountered two additional hermeneutic challenges that augmented postphenomenology with its phenomenological focus could not yet address. We addressed these challenges by combining augmented postphenomenology with five concepts from the hermeneutic theory of Hans-Georg Gadamer. In the fifth and final chapter we explored the current ethical debate in all its breadth through comedy, and more in-depth with regard to the privacy issues raised by Google Glass.

Even though most of this thesis focused on Google Glass, the augmented postphenomenological framework I presented in this thesis will hopefully provide a tool that is flexible enough to extend to wide variety of technologies through the introduction of new modes of exploration, and exact enough to gracefully handle the messiness of empirical reality. In other words, feel free to extend framework in such a way that it addresses both your philosophical theoretical questions, and your more practical empirical questions. Here are some suggestions of my own to further extend the work presented in thesis.

First of all, the work in this thesis has mainly focused on describing three modes of exploration: visual, auditory, and gestures. Many technologies in the past years, though, and possibly in the future, tend to rely on the sense of touch. Just think of all the touchpads on tablets, vibrating alerts on cell phones, and not to forget the keyboard I'm typing this chapter with. So a further inquiry into this mode of exploration might offer some new insights in the way we use smart phones and tablets.

Second, as we studied Google Glass, we often encountered issues related to communication, both verbal and non-verbal. In terms of phenomenology the debate has far from settled (cf. Zahavi, 2001). In terms of hermeneutics, though, Gadamer has said a lot more about it in the fifth chapter on language of his magnum opus *Truth and Method*. Could this work maybe help us to gain a better understanding of those technologies that directly mediate human relationships, such as WatchMeTalk, telephones, Skype etc ?

Third and finally, most of this thesis has focused on describing various dimensions of Google Glass. However, as I have shown in the fifth chapter, there is a whole debate on the various ethical aspects of Google Glass as well. Many of these questions focused on the good life. What kind of life do we want to live? How do wearable computers fit in our lives? Does the virtuous Google Glass explorer exist? Is it just that Google Glass has its current price tag, while many disabled people, who often have a lower income, could greatly benefit from it? These are all questions that demand thorough ethical discussion, and I hope they will inspire fruitful debate for years to come.

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