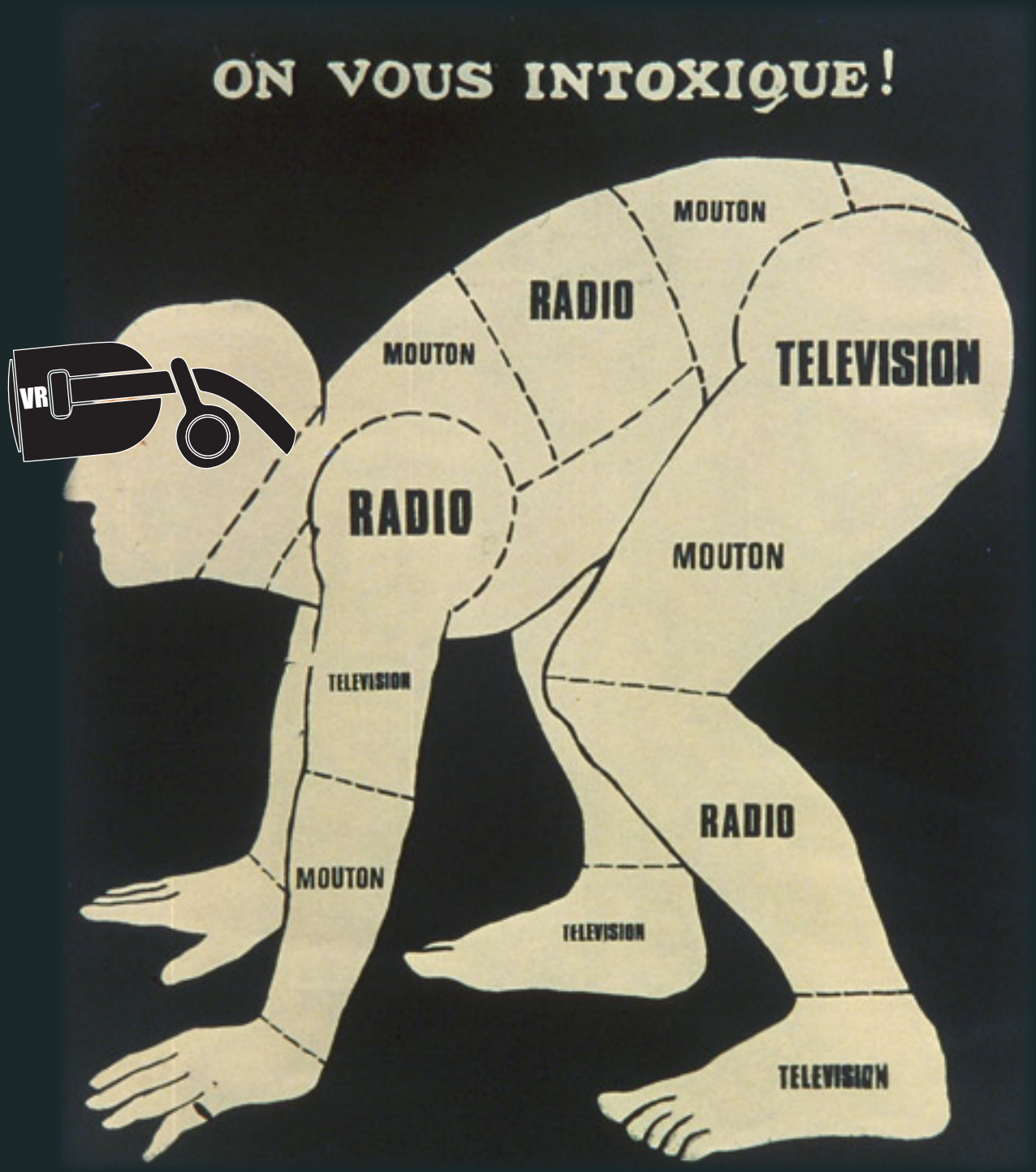
Universiteit Utrecht

In Your Face

An inquiry into historical and contemporary conditions of Virtual Reality



Research master's thesis, Media and Performance Studies, Faculty of Humanities
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Abstract

This thesis investigates the conditions in which virtual reality (VR) has been developing during the first half of 2017. The introduction of a variety of head-mounted display VR systems to the consumer market in 2015 and 2016 has revamped attention to this technology, and with it visions of it being nascent future medium. However, wild expectations have met with obvious and more fundamental issues. From the combined vantage points of social construction of technology and media history, prominent contemporary issues are situated in the context of their historical precedence. Respondents from various Dutch companies involved in the development of VR technology and content creation were interviewed. Additionally, discourse from the first half of 2017 and the historically proximate relevant period of the early 1990s were analysed. From this emerging cultural protocols are found and conditions in the orders of the semiotic and epistemic can be derived. Contemporary disputes over 360 video and 'real VR' bring to the fore how meaning is inscribed into VR as a medium. Epistemic conditions of physiology and the nauseating effects that have been experienced while using VR are found to be at odds with views on computer graphics. Additionally, it is shown how the topos of evoking immersive experience has been interpreted flexibly throughout history. Visions of how VR should be put to use — as a tool to enhance efficiency or as the ultimate form of escapism — are put to the fore as a site of contest in terms of cultural protocols. Amid dystopian and utopian visions, this thesis offers critical insights into the evolution of VR as cultural form. As a historically-informed snapshot, this thesis thus aims to be of use to the future media historian.

"There's an indefinable distance between a technology's potential and the circumstances in which it becomes practical to use that potential"
Howard Rheingold (1992, 102)

"No, no. Technology *is* our culture"
Jaron Lanier (cited in Barlow 1990, 45, emphasis in original)

Cover image: source unknown, but according to Benjamin Dawson, the person who sent it to me, it most possibly is a situationist artwork. Obviously I made a personal attribution.

Acknowledgements

Whilst riding my bike on the way to the library in the final week of working on this thesis, I was listening to *The Vergecast,* a weekly podcast in which *The Verge* staff members discuss technology-related news. The first topic addressed a leaked memo written by a Google employee on the effectiveness of and assumptions within the company's diversity policies. Even though this news was only vaguely related to my thesis topic (Google is among the big players in the emerging consumer VR market) the discussion that followed brought forth some enunciations which align neatly with what I want to address in the most abstract sense in this project. This has to do with the common sense, dare I say *hegemonic* way of thinking, about the relation between technology — therefore including media — and society. Generally, technology and society are seen as two distinct spheres, in which the former influences the latter unilaterally. Lauren Goode, science reporter for the site stated:

> To your point earlier Nilay [Patel, editor in chief of *The Verge*] about you know how technology and culture are so intertwined: I think it is striking a nerve. Because as we are starting to see: as technology gets more and more advanced… you know we look at these things kind of as entities separate from people. You know we use technology and technology is created, but it's easy enough to *remove the human element from it*. But the fact of the matter is: people who are working on coding, who are working on AI, who are working on self-driving cars, who are working on, you know, filters for facial recognition apps or whatever it may me, are human beings! They're human beings and so we all have these kind of unconscious biases that we bring into what we are working on. And there are concerns in the coding world about [...] these biases that sort of exist, what is being sort of built into the technologies we all use (my emphasis, *The Vergecast*, 11 August 2017, citation starts at 00:09:23).

Though it might seem to be stating the obvious, this comment struck me as aligning with the position from which I approach my thinking on this subject. The spheres of technology and society — and for that matter, also the sphere of science, whatever form it takes — should not be regarded as distinct from each other, as usually is done, if they are to be regarded as separate at all. In a reflective statement, Nilay Patel, editor-in-chief of *The Verge*, said that "the thesis of *The Verge* is that technology and culture influence each other, and [Google] is just another one of the biggest most influential companies in the world is exploding into popular culture" (*The Vergecast*, August 11 2017). I consider this master's thesis project on virtual reality to be taking place at this intersection of technology and culture. It thus might not come as a surprise that *The Vergecast* and the website that produces it is one of my favourite news sources. Speaking of influences, this section calls for some serious acknowledgements.

First off I would like to thank Nanna Verhoeff for encouraging me to pursue the research master's programme in Media and Performance Studies at Utrecht University, thus allowing me to further develop my academic skills. Without her 'spotting' my potential I would probably have not ended up here. Second, many thanks to William Uricchio not only for his patience, but also for providing the analytic tools and much needed guidance to tackle this thesis's immanently developing subject. Professor Uricchio's advice leading up to my

first academic publication on podcasting (a somewhat different topic) has also been invaluable. Thanks also to the International Documentary Festival Amsterdam (IDFA), specifically the *DocLab* (new media) department for offering me a job in the 2016 festival that allowed me acquire a unique position and access to professionals in the interactive media industry. On that note the respondents are also thanked for their cooperation. Next I would like to thank my study buddies. Jelke Bosma and Christian Sancto stand out because of their comments on earlier and final drafts of this document. Folkert Coehoorn, Ernee Derckx and Bram Harkema also struggled and stuck with me in the library. Our theoretical discussions on the structures of everyday (student) life helped me to get through the dark period that thesis-writing can be. Of course I wholeheartedly thank my parents for lovingly (and financially) supporting me. Finally there is the biggest figure in my life since I obtained my 'propedeuse': Linda Duits. Our relationship — academically perhaps best characterised and publicly accused of being 'elliptical' (Foucault 1985, 208)[1] — has resulted in you showing me many more places and ways of thinking than all the university education in the world could have taught me. I sincerely hope our love for (new) media, culture, technology, society and each other can stay unconditional, no matter what the form.

[1] In a reply to one of Linda's columns on the 2015 Maagdenhuis revolt at the University of Amsterdam, a commenter by the nickname of 'Basaal' wrote in Dutch: "Achja, is mevrouw Duits ooit wel eens op een feit, waarheid of überhaupt nuttige bijdrage betrapt? Het is de Asha ten Broeke van de meisjescultuur. Ze dankt haar 'bekendheid' aan haar controversiële relatie met een student, maar of dat de competente rebellie is die de UvA zoekt?" (Folia 2015) Foucault provides an interpretation of such an elliptic relationship: in ancient times, two partners, who usually are not on equal footing, benefit and learn from each other (Foucault 1985, 208).

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Introduction

It is often said that virtual reality (VR) will alter our world. Just like with any other new medium, discourse on VR is easily classified within the dichotomy of utopian dreams versus dystopian visions. The contemporary popular dystopian imagination has been crystallised in films like *The Matrix* (1999), whereas utopian dreams envision endless possibilities of VR working in every possible technology-related sector. A fashionable conception of VR's potential is its being an 'empathy machine'. According to a view voiced by prominent VR filmmakers Chris Milk and Gabo Aurora, this machine will ultimately be able to produce world peace (Bye 2017a). The present thesis, however, focuses on the area that lies somewhere in between this dichotomy by looking at what is actually at play in contemporary developments surrounding VR technology. Allow me to name just a few instances that illustrate how VR is, once again, emerging as a medium in the first half of 2017.

Multiplicity is perhaps the word that best encompasses the contemporary buzz around VR, especially when it is considered as a potential mass medium. The following conspicuous observations all emerged within the timeframe of January through July 2017. VR made an appearance at highbrow film festivals and similar institutions while appealing to the desires of the everyday media consumer. In spring of 2017, Oscar-winning director Alejandro González Iñârritu premiered *Carne Y Arena* as the first ever VR project to be part of the Cannes Film Festival Official Selection (Zeitchick 2017). The Venice Film Festival announced that their 2017 autumn festival will feature a competition for VR projects (Vivarelli 2017). In the realm of popular culture, pop artists *Gorillaz* set a new YouTube record by hitting three million views in the first 48 hours with the release of their "surreal 360 virtual reality" music video (Welsh 2017). Major Hollywood studios are producing VR experiences as tie-ins to blockbuster film and television hit series releases (Faughnder 2017; Hanlon 2017). Artworks in the form of VR sculpture experiences are being sold for hundreds of thousands of dollars to galleries including the Museum of Modern Art and the Whitney Museum of American Art in New York City (Giles 2017), while popular GIF aggregator website *Giphy* 'opened' the Museum of GIF Art (MoGA) in a VR application (Nafarrete 2017). VR has also entered the realm of social media: Facebook announced their *Spaces* platform, which allows users to interact with each other and 360 video content in a 3D virtual environment. The platform has been received enthusiastically — at least by the press (Statt 2017). Finally, *Porn Hub*, among the world's biggest pornography websites, released analytics from the first year of available "VR porn videos" which showed that this type of content currently gets half a million views per day, with some local increases in popularity of 250% (Pornhub 2017). All of this indicates that creators, curators and audiences alike are becoming increasingly acquainted with VR technology, with various applications of the technology following in the footsteps of established popular media and cultural constellations.

In terms of VR being put to use at the scale of a mass medium, some numbers show a less enthusiastic response from the average consumer. At the time of writing, several VR systems have been available on the consumer market, most of them for over a year. The market for consumer VR systems is being dominated by major communications technology companies and new media firms. All systems take the shape of 'goggles' or head mounted displays (HMD) that can be found throughout science-fiction from the past three

decades. Interfaces to interact with the content vary from controllers and wands to buttons on the side of the HMD. Facebook sells the Oculus (€450) headset, HTC the Vive (€900), Samsung their Gear VR (€100), Sony sells Playstation VR (€400) and Google sells both their Cardboard (€12) and Daydream (€120) setups.[2] Among these systems there is a variety of setups and affordances: the Oculus and Vive have positional tracking and need to be tethered to an expensive (about €2000 depending on configurations) computer with advanced graphics processors; Playstation VR is an add-on to their popular gaming console (about €300 depending on the model) and both Samsung's and Google's systems require a smartphone of the same brand (preferably one in the price range of €400 to €600) with exception of the Google Cardboard. Each consumer VR system has its own proprietary content platform, but VR content is also viewable on third-party headsets and publishing platforms such as Apple's iOS app store. The most common noted indication of 2016 VR headset sales show that out of a total of 6.3 million devices sold the Oculus is the least popular (with 240,000 units sold) and Samsung's Gear VR is the most popular with 4,510,000 sales (SuperData and Unity Technologies 2017, 16)[3].

Diversity in designs and approaches to VR as a mass or consumer medium show this sector to be an emerging market. According to one source, the revenue of the VR industry in 2016 totaled at $1.8 billion, which is almost nothing compared to other technology sectors like those of the console ($400B), mobile ($678B) and PC's ($718B) (SuperData and Unity Technologies, 2017). These figures strongly contrast the wild projections made for the same period. From 2014-2016, each year has been predicted as being "the year of VR" (Sathe 2014; Feltham 2015; Morris 2015). Even when it was established that consumer adoption had been slower than expected, headsets were announced by new players like Microsoft and Intel. Based on audience research, the BBC concluded that even though crucial issues like price, ease of use and compelling content still need to be resolved, "VR in-home entertainment definitely has massive potential" (Fiennes 2017). These discursive enunciations take on the familiar tone of hyperbole. For instance, projections of the near future estimate the VR sector to grow to between $21.5 billion and $27.4 billion in 2021, with the specific application of VR arcades reaching $45 billion in 2025 (Statista 2017; PWC 2017; Stone 2017). At the same time, the emerging market experienced some setbacks. In May, Oculus pulled the plug on their two-year-old internal animation production Story Studio (Lang 2017). Alt Space, one of the earliest social spaces where VR users could meet, was forced to shut down in August because they had run out of money and their investors had decided to not invest any more (Bye 2017b). Sceptics claim that these events are the writing on the wall for VR, perhaps because they are familiar with this rhetoric from the earlier wave of VR technology in the 1990s.

It is within these rumblings that the future form of VR as a medium is being moulded in the present. Indeed, I choose the contemporary moment as the site for my research precisely because it is trembling or bursting with diverging interpretations and innovation. At the same time I am inspired by (media) historians and thus will not leave out the precedents for contemporary practices. Today audiences have access to a

[2] Prices based on those found in online stores of the vendors as of August 2017.

[3] This number excludes Google Cardboard sales: with 88 million units sold the total of VR devices reaches nearly 100 million. Other systems sold: HTC Vive 0.42 million, PlayStation VR 0.75 million, Google Daydream VR 0.26 million (SuperData and Unity Technologies 2017, 16).

'new' category of consumer technology within a competitive market, whilst fundamental questions on how to create a technically compelling VR experience are still being researched. The main enquiry of this thesis can thus be formulated as follows: What are some of the conditions that VR — considered as a 'new' medium with distant and proximate historical precedents — is developing in? Some numbers were provided above to sketch out the contours and underline the actuality of recent developments in VR enterprise. However, economic circumstances are explicitly not an interest in this thesis, nor are the ideas and opinions of the general public. The conditions I am looking for can be considered at the same time obvious and more profound. Among the obvious I consider the practical issues that are at stake when it is considered socially awkward to wear a HMD, or the nauseating effects the goggles are believed to create. This stops people from wearing or buying VR systems and indicates this is not the path to becoming a successful popular medium. At the same time some issues can be considered more profound. This is because I assert that in thinking and talking about new or future media, fundamental ways of thinking about technology come to the fore.

From the outset this thesis starts from a paradoxical position because it is concerned with a medium as a technology that is emerging, destined to take shape in a cultural form (cf. Williams 1990). Sociologist and philosopher Willem Schinkel recently formulated this paradoxical position of technology as follows: "the temporal-paradoxical character of technology lies within the fact that technology makes the future actual in the present, in how contemporary technology refers to a time beyond the present, but it can only do this in the contemporary" (Schinkel 2017).[4] My interest for VR as an object for this thesis does not focus strictly on technology itself nor on the actual content that is created for it. What interests me is how this technological setup is imagined, or rather pushed, to be put to use as a medium as it takes its place among the many popular media technologies already in existence. The future form is taking shape through frantic discourses and a plethora of material conditions simmering right under our noses.

Art historians and media scholars have trained a historical eye on the development of 'new' media (Crary 1990 and 2000; Gitelman 2006; Marvin 1990; Williams 1990). Their studies show how media develop within dynamic historical conditions. It is within conflicts over meaning, cultural protocols, and regimes of knowledge that the shapes of media are formed. Moreover, historical relations to earlier periods lay bare how old conceptions and practices around media resurface in the present. From the angle of the historical development of technology, studies have shown how technology's artifactual form and the place it takes in society are influenced by various users with distinct dispositions (Pinch and Bijker 2012). By combining these positions I aim to analyse contemporary ways of thinking about VR by drawing from the past as a way to locate the present and the future. Consider what I am presenting as a limited 'snapshot', written in anticipation of future media historians.

This thesis is structured as follows. The next chapter is concerned with the organisation and motivations behind the accumulation of the empirical data — consider this a method chapter if you will. Here the theoretical framework of social construction of technology (SCOT) is taken as vantage point for the analysis. This approach is combined with influences from media-historical research. Since this study was conducted in

[4] This is my translation from the Dutch original: "Het temporeel paradoxale karakter van technologie ligt dus in het feit dat technologie toekomst actueel maakt in het heden, dat hedendaagse technologie verwijst naar een tijd voorbij het nu, maar dat alleen in het nu kan doen."

the present, interviews with a small number of respondents have been supplemented with research into public discourse on VR in two distinct timeframes.

The third chapter shows how some conceptual concerns around VR have historical roots that reverberate in the present. 360 video is the main concern here. It is discursively disambiguated from what respondents described as ‘real VR’. Deeper historical lineages to 360 videos can be found when compared to the technique of panorama. In the fourth chapter, the roots of what the respondents described as ‘real VR’ are found in the 1990s when an earlier encounter between VR technology and mainstream audiences occurred. Though both 360 video and ‘real VR’ aim for immersion or presence, a variety of conceptual approaches and technologies are used to construct these types of experiences.

This brings us to the fifth chapter in which ‘immersion’ and ‘presence’ are analysed in terms their telos and topoi. Once again going back to the origin of the term ‘virtual reality’, contemporary practices show interpretive flexibility in technologies that aim to evoke immersion. As we will see, the distinction between 360 video and simulated virtual environments at this moment in time brings forth a yearning, voiced by most of the respondents, for the conversion of these two approaches in volumetric captures.

The sixth chapter aims to tie the findings of the earlier chapters together and through this lay bare some of the conditions that VR is developing in. In the composition of the snapshot offered by this thesis, the figures of epistemological conditions, cultural protocols, and semiotic struggles are found among the problems and yearnings voiced in the data. These findings are understood in terms of the historical studies mentioned above. This then allows us to return to the paradox of technology in the conclusion. Since we are only able to speak of the future in the present, what we have found does indeed matter for the future. This brings me in the position to argue that the future form of VR as a medium is not simply that of a technology, but is as much decided by the culture in which it develops. Eventually I ally myself with Raymond Williams and his notion of cultural form. If VR is going to alter our world, we should indeed enquire into the conditions of the cultural form it is going to take.

1. Assembling the empirical data

1.1 Primary research frames: where SCOT meets media history

If we want to examine the way in which a technology develops, we should recognize that technologies take shape in society, *through* society. This, briefly put, is the position of those who describe themselves as social constructionists. Their research method has come to be known as social construction of technology (SCOT). By taking on a multidirectional approach in which the diversity among designs of technological artefacts or systems are key, this position is explicitly anti-deterministic. Though some conceptual differences can be made among social constructionist approaches — specifically with regard to levels of analysis and the ontological status of the actors— the focus is on the issues around technology brought up by the actors involved (Bijker, Hughes and Pinch 2012). Central terms in this historically-oriented approach are *socially relevant groups*, *interpretive flexibility*, and *closure*.

Socially relevant groups are actants who share a certain disposition from which they formulate and voice issues with regard to technology, specifically surrounding artefactual design. It is the dialectic between socially-voiced issues, possible design changes, and subsequently socially-accepted solutions that constitutes the process through which technological artefacts take shape. An exemplary social constructionist study has shown how the form of the now commonly known 'safety bicycle' developed (Pinch and Bijker 2012). By showing the interaction between social issues and bicycle designs over a period of about twenty years, the evolution of this widely-used technology is conceptualised in a multidirectional, not linear, model. It is the multiplicity of designs that show interpretive flexibility, which is defined by Pinch and Bijker as "not only that there is flexibility in how people think of or interpret artifacts but also that there is flexibility in how artifacts are *designed*" (Bijker, Hughes and Pinch 2012, 34 emphasis in original). To illustrate this using an example from the Netherlands, one can recognize how the social group of the elderly women wearing dresses gave rise to a particular type of bicycle. Known as (in Dutch) an 'oma fiets', or 'granny bike', this two-wheeler features a design in which the horizontal bar that usually connects the front part to the seat section of the frame is lowered so it is easier to mount whilst wearing long dresses.[5] Other social groups require different affordances according to their disposition. For instance, those who compete in the Tour de France have speed as their main objective, so their bicycles are designed featuring gears and thin wheels. Interpretive flexibility then shows how dispositions regarding the *use* of a technology can influence iterations in designs. The iterations of the racing bike and granny bike however are not as radically different as earlier designs from before the invention of the safety bicycle (Pinch and Bijker 2012). Technological development thus takes place in a multidirectional iterative process that, from a social constructionist standpoint, is structured predominantly on the basis of issues raised by social groups.

This brings us to the last central term for social constructionists: *closure*. After an initial period of radical variation and innovation, technological designs seem to stabilize towards a certain standard form — like the 'safety bicycle' mentioned above. This process is called closure and should again be understood in

[5] The names of these designs obviously are not fixed: they equally have a socio-historical connotation. Speculating a bit, I would argue that influence of second-wave feminism, combined with the changes in women wearing trousers becoming more fashionable, contributed to the name of the bicycle design being changed from 'lady bike' to 'granny bike'. On the more factual side, this bicycle design features protective casings for the chain and rear wheel so clothing doesn't get caught. This is to say: culture reflects in artifactual form and semiotic designations. We will see this again in chapter 2.

terms of socially-voiced problems. As Bijker, Hughes and Pinch define the term: “closure in technology involves the stabilization of an artifact and the ‘disappearance’ of problems. To close a technological “controversy,” one need not *solve* the problems in the common sense of the word. The key point is whether the relevant social groups *see* the problem as being solved” (2012, 37 emphasis in original). This shows how social constructionists do not focus on the materiality of technology and the abilities of designers being able to solve problems; rather, they analyse the positions social groups take up with regards to technological developments.

Ample historical academic work on the development of various media technologies in the times in which they were new can supplement the social constructionist position. Authors such as Carolyn Marvin, Raymond Williams, Jonathan Crary and Lisa Gitelman have a keen eye for the bigger socio-historical circumstances in which debates on media technology develop. Combining the SCOT and media-historical approaches is productive if we are looking to glimpse the possible shape of a future media form. Firstly, I have ‘unique’ access to the present conditions of VR development. Talking to people involved in VR technology development provides me with an ‘insider’ perspective; it allows me to analyse contemporary discursive formations in such detail that no historian could ever retrace. Secondly, by putting these findings in a historical perspective the approach touches on emerging cultural protocols surrounding media. This allows me to argue in the third chapter how these issues can be understood as being part of the meaning-making process that underlies the process of media development. Finally, interviews combined with discourse analysis are able to show how socially-voiced problems are not merely practical but deal with more fundamental ways of thinking about VR as a medium. This is where the ‘humanities’ angle of media historians is appended to the SCOT approach. Indeed, scholars like Gitelman and Crary focus and press on the problematic notions that the practices surrounding new technologies have to negotiate. From such a orientation they are able show how these ideas fight for acceptance in a tense discursive field. It is within this perspective that I aim to bring forward a snapshot of the discomfort that is experienced around VR’s contemporary form of the HMD.

1.2 Selection and acquisition of data

1.2.1 In the first half of 2017

As noted in the introduction, in the first half of 2017 we find a multitude of VR systems on the consumer market, with more systems being announced continually. The HMD seems to be the form that the mass consumer market VR systems are tending toward, and it was thus decided to be the main research object.[6] Within the discourse surrounding VR a myriad of problems can be found clinging to this artefactual form of the HMD. Among the most prominent are users experiencing nausea or other types of physical discomfort, as well as the social awkwardness of wearing a screen on your face, especially in public. Other issues include ease of use of the hardware, discovery of content, and current poor user experience (Fiennes 2017).

[6] Of course, there is ample historical legacy to other types of VR systems we find available at average consumer price points in the first half of 2017. VR systems have been in actual use for quite some time now in various sectors outside of the consumer market. Pilots can utilize specific simulators to keep up their flight hours and hobbyists around the world build cockpits and simulate all types of aviation through *Flight Simulator.* In medical applications rehabilitation installations in the form of CAVE like projection systems. A plethora of interactive art installations combine techniques in various ways. This to show that the popular artifactual form of the HMD was not always the dominant form for VR (see also Rheingold 1991, 99-100).

Compared to other popular new media forms such as the gaming console or smartphone, some VR systems are relatively expensive. Additionally, the new form of content puts audiences and producers at odds with each other over attention. Whereas previously the director was in control over what was seen, 360 videos and simulated environments give agency to the audience: they are free to turn their heads and not focus on the action. VR technology thus marks at least a slight shift in control over the framing of the image from the director to the spectator. This shift is familiar to those working in the interactive media sector, but new for filmmakers venturing into 360 video production. With exception of the last issue, all of these problems are not clearly tied to one social group; instead they are issues that, with the contemporary technological form of the HMD, could be voiced by almost anyone putting on a VR headset in the first half of 2017. As mentioned earlier, this study should not be considered as an economic or audience study. By focussing on socially-voiced issues I aim to bring to the fore the conceptual conditions that those who play a role in VR technology and content development work with. There are several motivations behind this.

First, the selection criteria of my respondents was adapted from being merely representatives of social groups to being industry professionals that are connected to socially relevant groups. Ranging from 360 video producers to technology developers, researchers, investors, and entrepreneurs, portraying a wide range of positions which are in some way or another invested in VR technology can be considered the guiding principle for the respondent selection.[7] Second, the added value of using VR or interactive media and technology professionals as informants for this research project is the ways in which their professional position informs their social position. Not only are they more knowledgeable about the subject because of their proximity and involvement in the development of technology and content; their discursive enunciations are also embedded within a specialised discourse on the contemporary situation. Moreover, their disposition generally includes a more detailed short- and long-term vision on where the technology is going. This adds the dimensions of time and imagination to the data, since within SCOT the only agency that the social groups have is voicing, accepting ('translating' in Bruno Latour's sense) or rejecting solutions to problems. Finally, all of the respondents were experienced with the most popular present day VR systems and their various affordances; such a sample would be hard to gather using merely audiences. Nevertheless, one should realise that the respondents fall within overlapping social groups and are themselves also consumers and audience members.

Data in this study is predominantly based on a sample of nine interview respondents supplemented with public discourse on VR. Respondents were approached for an interview through both informal and formal professional connections I set up whilst working at *DocLab*, the new media department at the International Documentary Filmfestival Amsterdam (IDFA) in the second half of 2016. In this sense the selection was based on my professional disposition as well: it gave me unique access to people in the industry. The selection and scope of the sample was limited to Dutch respondents due to the preference for face-to-face, semi-structured interviews, each of about one hour in length.[8] A majority of the interviews took

[7] This could lead one to consider this study within the tradition that has come to be known as production studies (see Mayer, Banks and Caldwell 2009). Though I am very sympathetic to the academic practice of production studies, I would argue that the majority of these studies focus on ideologies behind content creation, and not the technological, semiotic or epistemological conditions I am investigating.

[8] Transcripts of the interviews are available upon request. For privacy reasons, the names of respondents have been left out of the Utrecht University thesis repository version of this document.

place in professional work environments. At the start of the interview, the thesis project and SCOT example of the bicycle was explained to the respondents.[9] Some of the respondents knew each other personally, either from the Dutch VR community or from business dealings. As far as social groups go in this respect, respondents regarded themselves to be at least part of a professional group that is involved with VR technology.

Among the respondents, a broad categorization can be made between what I designate as 'entrepreneurs' and 'researchers'. All of the respondents work for a bigger institution or company, with the exception of the self-employed independent developer. Within the category of entrepreneurs I consider those who work for a company that is relatively young and primarily invested in making a profit out of developing VR technology and content. The independent developer, the CEO of a VR co-working space, the 360 video producer, and the CFO of a Dutch VR software startup all fall in this entrepreneurial category. The research category is composed of a creative developer, a physiologist and the three interaction designers at a Dutch multinational consumer technology firm. The companies and institutions that these researchers work at have a more vested position in the various branches of the technology sector in the Netherlands. Because of this, they are less dependent on the contemporary developments surrounding VR than the entrepreneurs. These companies and the respondents only sometimes integrate currently-available consumer VR systems into their products. (A complete overview of the respondents and descriptions of their enterprises can be found in Appendix A.)

Some explanations regarding the sample size and duration are in order. The selection of nine informants might seem arbitrary: VR is developing in a globalised world, so only talking to Dutch respondents might appear to be an unjustifiable restrictive choice. To this I would counter that, firstly, access to the respondents outweighed their representativeness as social relevant actors. The focus indeed was on discovering their respective positions to current issues both raised from their viewpoint and found in public discourse. Secondly, the interview (in the researcher's native language) is a tool that provides the data from which categories and structures of thought can be abstracted, as will be shown in the results. A second possible objection: even though I emphasize the importance of the current timeframe, in terms of technological development the research period could be considered unduly short. Seeing that the development of the standard bicycle and many media forms usually takes several decades it is indeed not possible to consider this study a proper genealogy. Nevertheless, the selection of the respondents and accumulated interview data allowed me to infer abstract ways of thinking about VR by comparing the respondents' various positions. Above all it should be kept in mind that the aim of this project is to provide a snapshot, not a complete picture, to be of use for future media historians.

The limits of the sample — nine respondents from only partially related industry positions — were sought to be compensated by additionally analysing public discourse on VR. This discourse was analysed by following a selection of predominantly US-based websites, newsletters and well-known mainstream publications specialising in VR and new media technologies from January to June 2017. English-based

[9] It must be noted that among the respondents an eagerness to talk about augmented reality (AR) as the more acceptable future form of audiovisual content was present. Struggles over meaning and application of AR versus VR are left out of this analysis. In the view of the creative director AR is "VR content without the background" and does not encounter social awkwardness because the goggles are see-through. Such conflations over meaning can suffice as a topic for another thesis.

sources were chosen over Dutch ones primarily because of a lack of the latter, both in terms of availability and quality. Moreover, sometimes respondents referred to some of the English sources. Specialised publications include the *Voices of VR* podcast, *Road to VR*, *Upload VR*, *Haptical*, *VR Scout*, and *The Verge*; other sources include *Wired*, *Variety*, *The Los Angeles Times*, *The Guardian*, and *The New York Times*.[10] Because the collection of the data was an ongoing process, some interactions between VR-related news events occurred and were occasionally discussed in the interviews. Sometimes follow-up questions and answers were discussed, but this correspondence was left out of the data sample because they did not offer any additional insights. Therefore, all citations in this document are directly quoted from the interviews. After the interviews and contemporary discourse analysis had been completed, additional research into VR discourse in the 1990s was conducted.

1.2.2 In the early 1990s

During the interviews, some respondents indicated that the current hype around VR had a certain historical precedent. For instance, the CEO of a VR co-working space described the contemporary available products in terms of a "wave" — he remembered how as a child in the nineties he got Nintendo's *Virtual Boy* as a gift. Indeed, in the period of the early 1990s we can find a wave of commercially available VR systems. These configurations are strikingly similar to some of those that are available on the market in the first half of 2017. By analysing the discourse surrounding these early VR setups that were available for the masses, this proximate historical period was excavated to dig up emerging cultural media practices and issues surrounding VR technology. This then invites us to compare the early 1990s discourse to the findings in the contemporary moment. What ways of thinking remain? And what kind of problems have been addressed?

To get a grip on the amount of attention payed to VR from the 1990s up to now, an analysis of newspaper articles was conducted by using the Lexis Nexis database (see Appendix B for a graphic representation of this). Among the search results from Lexis Nexis, articles of major news outlets (*The New York Times*, *The Guardian*, *Forbes*) were analysed in terms of what kind of VR technology was described, what kind of possibilities were imagined, and what problems were voiced. In addition to these news outlets, archives of more specialized magazines (*Rolling Stone*, *Mondo 2000*, *Wired*, *Scientific American*) and some peer reviewed publications were used as resources. The selection of the issues (which will be discussed as findings in the following chapters) is based on their prominence in the interviews as well as older and more recent discourses. Due to the amount of material found, the analysis below is based on sources that stood out. Thus, the overall analysis should be regarded as exemplary, not exhaustive.

[10] Some of the bigger publications are also producing and publishing 360 videos, the approach to and contents of which were left out of this analysis for reasons of size and scope.

2. Conflicting meanings over VR

As a vantage point I take a prominent contemporary dispute over the term 'VR'. As noted, ample 360 video content is being produced and published online in the first half of 2017. Moreover, the range of spherical cameras and platforms that can record and publish 360 audiovisual content has settled on fairly accessible price points, boosting the production of content. The appearance of this 'new' type of content creates a field of tensions over what meaning should be ascribed to it.

In this chapter this conflict is firstly situated in present-day discourse in the popular press and in a local example provided by the respondents. Additional discursive enunciations show that 360 video's claim to VR is conceived and problematised of in terms of 'the cinematic'. Finally a historical zoom-in on audiovisual immersive entertainment practices provides access to the fundamental motivations of their creators. My analysis will show how the conflict over 360 video claiming to be VR can be understood in terms of two distinct conceptual categories. For 360 video, the contemporary technology forces it to stay within the category of the panoramic. In the chapters hereafter, a dive into the historically more proximate period of the 1990s reveals distinguishing factors that can set 360 video apart from 'real VR'.

2.1 Stop calling 360 video VR

In 2015 *The New York Times* shipped a cardboard HMD viewer — a version of the Google Cardboard — with their Sunday newspaper and announced that they would be publishing 360 content through their *NYT VR* smartphone application. This led popular tech magazine *Wired* to demand to "Stop Calling Google Cardboard's 360-Degree Videos 'VR'" (Smith 2015). In a piece on immersive entertainment experiences, *The Verge* reporter Brian Bishop acknowledges how "virtual reality — itself a form of immersive entertainment — is having [a problem], with room-scale experiences and 360-degree Facebook videos all casually labeled 'virtual reality' in the name of marketing. In the end, the names cease to mean anything at all" (Bishop 2017). In the interviews, this notion of the meaning of VR and its conflation with other forms of media was also present, because of a very local example.

Most respondents were also quick to disambiguate 360 videos from what they called 'real VR'. Out of the respondents, those who were involved in the actual production of VR content all mentioned the VR Cinema as a problematic entity for larger audiences to get acquainted with the technology as a medium.[11] The publicly accessible VR Cinema was opened in Amsterdam in 2016 by media and event company &Samhoud. Clearly modeled after a very familiar form of mass entertainment, it introduced a fairly large audience to 'VR'.[12] The 'cinema' is comprised of about 30 swivelling chairs in which spectators take a seat before they put on a Samsung Gear VR headset and headphones. A very limited choice of 'documentary' or 'thriller' type of content is offered on the spot. After the HMD is mounted and determined to be comfortable and working, a 360 video of about 15-20 minutes is played. In this, the notion of 'VR' is put in the cultural form of 'cinema' whilst screening a specific type of content: 360 video. Thus the VR Cinema mashes up the

[11] In the group of respondents involved with the 360 video productions I count the CEO of the VR co-working space, the creative director, the 360 video producer and the independent VR developer. For an overview of the respondents, see Appendix A.

[12] &Samhoud was neither available for an interview nor willing to disclose the amount of tickets sold when contacted. The *VR Cinema* opened up a venue in Berlin which had to close because they could not accumulate sufficient ticket sales (personal communication from a former employee at the Berlin *VR Cinema*).

meanings that are prescribed to them by various social groups: the larger audience, traditional filmmakers and 360 video or VR producers.

Though the *VR Cinema* provided a semi-collective, quasi-cinematic experience by providing HMDs to a group of people, the 360 video content shown problematises some of the affordances of VR technology. According to the independent VR developer respondent, setups like the VR Cinema have an effect on the public perception of VR: “I think that most people experience VR as a 360 video, which makes them think 360 degree video is VR.” The 360 video producer and one of the interaction designers at a Dutch multinational consumer technology firm voiced similar issues with the VR Cinema. If these respondents can be considered to be part of a social group producing VR content, this overlap in interpretation of the term ‘VR’ is problematic since it gives the wrong impression — save for the 360 producer whose interest it is to sell 360 videos and sees the cinema as a familiar way to distribute his/her works. The prominence of 360 video claiming to be VR, in practices such as the VR Cinema, shows VR to be understood in the terms of the familiar experience of the cinematic.

2.2 Cinematic framework

Also on the side of the producers, contemporary views on 360 capturing technologies are predominantly being conceived in terms of being cinematic productions. Writing from his experience as a director, producer, and head of post-production for several VR production companies, including critically acclaimed VRSE and Milk(VR), Armando Kirwin has reflected on the state of the “360 film industry” (Kirwin 2017). As a pioneer in the field of 360 video productions, Kirwin describes elements of the production process that until recently were obstructively costly, such as the assembly of 360 camera rigs, stitching software, and distribution platforms. Kirwin compares the current state of the 360 industry to that of the development of film where “the transition to digital technology democratized the playing field” (Kirwin 2017). The release of consumer products that enable the production of 360 video has made the field more accessible: “[t]his all seems so logical in hindsight, but we ignored the obvious lesson that the means of production in Hollywood was once proprietary and eventually became completely democratized…and that it was inevitable that 360 film would quickly follow this exact same path” (Kirwin 2017). In terms of SCOT we can recognize a relatively quick stabilisation of 360 video capturing technology, understood with reference to the media-historical and hegemonic Hollywood production model.

When asked, the respondent who works as head of post-production at a VR production company in Amsterdam (the 360 video producer) agreed with Kirwin’s analysis. This respondent can be categorised in the same professional and social group as Kirwin, for they have similar tasks in the production process and portray the same struggles. The Amsterdam-based VR production company also built their own 360 camera rig and struggled with the hardware and software; but as a team they also struggled with translating storytelling techniques: “[Newcomers to the field of 360 production] can work with [new and publicly available] gear without all the problems we encountered, and look at what was made before […] this is an advantage for them, but at the same time they might not yet understand the inner workings of the medium, because they lack experience.” These problems indicate that in production strategies the 360 video technology and the familiar cinematic form clash.

Comparisons to Hollywood and traditional cinema hint at the tactic of narrative, but this storytelling tool is problematised by 360 captures. This not only has to do with the current state of 360 cameras, but also with the conventions —the "standardized way of doing things" (Becker 2008, 56) — of the cinematic.[13] The new perspective for the viewer forces producers to break with conventions: "We are learning to sacrifice the surety and control that comes from linear narratives. It's why we're investing an awful lot of time and energy into developing new visual and spatial audio cues that guide users through an experience" writes "socio-political storyteller" James Hedley (Hedley 2017). "Emerging" film director Ilya Rozhkov stated that "shooting a movie in virtual reality requires a different mindset and skills" because "[i]n 360-environments it's very hard to force the audience to direct their attention towards a certain point" (Ergürel 2017). Attitudes and considerations like these were also voiced by the 360 video producer respondent: "You have to consider it to be a completely different medium […] I think that guiding the viewer is very important to improve storytelling in a way." Approaches to guiding the viewer are well developed in areas ranging from museum exhibitions to gameplay, but the dominance of the cinematic framework seems to make the 360 video producers tend towards reinventing the wheel. However, 360 videos themselves can be considered to already have conventions of their own.

When cinematic conventions are broken, new ones for 360 videos quickly appear. These are constructed and constrained by both the physiological effects and the familiar cinematic frame of reference that the producers work from. The contemporary arrangement of the HMD and the 360 video camera force the viewer to stay on the exact spot. Disjunctive positional movement by the camera or the body produce equilibrium conflicts, causing nausea and other physiological problems (see also 3.3.3). Moreover, the possibility to look beyond the frame, in a 360 sphere, problematises other traditional storytelling techniques. In his production practice, the producer voiced some new conventions and noted how he tries to go against it: "at first people said 'you can't edit in 360 […] it's confusing and makes you nauseous, it takes you out of the story'. But I am trying to find new ways of editing, camera movement for example, that go against the status quo to see if there are other ways to, for example, speed up an edit." Here we see how the conventions of the dominant cultural form of film (the cinematic) enters into conflicts with the affordances of 360 video technologies. This is problematic not only in the practice of video producers but perhaps more clearly when it comes to the understanding of how VR is understood as a medium. The practical and conceptual problems surrounding 360 video seem to be a still-unresolved issue by the first half of 2017. This is because it is only in the past couple of years that affordable 360 cameras and systems on which to view this type of content have become available, the popularity of the latter being as widespread as the amount of cardboard devices sold (see footnote 4). A look into the past of audiovisual immersive entertainment practices can bring in deeper historical motivations to the constraints of contemporary conventions. In turn, this can inform the dispute over 360 video claiming to be VR.

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[13] Deniz Tortüm, though not talking about 360 video, has rightly noted that the notion of what is considered to be cinematic suffers from the hegemony Hollywood has over the term: "Most VR practitioners or academics say, 'VR is not a filmic medium. It is not cinema. It is completely something else. It is its own medium.' But when they say it is not cinema, they are generally thinking of one particular strain of cinema, which is probably the mainstream Hollywood cinema. The thing to remember is that cinema is not one unified medium. There are lots of different cinema histories. I think that several of them, especially the ones that are obscured by mainstream cinema, the more experimental traditions, have much more to inform VR practice today." (Lacey 2017). Conventions are also reconsidered in other cultural forms of media, such as live broadcasting. A host from Belgian broadcaster VRT described live reporting with the use of a 360 camera as "learning to walk again, to learn my job again" (Scott 2017).

2.2 Deeper history of immersive entertainment

Immersive experiences, whatever shape they may take, are not new. Investigating the meaning of the contemporary notion of 'immersive entertainment' in popular culture, Bishop writes: "[i]t may sound a little futuristic, like the world of gaming bleeding into our waking life, but audiences have already been enjoying immersive entertainment for decades under a different name: theme parks" (Bishop 2017). This quote shows how the framework of interactive virtual environments is related to the feeling of immersion. Bishop considers theme parks to be an original form of immersive entertainment. However, theme parks should historically be considered only one of the fairly recent iterations of entertainment installations that are supposed to allow the viewer to be transported elsewhere.

A more fundamental type of installation that aims for immersion can be found in the panorama. William Uricchio sheds a light on the "deep history" of the panorama and the abundance of iterations that can be found in the history of modern Western Europe since the eighteenth century (Uricchio 2011, 231). In the patent concerning the panorama, granted to Robert Barker, we find an unambiguous enunciation of the goal of immersive installations: Barker (cl)aims to make the viewer "'feel as if really on the very spot" (Uricchio 2011, 226). I follow Uricchio in regarding the panoramic as "a particular set of strategies for achieving this virtual and immersive state, standing as a technological constellation that enjoyed a certain prominence and persistence" (Uricchio 2011, 226). In the contemporary situation we can see how older yearnings pop up again in contemporary considerations and practices with regards to commercially available VR technology, especially when VR is considered to be the next mass medium. From this perspective I assess the longing to experience a medium that transports you elsewhere as a topos, or indeed "a red thread of interests and strategies that can be followed across history and media forms" (Uricchio 2011, 226; see also Huhtamo 1997 and 2011).

As seen in the example of the VR Cinema (see section 2.1), respondents often expressed concerns over affordances between the approaches of 360 video and virtually-simulated environments. Moreover, respondents projected technological innovations into the near future that would provide a fix for these concerns (see section 4.3). Such a position would import the trope of linear technological progress into developments in VR technology. This understanding of history, however, is irreconcilable with a social-constructionist position; as Uricchio writes: "we might be inclined to look at the long haul of development, from Barker's painted circular canvases and framing devices to QuickTime, and argue (mistakenly, I think) for a teleological notion of technological progress and with it strategies to provoke immersion" (Uricchio 2011, 236). Looking at the realm of 360 captures, we have seen several strategies and conventions come to the fore that aim to fulfill a yearning for immersion. In the contemporary situation, we find a social group of mostly traditional filmmakers coming into the actual practice of creating moving panoramas — for them a completely different medium. However, the cinematic conceptions remain constrained by the technological possibilities of the panorama. At present, the viewer has to stay put in the exact same spot as the camera was to feel as if they are on the spot that is represented. Thus we find in the conflict over 360 video claiming to be VR not a progression of sorts, but transgressing and re-emerging of frameworks and topoi: the cinematic, the panoramic, and immersion. Now that we have investigated the contemporary practices and frameworks of the 360 video side as fitting within the historical order of the panorama, the question as to what constitutes the category of 'real VR' still remains to be addressed.

This chapter has analysed how in the first half of 2017, the technology of 360 video captures is making a claim to be understood as VR. In the contemporary situation, we find a dominant cultural framework of the cinematic, with filmmakers venturing into 360 relying on the terms and techniques acquired through their work in cinema. By shedding a historical light on the practice of the panorama and comparing it to contemporary conceptions, 360 video production and other media conventions are shown to be in conflict. By tracing the deeper history of the panorama, it was argued that 360 video does indeed remain within both the conceptual category and the practices of the panorama. When the 360 video producer's moving panorama productions encounter mass audiences, it makes a disputed claim to being VR. Various positions in the field are of the opinion that 360 video should be disambiguated from what they designate as 'real VR'. In order get a sense of what constitutes 'real VR', it will be incumbent to return to the emergence of the term in the 1990s.

3. VR's historical precedent from the early 1990's and contemporary reverberation

As we have seen above, respondents disambiguated the contemporary approach of 360 video from 'real VR'. This chapter aims to put present 'real VR' (discursive) practices into a historical perspective by returning to the origins of the term 'VR' in the 1990s. In the proximate period of the 1990s, early promises and problems together formed conceptual categories that still play a role in today's VR discourses and practices. Moreover, the rudimentary artifactual form of VR from 25 years ago looks surprisingly familiar to the type of systems available on the consumer market in the first half of 2017. What is found in the advent of the 1990s is the emergence of cultural protocols (Gitelman 2006) and topoi (Huhtamo 1997), that recur in the contemporary understanding of 'real VR'. In what follows, an outline of the waves of attention payed to VR is provided. In these early public experiences with this new technology the telos of VR was formed based on imagined possibilities and prominent problems, many of which continue to reverberate today. Aligned and infused with the results from the findings in the archives, the contemporary moment is taken into consideration. This will allow me to highlight the interpretive flexibility surrounding VR today.

4.1 Contour of VR waves 1989-2016

Using the Lexis Nexis database, it was found that the earliest appearance of the term "virtual reality" in public press releases occurred in 1989. An increasing amount of articles containing the combined search words "virtual reality" is published from then on up to 1995, with almost 3000 results (this was the year Nintendo released the *Virtual Boy*). In the five years after this, the amount of search results drops but stays at around 2500 per year. The turn of the millennium sets a lower range of between 1100 and 1500 articles per year. It is not until 2014 when products like the *Oculus DK2* come to market that numbers surge again, hitting almost 3500 in 2014 to over 19.000 in 2016. (See Appendix B for a graphic representation of these news waves.) This indicates that ample attention was paid to VR in the 1990s.

4.2 Early VR technology and imagined possibilities

From the perspective of the present, the similarity of the shape of VR technology is perhaps most striking. If Barker's patent from 1787 is taken as an Archimedean point for the panorama's history (see chapter 3.1), then the *Reality Built for Two* (RB2) VR system could be regarded as such for 'real VR'.[14] Developed by (among others) Jaron Lanier — to whom the coining of the term 'virtual reality' has often been attributed — at VPL research, this setup combines many of the technologies and idea(l)s that can be found today (Blanchard et al 1990). Combining an HMD (Eyephone) with interface gloves (DataGloves) or full body suits (DataSuit) hooked up to a computer, multiple people are able to share experiences in virtual worlds (Ceretas 1990). The topos of immersion is found here in combination with positional tracking and computer generated images:

> A user wears a special helmet that contains two small television screens, one for each eye, so that the image appears to be three-dimensional. The helmet prevents anything except the image from being seen, immersing the user in the simulated scene. A sensor mounted on the helmet keeps track of the position and orientation of the user's head. As the head turns, the computerized scene shifts

[14] Leaving out obvious earlier historical inventions such as Ivan Sutherland's 'ultimate display', Mortan Heilig's Sensorama and Scott Fishers 'Aspen Movie Map' from the 1960s (see Rheingold 1992). *Reality Built for Two* stands out for it contains most ideas that resonate today.

> accordingly. […] The virtual environment gives you the opportunity to actually feel present, and I think that's a compelling illusion. (Pollack 1989)

A distinguishing affordance of this technological setup is the possibility of moving around in the virtual scene, as opposed to being stuck in one place like in a panorama:

> Thus if a computer can send signals to mimic those sent by real objects, the result will be virtually indistinguishable from the real thing. Computer engineers work meticulously to create mock-ups of actuality that send the right signals. These mock-ups are more than just images on a screen. They are three-dimensional moving pictures constantly adjusted as you 'move' through a scene by turning your head or moving your hand or body (Dyson, 1990).

This description speaks to the essential characteristics that respondents use to disambiguate 360 video from 'real VR'. Thus, these conceptions of 'real VR' are already present in the encounters with VR systems in the 1990s. (We will return to the topic of immersion in chapter 4.)

Those who reported their experiences with early VR systems in the 1990s also imagined future scenarios. Dominated by the idea of shared virtual worlds, the range of possibilities is as wide as can be found today, with popular imaginative visions ranging from virtual tennis to virtual surgery. In fact, the example of the shared pre-operations for doctors provided in the interview by the interaction designers at a Dutch multinational consumer technology firm were already experimented with early on (see also Woods 1989). Outside professional applications, VR technology was envisioned as becoming a "personal portable device, something like a Virtualman, simply a pair of glasses that would allow you to enter what has become known as 'virtual reality' (also called cyberspace in the cyberpunk genre of science fiction), at your leisure and whim" (Ceteras 1990). But before these projections could become an actuality some 'technical hurdles' needed to be overcome.

3.3 Technical hurdles and solutions, then and now

3.3.1 Cost

The physiologist noted how he observed that the most prevalent factor in contemporary developments of VR technology is the decreasing costs of VR systems. From his position in the social group of scientific researchers, he works with the means that give access to simulation setups not available for the average consumer. From this perspective he sees VR products becoming commercially available as they are imported from other sectors, predominantly the communications and entertainment industries. The lowering of costs even leads some of his fellow researchers to make use of these systems in their scientific research. This takes the 'seriousness' out of VR-related research and applies it to 'fun' purposes on a mass scale (see chapter 6.2). In the early 1990s cost was found to be a dominant problem voiced mostly on behalf of the average consumer: "Virtual reality must overcome several hurdles, including expense, before it can be widely used. A helmet display, which often has to be custom-built, can cost $90,000 to $200,000 […] The VPL Data Glove costs $8,800. The sensors generally used to determine head and hand position […] sell for at least $3,000" (Pollack 1989). Cost of VR headsets with tracking has since decreased to the point where

sets of HMDs and tracking beacons (the *Oculus* and *Vive* systems) are sold for a total price of below $1000 in the first half of 2017, but these systems still need a $2000 computer attached to it to produce the requisite graphics. Even though the cost of VR systems has diminished, when looking at it from an average consumer perspective the CEO of a VR co-working space still considered the price to be on the high side. He expected that future price drops could increase consumer pull, though he was quick to note that this should include attractive content and hardware features such as inside-out tracking. This shows how entangled the problems of the current HMDs are, even without separating the socially relevant groups who voice these problems. An additional cost problem that was present in the 90s and is still faced by the consumer today is that of processing power: a desktop PC with the minimal specifications for these headsets at this point costs more than the headsets. The costly element in these computers is the graphics processor. From the discourse in the 1990s, graphics were seen as a issue of their own.

3.3.2 Graphics and performance

Problems concerning graphics performance and accuracy can be considered a second major issue. In the early days "'[t]he three biggest problems in VR are performance, performance and performance', [Henry A. Sowizral, who led a VR research project at Boeing Computer Services] quips, referring to persistent inadequacies in the state of the art for virtual reality displays, computers and software" (Gibss, 1994). The interconnected problem for the displays, computers and software resulted in low resolution images, with the graphics being "slow and chunky" (Pollack 1989). The issue of graphics can be seen as having two important sides to it: the practical problem of nausea and the ideal of flawless mimesis. The latter can be subdivided into two conceptual approaches: photorealism and the realism of the simulation.

3.3.3 Comfort and nausea

In the 1990s the problem of nausea was produced not only by the performance of the graphics processors, but also by their sheer size. As a result, HMD's were clunky and had relatively small screens: "Combined with a strictly visual illusion of movement, the weight [of the HMD] induces motion sickness in many wearers. Nausea and headaches are just the beginning" (Gibbs, 1994). Even if this was not a problem "artificial reality systems might cause nausea if the simulation differs slightly from what is really happening" (Pollack 1989). In the present moment possible solutions to these these physiological problems are being vigorously contested.

Even though the sizes of headsets have shrunk and the quality and performance of screens and graphics processors have increased, the problem of nausea still prevails. It is one of the concerns that the physiologist respondent is heavily invested in from his position within the social group of simulation researchers. Developer releases of HMDs that were released in 2016 had lower refresh rates, which had an effect that has been described by an HTC Vive developer as "judder" or "loss of detail, and quite likely eye fatigue or even increased motion sickness" (Abrash 2013). The conflicts that arise between the optical system and equilibrioception should be recognized as a problem for not only many HMD users, but also as a perhaps more fundamental issue as voiced by scientists who work on vestibular motion and simulations. Going into more detail on how the human eye perceives depth, the respondent pointed indirectly to how the contemporary state of knowledge about optic perception problematises the technological arrangement of the screens and lenses in HMDs. The visual perception of space is accounted for by at least two functions in the

eye, namely accommodation and vergence, together known as the vergence-accommodation effect. Accommodation is the process through which the muscles in the eyes change the shape of the lenses, which allows for variable focus (prescription glasses or contact lenses are a very common technological fix to problems with this process). Vergence is concerned with the relative positions of the eye that create a parallax effect and allows perception of distance. However, conflicts in the vergence-accomodation effect arise with HMDs, since the device comprises a screen close to both eyes that cuts off any vision to the outside.

From the physiologist's perspective this intersection of screen and optics leads to three problems. Firstly, although mediated by lenses, accommodation cannot occur because there is only one surface, the screen, to focus on. Secondly, though generally each eye gets provided with an individual image, the vergence effect cannot take place because there is no physical depth to perceive: the distance to the screen remains the same whether or not the object perceived is portrayed as being nearer or further away. Whatever is projected, then, is an illusion: "it is by definition a non-natural situation that is trying to simulate a natural situation [and] by definition you are creating an illusion because the world you are offering is not real(istic) [in Dutch: reëel]".[15] Thirdly if the screens are watched from such a distance that the vergence effect does not get trained, lazy eye complications can develop with young children — this problem was known by the developers of the Virtual Boy (Molly 2016). Here, the technological setup of the HMD places knowledge produced in the discipline of physiology at odds with the developers or enthusiasts who aim at creating a perfect illusion. The physiologist respondent stressed this by referring to an example from Dutch public discourse.

VR technology enthusiasts take positions towards this issue by suggesting solutions to the problems posed around the technology. Improving graphics is often voiced as a solution to the problem of nausea caused by the HMD. The physiologist noted how he became frustrated when, in 2014, Alexander Klöpping, a technology reporter and enthusiast showed an Oculus DK2 headset on Dutch prime time television. When the presenter complained about feeling sick after experiencing a demonstration of the headset, Klöpping stressed how future versions of the headsets would not have this problem because of improved graphics (De Wereld Draait Door 2014). The assumption that better graphics overcomes the nausea issue is also found in early VR discourse. In the early nineties, NASA researchers claimed that "any discomfort people reportedly experience is a direct result of sluggish system performance and low-resolution display. All you need is a better system" (Antonoff, 1993). According to the physiologist, this conviction not only ignores the fundamental vergence-accomodation effect but moreover negates the fact that a very large majority of the population has highly personal and very specific problems with their eyes. Here we find the social group of people with eye problems as a subset of those who experience discomfort in an HMD, supported by the social group of the physiologists, who in turn are at odds with the social group of 'graphics believers'. The issue found at the advent of the technology has thus only partly been addressed: the design of the HMD has only slightly changed in terms of optics, even though graphics may have improved and will likely keep getting 'better'. Thus, improved graphics is voiced as a solution but conflicts with physiological knowledge. This

[15] This works differently in other screen-based media because they do not close the eye off from everything else around it: the eyes and inner ear can correct what is perceived by using the surroundings of the screen as bearings for balance.

leads to a conceptual approach to graphics that brings forth another site of contest: visualisation versus mimesis.

3.3.4 Two conceptual approaches to graphics

Outside practical concerns raised by the quality of the graphics, a more fundamental or conceptual approach can be found in the early 1990s and also recognised at the present moment. The views of some of the social groups identified in this study can be aligned with these conceptual approaches.

Scientific American's October issue of 1987, centred around the advent of supercomputers, featured a cover article on innovative interfaces of the "artificial realities" that these computers were able to generate (Foley 1987). This article features descriptions of the HMD and DataGlove interface that are often found in adjacent early VR discourse. Author James D. Foley describes the combination of these technologies as follows:

> The ultimate objective of artificial-reality research is to develop a simulated environment that seems as 'real' as the reality it depicts. The profoundest strength of the interfaces, however, may lie in their ability to go beyond reality itself, by modeling in concrete form abstract entities such as mathematical equations and by enabling users to surmount problems of scale in manipulating atoms and galaxies alike (Foley 1987).

Here we see a division between displaying data in new ways on the one hand, and a mimetic ideal on the other. The mimetic ideal aims to get as close to reality as possible: Jaron Lanier stated how "Virtual Reality has to feel real or it's not a reality" (Barlow 1990). At around the same time technology journalist Benjamin Woolley, writing in *The Guardian*, described how in terms of computer graphics "research has led to two distinct approaches to reality" (Woolley 1989). There is visualisation that is concerned with "the computer providing a way of seeing those bits of it that cannot be seen using conventional instruments" (ibid.) The other view on graphics is vested in "artificial realism" (Ibid.). Again we can notice the platonic ideal of mimesis, in which the aim is to make the simulations resemble reality to such a point that "the result will be virtually indistinguishable from the real thing" (Dyson 1990). The mimetic ideal can be regarded as being in the same category as the notion that physiological discomfort will be solved by improved graphics. Among the respondents, this conceptual distinction was also found.

The first conceptual category envisions VR as a tool to provide interactive visualisations of that what cannot be seen using conventional 2D media. The creative director at the IT firm, the interaction designers at a Dutch multinational consumer technology firm and the CFO of a Dutch VR-software startup all discussed the possibilities of VR in these terms. In all cases it is a matter of presenting data in new ways. The IT firm where the creative director works sells a system to soccer clubs that uses the recorded movements of the players during a match. This is then visualised in a simulation, after which players can take up the positions of their teammates by putting on an HMD. The interaction designers at a Dutch multinational consumer technology firm discussed a situation in which CT-scan and X-ray results were analysed by doctors using a 3D visualisation. In this case the doctors did not have to translate the 2D images into 3D models in their heads themselves; they could use HMDs to manoeuvre around the model to understand it using

proprioception. Thirdly, the CFO of a Dutch VR software startup noted how their primary product is making LiDAR data point clouds accessible in other 3D visualisations. For example, the company's algorithm can integrate LiDAR laser scans with images and models published on Google Maps. This allows for a 3D representation of an actual environment. The 3D modelling makes it possible to move around in the content through the use of commercially-available HMDs. In terms of social groups, we find both researchers and entrepreneurs in this category of people who use VR as visualisation tool.

The second conceptual category, which aims to create a degree of representation that is visually indistinguishable from reality, is not found within a specific group of respondents but seems to be a theme that emerges across all groups. Screen and graphics technology developers together with content creators articulate this position most prominently — they want the best displays and graphics to display content in order to trick the viewer into believing that what is projected is 'real'. However, mimicking sensory experience with the technology at hand makes this point a dispute that goes beyond issues of photorealism and optics. Yuval Boger, co-founder of VR software platform OSVR, has described the telos of HMD graphics as follows: "[a]chieving 'retinal resolution' is the ultimate goal for headsets, where at a certain pixel density, even people with perfect vision can't discern any additional detail" (Boger 2017). Jason Paul, general manager of VR strategy at major graphics processing unit manufacturer Nvidia stated that "it would take us about 20 years to achieve resolutions that can match the human eye" (Durbin 2017). These technology developers thus focus on the optic capabilities of the eye. Among respondents from various social groups, however, it was noted that adding more senses to the experience could contribute to the sense of being present in the virtual environment. These range from more familiar techniques such as 3D sound and proprioception to the more elusive sense of smell and haptic feedback. Unfortunately there is no space to dive into these additional techniques here.[16] However, the realisation that visual representation is not key seems to have been present since the nineties.

3.3.5 Graphics are not everything

Regardless of whether the approach to graphics is concerned with providing a visualisation or a mimetic image, a distinct discursive position can be derived which holds that the accuracy of the simulation is not key to evoking a sense of immersion. This section puts forward the position that graphics are *not* key (I will return to the definition of immersion in detail in chapter 4.2). Again, it is difficult to fix this position to a specific social group. First hand reactions to the VR systems in the early 1990s describe the effect of the technology as overwhelming and effective despite low quality graphics: "The images are low resolution, and the graphics slow and chunky, but the overall effect is still every bit as magical and stunning as I had hoped" (Ceteras 1990). Because of the low quality of graphics it was noted that "while realism may have something to do with VR, it is not a necessary condition by any means" (Gibbs 1994). From this perspective the topos of immersion or the effectiveness of the simulation can be disambiguated from the ideal of mimetic representation.

This distinction was also found in the interviews. Approached by physiologists as a tool for an experimental setting, screen-based simulations are used to conduct experiments on human subjects, to set

[16] See Foley 1987; Gibbs 1994; Rheingold 1992 and Stix 1991 for more on haptic feedback development in the 1990s. Haptic gloves and vests are still in development in the first half of 2017. For an insightful academic analysis of the phenomenology of the body as digital media interface see Hansen 2006.

up rehabilitation exercises, or to test new equipment.[17] When working together with third party companies to create training simulations, mimetic motives are often encountered:

> They say: "we want the [graphically] most advanced simulator." Then I ask: "why do you want to have the best looking simulator?" and they say: "because it looks nice and we think it is better." It is at this point where I ask them why they think it looks better almost all of them fail to provide an answer.

From his experience the desire for 'better immersion' is often brought up, but from a research and training point of view better graphics miss the point. Better graphics do not necessarily lead to better immersion, especially if there is a task at hand. Moreover, physiologists assume that the more accurate the representation, the more the physiological effects, like nausea and headache, are likely to occur.[18] The researchers at the Dutch multinational consumer technology firm agreed that in developing products, their focus is on the effectiveness of the simulation and the task at hand, not the accuracy of representation. The ability to move around in a space makes VR "ten times more immersive than 360 video even with less graphics." The ability to move around and the sense of presence this creates is addressed by developers who are concerned with creating the contents of the simulation. Again, we will return to this in chapter 4.2.

For the immersive, 'real VR' experience realistic interaction with the environment is crucial. This position was voiced among the respondents by the developers that programme the virtual environment. The creative director of the *Beyond Sports* system (described above in 3.3.4) noted how realism is not key to his product, but at the same time he keeps working on improving the graphic detail of the soccer players' 3D models. This shows an ambivalent position on the side of the designers of virtual worlds towards visual mimesis. Here we find realism of the interactive elements of an environment to be a more crucial concern.

Achieving realism on the side of 3D modelling presents a challenge for developers, since the independent developer additionally stressed that for the current state of technology "it is a lot of work to make [human facial expressions with the use of game engines] realistic, to give a soul to 3D avatars or models. This is why you usually want to stay a little bit more abstract, because as a human you notice glitches quite quickly." This developer thus discussed realism here not in terms of an exact visual copy, but the "comprehensibility of the environment and its graphics." By this he means how the objects in the virtual environment interact with the users' movements. He discussed simulation in a training module he designed for Ahold, in which employees are trained how to stack pallets.[19] This setup involves the HTC Vive HMD for interaction with the controllers. Because the pallets are objects of manipulation, the experience involved simulating the physical experience of moving things around. In the context of this simulation, the most 'realistic' experience was when "the pallet drops when you bump it into the virtual table with a certain amount of force, it falls on the floor and you have to pick it up again." Thus we can identify here not only how the

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[17] When discussing VR as a purely entertainment medium, the physiologist was of the opinion that the escapism immersive technologies offer satisfies merely to a "banal" sugar rush. Recalling a story of how his peer researchers looked down upon his involvement in the development of a ride in a Dutch theme park shows how, in this professional group, a certain disdain for 'fun' applications of this type of technology exists.

[18] The epistemological framework on which this assumption is based has been published in a paper co-authored by the respondent: see Bos et al. 2008.

[19] Walmart also announced that is would start training employees with VR headsets (Feloni 2017).

graphic design of the virtual environment incorporates a strictly visual element, but also how this becomes linked primarily to the task of the simulation. As such, realism becomes subject to interaction with the environment. From this it may be concluded that, for the designers of interactive virtual environments, ranging from physiologists to independent developers, an effective simulation is seen as belonging to a separate category than the mimetic ideal.

4.4 Negating the nineties

Questions of cost, graphics and cases of practical use for VR technology in the nineties presented in my analysis seem all too familiar when looking at the contemporary moment. I have argued with an emphasis on similarity: the material I presented should be considered as exemplary positions from the nineties that reverberate in the present. As can be derived from the discourse discussed so far, a widespread belief in VR and the ability of technology to overcome the problems it experiences exists both in the 1990s and today. However, some of the problems found 25 years ago still persist. To counter the accusation of being as irreflexive to the nineties as some the contemporary discourse on VR is, some notable exceptions should be signalled here. Three issues that were more prominent in the 1990s compared to the first half of the 2017 are: meeting other people in VR, the end of transportation, and telerobotics.[20]

The 'social' aspect of VR has gained some attention with the launch Facebook's *Spaces*, but Jaron Lanier's conception of VR as "the telephone, not the television of the future" (Barlow 1990) is overshadowed at least by those who want to create cinematic or game-like experiences in VR. This very crucial definition of VR as being an interactive medium was recognised to still be present in the previous section (4.3), but at this stage it seems to have taken on another shape. Today the prominence of social networks in what has become known as 'social media' does not (yet) envision this happening through the use of VR technology. The CEO of a VR co-working space noted that it "seems to work" because it allows users who do not have access to an HMD to interact with those who do. No matter how hard Facebook is able to push this, this application has not yet taken flight.

Plugging into a VR system to be able to work at home or travel without moving (Barlow 1990; Pollack 1989) seems to have seeped into early conceptions of the internet as 'data superhighway'. Telerobotics seems to be the most absent element in today's discourse, with the exception of personal drones that connect a live visual feed from their onboard camera to the HMD of the pilot. It should also be noted that in the early nineties haptic feedback seems to have been a more prominent idea in the promise of VR (see Foley 1987; Gibbs 1994 and Stix 1991) than it is in the first half of 2017. Perhaps these imagined possibilities will gain importance again outside the exposure time of this study's snapshot. One last dissimilarity between the 1990s and today is surprising. In the 1990s researchers complained that the abundance of attention to VR at the time set impossibly high standards for what the technology at the time could make come true (Pollack 1989; Gibbs 1994). Considering all the issues brought forward in this chapter one would expect such enthusiastic positions to appear again.

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[20] In relation to VR in the 1990s, Boddy has analysed how the topos of VR as 'telepresence' finds itself in a discursive field with other historically dynamic formations such as gender or media (Boddy 2004, 68-78). I did not encounter similar issues in the contemporary findings, except for the issue of virtual harassment, but this took place just before the first half of 2017.

This chapter has shown how there was a hype around VR in the early 1990s in which some elements of what the present-day respondents describe as ‘real VR’ can be found. Digging into the history of the notion of virtual reality thus shows how most of the ideas that emerged then are still in discursive circulation today. In this period expectations were formed and not met; it remains to be seen whether this will happen again in 2017 and beyond. Even though some technical hurdles have been overcome, conceptual categories and end goals of VR are still at odds with each other. We find the topos of immersion or presence, the feeling ‘as if on the very spot’ in both the categories of 360 and VR (see 5.2). What I have tried to show here is how the conceptual categories and cultural protocols found in the form of imagined applications manifest historical similarities. In terms of SCOT and its focus on the issues voiced by social groups, it has been found that some of the earlier problems have been addressed but have not reached closure. and Ideas and conceptual categories from the early 1990s reverberate today, although some differences can also be noted. If anything, comparing the present day discourse to what is found in the early 1990s brings to light an overall belief that VR technology will overcome the problems it experiences. Elements of what was described as ‘real VR’ by the respondents have now been historically excavated. Here we find consistent conceptual frameworks but varying imaginations of the application of VR technology. The next chapter will examine the constitutive elements of the desired effect of the technology.

4. Immersion: interpretive flexibility of a topos

Both 360 video and 'real VR' aim to create an experience that transports the audience to another place. Barker's 'feeling as if on the very spot' (see 2.1) aims to create a sense of presence. Immersion will be defined shortly in 4.2, but it should be noted here that in the interviews the respondents used both terms (presence and immersion) interchangeably. Comparisons to other media (e.g. film, games, novels and 'choose your own adventure' books) were frequently made to note that presence or immersion can also occur with these types of technology.[21] The goal of creating 'immersive' experiences can thus be understood as a topos, for it occurs across times and media forms. Additionally, the dissimilarity among installations, ideas and practices found in the history of both the panorama and virtual simulations can be understood by means of the SCOT notion of 'interpretive flexibility'. This chapter aims to bring forward some of the contemporary practices and technologies surrounding immersion, thereby showing how these can be understood in terms of interpretive flexibility and topoi.

4.1 Interpretive flexibility and topoi

In the previous chapters I have attempted to show how ideas and conceptual schemes about the uses and ends of VR can be seen to have a historical lineage: similar ideas emerge at different periods of time. Ideas surrounding media have been analysed by Errki Huhtamo through the concept of 'topos', which he defines as "cyclically recurring elements and motives underlying and guiding the development of media culture" (Huhtamo 1997) whose "origins and manifestations are both created and conditioned by cultural forces" (Huhtamo 2011, 37). Topoi function in the discursive realm, and can become embodied in media technologies through a process of cultural inscription. Discourse on topoi, as the site of contest for cultural forces, is thus considered to give shape to different types of media dispersed through history.[22] In the previous chapter, I have shown how categories of thinking around VR formed at the advent of the 1990s mostly align with the main conceptions that surround the medium today, despite notable differences in its actual application. The present recurrence of the yearning for immersion thus makes clear how immersion can be understood as an elusive topos. However, to get a grips on the processes of cultural inscription, the topos of immersion should be substantiated by the actual approaches to summoning this feeling. As we have seen, the ways of reaching this immersive state are diverse and, moreover, tied in to the views of different

[21] A funny 'vice-versa' discursive enunciation popped up whilst writing this thesis. In a promotional clip for the 70mm release of Christopher Nolan's *Dunkirk* (2017) the director describes the cinematic experience as follows: "The immersive quality of the image is second to none. We really try to create the sensation that I could describe as virtual reality without the goggles" (IMAX 2017).

[22] It must be noted that what I am pursuing in this thesis comes quite close to what Huhtamo was hoping for in the 1990s: "Jaron Lanier's utopian vision of virtual reality "as the telephone, not as the television of the future" can thus be seen as another incarnation of a *topos* well known more than a hundred years earlier. It remains to be seen, if Lanier's discursive version of VR will ever be realized, or if the rudimentary technology which inspired it will finally be moulded into a form which is closer to the economically and ideologically constrained structures of broadcast television than to those of telecommunication. The discursive formations which enveloped and molded the emergence of virtual reality technology around the turn of the 1980's and 1990's would provide an appropriate subject of study for the kind of an approach I have been trying to delineate" (Huhtamo 1997).

socially relevant actors. In this chapter I will suggest that this diversity is best understood in terms of interpretive flexibility.

Interpretive flexibility, as a term formulated within the SCOT tradition, designates the methodological orientation "not only that there is flexibility in how people think of or interpret artifacts but also that there is flexibility in how artefacts are *designed"* (Bijker, Hughes and Pinch 2012, 34 - emphasis in original). Unlike topoi, which deal with abstract discursive formations, interpretive flexibility allows us to focus on the materiality of artefacts. The cultural inscription of topoi — how people think about artefacts — can thus be found in the material design. From the SCOT perspective remnants of design decisions are related to problems voiced by social groups: "Because social groups define the problems of technological development, there is flexibility in the way things are designed, not one best way" (Bijker, Huhges and Punch 2012, 6). For instance, it was the problems voiced by the social group of elderly women wearing dresses that gave rise to a particular shape of bicycles — in Dutch aptly called "oma fiets" (granny bike). Now, if we combine the notions of topos and interpretive flexibility with the findings from the contemporary and the 1990s, we can shed a historically informed light on what constitutes immersion.

4.2 Evoking immersion

Accounts of early VR technology experiences bring to the fore fairly clear ideas on immersion and competing ideas on what constitutes it. In a description of the development of preliminary VR technology, Howard Rheingold tries to define the concept of immersion:

> The 'user' began to become the 'operator"'. The job of creating the feeling that an operator is inside a simulated space has two aspects: First, the perceptual technology must convince the operator that the simulation is a three-dimensonal environment that surrounds him or her; this aspect has become known as 'immersion'. There is another key idea, however—the question of whether the operator is a passive observer in this environment (as in Sensorama) or has the power to actively navigate and explore it.' (Rheingold 1992, 100).

> The idea of *immersion* — using stereoscopy, gaze-tracking, and other technologies to create the illusion of being inside a computer-generated scene— is one of the foundations of VR technology. The idea of *navigation* — creating a computer model of a molecule or a city and enabling the user to move around, as if inside it — is the other fundamental element. Nothing about either of these key elements requires that they be implemented in one specific kind of technology. (Rheingold 1992, 112-113, emphasis in original).

Rheingold thus considers immersion and navigation as constitutive elements that sets ('real') VR apart from other media. What he means with the last sentence of the second quote is there is not one specific technological approach to evoking the feeling of immersion; this is evidenced by the plethora of materially distinct (interaction) designs that can produce it. This speaks directly to the interpretive flexibility in installations that aim to evoke immersion: there is not one best way. For the respondents, when discussing the notion of immersion, similar characteristics were brought up.

The respondents articulated a unified view on what immersion feels like; and they also noted that the experience is inherently ephemeral. The physiologist described it as “the feeling of being elsewhere”; and the creative director defined immersion as “the feeling of presence.” Describing their first experiences of immersion, the independent developer said “it felt like I was transported to another dimension” and the CEO of a VR co-working space noted how “it feels like you’re simply somewhere else, pure escapism in the sickest form, mentally and physically — that’s the strange thing about it.” However, the accounts of feeling immersed by contemporary VR systems were scarce: respondents only ‘truly” experienced immersion or presence a couple of times. One of the interaction designers at a Dutch multinational consumer technology firm stated that “I think immersion is a delicate thing; it is very easy to break it.” From their frequent experiences with headsets, the independent developer and the CEO of a VR co-working space were most explicit in noting how one becomes familiar with the effects of the technology. Reflecting on this the independent developer realised how “back then only the visuals were enough for me, and now after a while I need other senses to be stimulated to get to that level of presence in this other world.” Since it is the respondents’ jobs to design and enhance experiences, they pay attention to the application of the techniques used such as stitch lines or output resolution. Thus, the respondents may have lost the overwhelming effect that novel users feel. This initial feeling can thus be equated with Rheingold’s definition of immersion: the illusion of feeling present in the space. This, perhaps, is where the conflict over the terms ‘presence’ and ‘immersion’ comes from: Rheingold defines immersion as feeling present.[23] ‘Real VR’, however, requires another key element besides the feeling of being present in the environment: the ability to navigate the space.

As Rheingold states, a second key element to VR is the ability to move around (navigate) in a virtual space. It might not come as a surprise, then, that it is predominantly through this affordance that 360 video was disambiguated from VR systems. Even if 360 video systems fool the user into believing that they are surrounded by the capture, the sense of immersion breaks because it is impossible to navigate the space. Yes, the observer can turn around, but this keeps these approaches within the category of the panorama. The topos of immersion is clearly there, but the way 360 video systems are designed now does not seem to convince most of the respondents that are invested in VR interviewed in this study. However, practices such as the VR Cinema show that 360 video is still considered to be VR by others in the field. Again, discursive enunciations in first-hand accounts show this. As Niklas Lindstrom, head of interactive production at advertising agency Droga5, put it in an interview with *Forbes*:

> My strongest sense of immersion has been game engine-based experiences in mixed reality where I am able to use more of my senses—where I have been able to move around in the environment and interact using my hands and physical objects, or using hand controllers instead of passively viewing the content play out, predetermined in 360 degrees (Hanlon 2017).

The independent developer stated that “I don’t feel immersion in 360 video, even if it is stereoscopic. […] Immersion only happens when things get physical, when you can move your body and the world reacts to it.”

[23] I am explicitly leaving out debates on presence in terms of performance and liveness here — yet another good thesis topic.

Both the creative director and the CEO of a VR co-working space noted how they feel “less immersion in 360 video” and are often bored easily by that type of content. They voiced the wish to move around in 360 video (see 4.3). For the interaction designers at a Dutch multinational consumer technology firm, movement taps into our phenomenological understanding of the world: “the way that you physically interact with the world, the way that your body and your brain integrates what it feels from your muscles and what it sees, this is basically integrated into understanding.” Indeed, as Rheingold writes, the ability to move around in a space and interact with the environment is constitutive of VR. Much present-day discourse, however, shows that interaction is a requirement for evoking the feeling of immersion. 360 video captures, remaining in the conceptual framework of the panorama and the presence it evokes, are thus incapable of producing environments that can be moved around in. Here we arrive at the interpretive flexibility in methods of producing such captures.

4.3 Capturing depth

Although 360 video captures can produce some sense of immersion, current techniques lack the ability to capture depth. This is a necessary requirement in order for the environment to be explored through moving. The respondents often brought up the technique of “volumetric capturing” as a nascent technology that could provide a solution to the socially-voiced problem of movement in 360 video captures. From the optimistic sentiments of the respondents and descriptions found in contemporary public discourse, volumetric capturing technology becomes inscribed within the topos of immersion. Volumetric capturing takes place within the register of real VR, but it is understood in terms of providing a solution to the problems of 360 video. Interpretive flexibility in this regard is visible in the diversity of approaches to creating the possibility of moving around in captured footage.

The CEO of a VR co-working space is convinced that, to a certain extent, 360 video-capturing technology can provide experiences aimed at immersion. Capturing technologies are going to evolve, however:

> […] just a little bit more, until of course you go volumetric and you can finally move around in video, that is going to be awesome. […] In the end I think that video is just texture on a realtime rendered game engine model. Once you have enough processing power to render video on a 3D model in realtime because it is volumetric…there is no difference anymore.

The same wish was voiced by the 360 video producer. Even though the imagined volumetric technology described here currently does not exist, this enunciation shows a distinct sense on what this capturing technology is *purported* to achieve. Captures of real world scenes should be mapped in such a way that they are accessible as a virtual environment to move around in.[24] To arrive at this point, new types of technology in terms of software and hardware are being developed. Interpretive flexibility is prominent among the approaches to imagining how this convergence might be achieved.

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[24] An example of such a project was provided by the creative director: *In the Eyes of the Animal*, produced by Marshmallow Laser Feast (see Visnjic 2015).

A first example was offered by the 360 video producer himself and backed up by the CEO of the VR co-working space. Using a stereoscopic 360 camera, the data from the left and right lens are processed in rendering engine Nuke to create a depth map. This allows for slight head movement and can thus create a sense of parallax. However, this technique is still in an experimental phase both in- and outside of the 360 video production company. Those who are working on these types of techniques are acknowledging the problem of movement and trying to overcome it by using mostly widely available hardware and software. In terms of interpretive flexibility, other approaches show the creation of new types of hardware.

A second, more salient example of the artefacts involved in creating volumetric captures is found in the development of new capturing technologies, specifically cameras. The Tribeca film festival in spring 2017 witnessed the premiere of *Within*, a short video shot with the Lytro Immerge volumetric camera. As described by Lytro's VP of engineering, Tim Milliron, the Lytro recording technology works like "[a] whole lot of different cameras to capture lots of different viewpoints in the scene. […] You merge the slices and convert that into a 3D model" (Lytro 2017). Thus, the video feed generates the 3D model by comparing the x- and y-coordinates of the images. Zach Richter, *Within*'s director, describes the system as:

> Being able to move freely inside of a virtual reality space, I mean that does take us to the next level […] if we just shot this in 360 video, we would never be able to move around. When the viewer puts on the headset, as they move around the space, there truly is a sense of volume, a sense of parallax and it helps to establish this sense of human-ness, of realness (Lytro 2017).

It is interesting to note that the director speaks of a 'sense' of volume: the Lytro Immerge camera creates an illusion of depth through photogrammetry. Actual depth data is not generated in these captures; instead it is approximated by the software. Lytro's camera solution, therefore, is fundamentally different from the approach put forward by the volumetric capturing company respondent from a Dutch VR-software startup.

A third approach to volumetric capturing is found in a product made by that same Dutch VR software startup. The company uses data generated by LiDAR laser scanners, commonly used in construction and traffic sectors for their accuracy on the z-axis (depth), to convert the capture into a point cloud dataset. According to the CFO of a Dutch VR-software startup, the advantage of LiDAR scans compared to photogrammetry is their ability to scan an entire scene and efficiently create a 3D model. Photogrammetric scans such as Lytro's Immerge record a limited surface or contours of an object, which leave parts of the subject incomplete in a 3D environment. LiDAR scanning technology, combined with algorithms to convert the data into models, thus make it possible to easily generate a complete virtual simulation of a captured environment. Using an HMD that features tracking, one is able to freely move around in the space and experience it from every possible position. This then fulfills Rheingold's prerequisites for the creation of immersion and can be considered 'real VR' according to the criteria of the respondents. Moreover, it captures an environment and overcomes the limitation of 360 video. However, the CEO of the VR co-working space's wish of "walking through video," or the actual convergence of 360 video and environments that you are able to move around in ('real VR') is not reached through any of these technologies.

This chapter has shown how the technological approaches to creating the feeling of immersion is flexibly interpreted relative to the (dis)positions of the respondents. Moving around in a virtual space based on data captured in reality, preferably to the point where it gets indistinguishable from the real world, should be regarded as the telos of VR. In this study, this includes the discourse and all of the respondents save for the 360 video producer who still considers his productions to be called VR as much as any of the technologies mentioned above. From first hand accounts, it seems as though contemporary technology (aside from 360 video cameras) is able to create a temporary illusion that partially achieves this. Moreover, the feeling of immersion seems to be fleeting: respondents noted how they got used to new headsets, types of content, or interaction affordances. To take a step back (as this thesis is trying to do by providing a snapshot): what has been discussed up to now can provide the means for a more historically informed analysis of the contemporary. In the next chapter, the findings presented above are understood as being the building blocks of the cultural protocols and epistemic conditions in which VR is developing.

5. Historical and contemporary conditions of VR

Now that we have gone in depth on a selection of issues surrounding VR technology and its imagined application as a consumer medium, in this chapter I will argue that within these findings more fundamental conditions can be found. These conditions shape the contours of a future (mass) medium as much as the practical and design iterations to be found throughout the development of VR technology. The type of conditions I drive at are perhaps best characterised as being 'less obvious' and more profound than the problems voiced by social groups in the SCOT approach. Moreover, these conditions seem to be more interconnected with each other. A spectrum of studies ranging from media and art historians to sociologists of science have previously laid bare these abstract conditions. But before going into these conditions I will present a fundamental distinction among the respondents.

In chapter 2, respondents were characterized as either 'entrepreneurs' and 'researchers'. To infer more fundamental conditions in which VR is developing, a more abstract distinction can be made. A productive categorisation of conceptions surrounding VR is found in the meaning ascribed to the end goal or telos of VR technology. On the one hand VR is applied and imagined as a tool, whereas, on the other, it is portrayed as an end in itself. The former conceptual approach is voiced by those respondents who work on applying technology within professional environments. Among them are those who create simulations used to train people for specific tasks. This category also includes those who see the affordances of VR technology as providing new ways to display and process information. The category of those who see VR as an end in itself contains or overlaps mostly with the enthusiasts who envision VR as an entertainment medium. Among the work of these respondents, frames of references from of other media, like that of the panorama, cinematic and gaming environments are present. Seen as the ultimate form of escapism, this group understands VR as being able to evoke immersion and providing convincing mimicry. In this categorisation we thus find similar motives to those who approach computer graphics as a unique visualisation tool as against a way of realising the ideal of mimesis (see 3.3.4 and 5.2).

5.1 Semiotic struggles, cultural protocols and epistemic conditions

Many media historians point toward various types of conditions that determine the development of media in society. Lisa Gitelman (2006) inquires into the role media take up as new bearers of cultural inscription and the protocols that arise around them. Gitelman researches the phonograph and the world wide web, media we have since become accustomed to, in a time in which they were considered new. Her approach "permits an account that is exacting, and at the same time broadly suggestive of the ways that new media emerge into and engage their cultural and economic contexts as well as the ways that new media are shaped by and help to shape the semiotic, perceptual, and epistemic conditions that attend and prevail" (Gitelman 2006, 11). From this perspective media do not arrive from somewhere outside of society in a rigid form. In fact, they are malleable and subject to certain conditions: the various regimes of language, experience and knowledge. Gitelman provides examples through her case studies, but she does not explicitly define what she means by these conditions.

Gitelman gives a hint at how these fundamental conditions can be understood when she elaborates on the historical context of her case studies. In the case of the phonograph, a multitude of social factors, such as the agency of women in domestic environments, influences the meanings that historically and

contingently became attached to this new medium. Gitelman brings to the fore how the technical and cultural protocols surrounding the use of specific media are based on semiotic conditions: it is the struggle over meaning by media technology developers, end users, and other factors that gives shape and significance to media technologies. However, the shapes of media are not defined solely by the meaning that is prescribed and inscribed to their development and usage. For audiovisual media, one has also take in account understandings of, for instance, visual perception.

Like Gitelman, Jonathan Crary analyses the historical practices and procedures that bring about perceptual conditions—conditions that belong to the discursive realm. Crary's position shows how these conditions can transgress onto, and in this way construct, the body through social practices or protocols. His emphasis on regimes of knowledge lead him to point out epistemological conditions that shaped modern Western ocularcentric society. Crary traces a genealogy of regimes of registration through the body, and shows how 'the visual' and 'the observer' are constructions resulting from the intertwining histories of knowledge and optical technology. Crary's aim is to "suggest some of the conditions and forces that defined or allowed the formation of a dominant model of what an observer was in the nineteenth century" characterising these forms as a condition of modernity (Crary 1990, 7). The observing individual, as we now know ourselves, is the product of a fairly recent conception of the body and the allocation of perception within it. Crary shows this by analysing the emergence and disappearance of the camera obscura and the role it played in developing a new field of knowledge about the visual. These function as the "conditions of possibility" that effectively produce notions such as 'attention' (Crary 2000, 10). To get a grips on the abstract notion of attention, it is considered "in terms of this massive accumulation of *statements* and concrete social *practices* during a specific historical period that presumed the existence and importance of such a capacity" (Crary 2000, 23 original emphasis). Crary shows how social practices are inextricably linked to or informed by implicit fundamental assumptions about the observing subject. This is where conditions of possibility are brought into historical relation to media technologies and epistemic debates over objects of knowledge. For instance, Crary reconstructs rivalling theories of the separation of the senses and color perception (Crary 1990). Harking back to Gitelman, we have now identified both the semiotic and epistemological conditions under which media take form. Drawing on the findings presented in the previous chapters, I will now suggest what topics can be considered contemporary conditions surrounding the development of VR.

5.2 Present epistemic conditions and cultural protocols

Epistemic conditions played an equally important role in the past as they do in the present. My findings lead me to conceive of at least three conditions that deal with epistemology, cultural protocols and semiotics.

To start with the epistemological, we see that the issue of physical discomfort brings to the fore a deeper tension than merely vomiting users. As discussed in chapter 3.3.3, the current state of physiology leaves open some room to expand this physiological field (see Bos et al 2008), but at least is convinced that the current design of the HMD is problematic. The established issues of the vergence-accomodation effect and the closed-off design of headsets are accused of causing physiological effects for at least a certain demographic group. An opposing standpoint, voiced by the social group of display, graphics and content designers, sees the solution for this problem in improved graphics performance and screen resolution. Apart

from the fact that we can recognise quite clearly the quarrel over technology from a SCOT perspective, I argue that this conflict is concerned with an element of knowledge and can thus be considered an epistemological condition. The conflicting positions work from opposing world views. As an effect, either the design of the HMD must change or physiological research has to adapt their frame of reference.

Related to this issue is the dispute over the purpose of computer graphics. This topic has to do with epistemology, but more importantly it should be considered as a struggle over to what end VR is imagined to be put to use. As discussed in chapter 3.3.4, two conceptual frameworks to computer-generated graphics can be found in the 1990s. On the one hand there is a yearning for visual realism which mimics actual perceptions of the real world. On the other, computer graphics are considered in terms of the unique abilities it has to present data in a three dimensional environment (visualisation) that the user should be able to navigate. These frameworks were found reverberating in the contemporary discourse. Here, I would like to consider them as parallel discursive formations that influence the development process of VR. As the CEO of the VR co-working space described his vision of VR technology: “[it is either] optimisation and efficiency, which is what makes the world go round, or entertainment and escapism. There is not much in between.” This observation obviously represents the division among the respondents noted at the beginning of this chapter: between those who consider VR as a tool applied in various situations versus others who consider VR to be a medium and an end in itself, as ultimate form of escapism. Mimicking reality by providing the graphically most advanced simulation is aligned with the escapists. Those who consider VR as a tool are less concerned with the accuracy of the simulation in mimetic terms; they focus instead on how effective a simulation can be in a certain situation.

This brings us to the next condition. When VR is conceptualised as a tool that is subordinate to an end, it is usually done so from within a framework of efficiency. For example, in the health science sector both the physiologist but more so the interaction designers at a Dutch multinational consumer technology firm can be understood as working from the premise of efficiency. The numbers and graphs that at the start of the day determine what part of the process can be optimised are the same as what counts for the ultimate success or failure of a certain application. As the lead of the interaction design lab at a Dutch multinational consumer technology firm put it: “it is indeed the case that on the one hand I have a certain idea of what counts as good, but I also have to be able to support this claim, so then I turn to quantifying it.” The CFO of a Dutch VR-software startup spoke from a similar position. Their product is primarily marketed as a process optimisation tool. In these applications the framework of efficiency then puts emphasis on the effectiveness of the simulation, not the accuracy of the graphic representation. The independent developer who creates training simulations also aims at creating effective simulations when he builds training environments.

It should be clear that the ethos or dogma of efficiency applies to everything process related, not just VR. Needless to say, this condition is one of the constitutive the rules of capitalism. On a meso-epistemological level one can recognize how this fits within a typically modern, Western style of thinking (Foucault 1966). In a similar fashion, Crary argues that physiology in the nineteenth century reformed its object of knowledge to fit “the productive requirements of economic modernity and for emerging technologies of control and subjection” (Crary 1990, 87). The use of simulation technology to increase efficiency may be considered as ‘in your face’, but it also takes place within the fundamental structures of the contemporary moment. On a micro level, those who think from this vantage point of efficiency can be said to have this as a

frame of meaning.[25] However, it is from this frame of efficiency that these discursive enunciations inscribe meaning to VR as an applied technology.

5.3 Semiotic struggles and closure

This brings us back to the semiotic struggle over the meaning of 'real VR' and the arguments of social constructionists. Among the various practices and technologies we find in early 2017, what types of closure can be found? Bodily movement and interaction are seen as crucial to evoking the feeling of immersion or presence in the environment. We have seen how the practice of 360 video content production makes a claim to the term 'VR'. This comes at a time when ample content is easily accessible online that is not necessarily to be viewed through an HMD. Additionally, we have seen how familiar cultural protocols of other media forms, the cinematic, are being applied to 360 video captures. These conditions might make the claim to VR more overwhelming, but they cannot deny disputes over how people understand VR as a medium. Historical evidence points towards distinctly different lineages with a similar immersive goal. 360 video captures are best understood as fitting within the practice of the panorama that goes back a couple of centuries. This technique aims to put the observer on the spot that is represented, with the ability to turn around. The technical limitations of 360 capture and display options then pose a limit that constructs the differentiation from 'real VR'. It is the ability to move around in a virtual space that is immediately present at the advent of discourse on VR in the 1990s. My findings from a small group of informants and from other discourse show that this is still considered necessary for VR today.

The disdain found among all respondents — save for the 360 video producer — for 360 video content being understood as VR can be understood in terms of closure. From their positions in the industry and experience with the technology, 360 video content was not considered VR. In this sense, looking at the data I acquired, this problematic claim seems to be ignored.[26] So, this actually resembles to how social constructionists define closure: "to close a technological "controversy," one need not *solve* the problems in the common sense of the word. The key point is whether the relevant social groups *see* the problem as being solved" (Bijker, Huhghes and Pinch 2012, 37 emphasis in original). Issues raised with the failure of 360 video content to evoke a feeling of immersion are answered by providing the requirement of interaction and bodily movement. Respondents who are involved in creating content for entertainment purposes voice 'volumetric' captures as an *imagined* solution. A second instance of closure, I would argue, can be found in the persistence of the design of the headsets. The engineers from the various companies seem to be sticking to the form factor of the HMD, even though it is likely to cause physiological problems with some social groups (users with eye problems, for instance) and sales are underwhelming. The awkwardness of wearing HMDs in social settings might be frowned upon, but it could disappear in the future; as we have

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[25] 'Frame of meaning' is a term that I take from social constructionist Bernard W. Carlson. In a very similar fashion to Gitelman, Carlson analyses the disputes over the medium of film in the early 1910s. It was the 'frame of meaning' according to which film was supposed to be experienced passively that shaped the still-present movie-going experience. This frame stood in sharp contrast to the assumptions from which Thomas Edison developed his projection technology (Carslon 1992).

[26] There are two big other indications from the industry of how 360 video or cinematic approaches are not being accepted as having enough potential for VR. The closing of the Oculus Story Studio mentioned in the introduction marks the first. A second is the Venice Film Festival and their competitive VR section. It is yet to be seen if this category includes pure 360 videos, or makes 360 captured footage only a part of an immersive experience.

seen, cultural protocols surrounding media are malleable. Perhaps on the level of cultural closure it is too soon to be definitive, but I do signal it as an issue here.

One point where closure is definitely not upon us is in the volumetric capturing techniques discussed in chapter 4.3. Here, various approaches to creating a 3D representation of a space that can be moved around in are still in development. However, as we have seen, at the beginning of 2017 various approaches to these types of captures are still being interpreted differently. Ranging from using stereoscopic data from 360 video cameras to fully mapped LiDAR scans indicates there is radical variation and fast-changing technological possibility.[27] What is interesting to note here is how the 360 video producer is aware of the problems his regular productions pose to the feeling of immersion. Because of this, they are experimenting with creating depth maps using the difference of the angle between the lenses. In this we can see the social group of 360 video producers addressing a problem voiced by other social groups. This could indicate a translation: they are using an affordance of their camera setup to evoke a sense of immersion. Nevertheless, this type of content is useless on many of the present day headsets — predominantly those driven by smartphones, like Samsung Gear VR, Google Cardboard, and Google Daydream — for they do not feature 6 degrees of freedom tracking. Whether or not this is a step in the direction of closure thus remains to be seen.

In short, other than the 'in your face' issues of the HMD involving physiological problems and social awkwardness, deeper conditions also structure the development of VR technology. I have analysed my findings in terms of conditions belonging to the registers of epistemology, semiotic struggles, and cultural protocols. These conditions then are the framework or worldview from which VR is currently imagined as a tool *or* a future medium. However obvious or profound they may seem, they are no guarantee for the future form of VR. However, the outset of this thesis is vested in the paradox of technology. From this paradox we realise that, in thinking about (media) technology, the future is at stake in the present since the present is the only period in which it can develop. Now that we have located the future in the present by bringing in conditions found in the past, the time has come to release the shutter.

[27] Describing the state and process of technological development in the VR sector, the CEO of the VR co-working space noted how "steps are being made but we always say that on the one side everything is going really fast and on the other side everything is going really slow." By this he meant that in the enthusiast or investor scene set expectations have not yet been met even though hardware iterations and improvements follow each other up at a rapid pace. Now, from a social constructionist viewpoint, one might add that it is mostly the social concerns that slow down this firm belief in technological progression.

Conclusion

This thesis has sought to find out in what circumstances VR technology is developing and being imagined as a medium in the first half of 2017. With a social constructionist approach, issues with current versions of commercially available VR systems and HMD's were identified as entry points to problematise VR. The issues discovered were not only material issues; conflicting frameworks of meaning were also discerned — debates over what counts and constitutes VR and its topos of immersion. Talking to respondents who are involved with developing VR technology applications and content revealed disputes in the orders of the epistemological, semiotic, and cultural. From these circumstances I will conclude by providing some general observations.

The appearance of VR technology on the stage of the consumer market brings forth questions over VR's use. The entertainment, communications, and IT sectors imagine VR becoming a mass medium and see its technological development an end in itself. These conceptual conditions set the terms on which the meaning and use of VR is being developed. This development should be considered as a primarily cultural process: I would argue, with Jaron Lanier, that technology *is* our culture. Immersive experiences developed from a consumer culture standpoint in which we see cinemas and arcades popping up to provide access to a wider audience. At the same time, VR technology can be seen being put to use in health, business and research sectors as a technology that increases efficiency. These varying approaches portray the interpretive flexibility around VR as a medium. Of course it is a possibility that these uses and approaches to VR will live side-by-side — like the racing and transportation bicycles — or the contemporary hype around VR as an entertainment medium may die out once again. Diverging views on VR as a tool versus it being imagined as a mass medium can be understood to a greater degree when historical lineage is taken into account.

Comparing the periods of the first half of 2017 to the advent of the 1990s lays bare general continuities and discontinuities in the way VR is and has been conceived. Cultural framing determines the means and ends of VR as a medium. The ways that the various interconnected technologies are put to use can question the cultural framing, which leads to conflicts in setting protocols and determining semiotic demarcations. In this regard, the emergence of 360 video captures problematises what is understood by the term 'VR'. Whereas conceptions of using VR to meet and interact virtually can be found in the past three decades, a cinematic approach can be seen to be a contemporary construction. Provoking the feeling of presence in a scene where one can merely look and not act problematises the imagined possibility of VR. Moreover, the mimetic yearning for improved graphics is at odds with the epistemological condition of physiology and headset designs. Current disputes about the meaning of VR, and what type of VR systems or content allow for a truly immersive experience, are important since they influence the future shape of VR.

The results presented in this thesis give some indications for further research. First, a micro level production studies approach to new media companies involved with VR can bring to the fore more specialised practices. Comparing these practices across more companies and sectors could bring to light the developmental process of cultural protocols. Second, a more theoretical approach could investigate the bodily aspect that is so important for VR. This could situate the construction of the body through contemporary technology. Third, more audience based research could open up the scope used in this thesis and can chart other issues and relevant social groups. Finally, the bigger question as to why VR failed in the

first wave is left open for the more thorough historian to address in an archaeological manner. This will eventually open up the possibility of putting together a genealogy of VR.

As a final consideration I would like to compare VR to the cultural development of other media and the cultural form it takes. Looking back on the development of television, Raymond Williams famously analysed the shape this medium it took in various societies as a 'cultural form' (Williams, 1990). From the diversity in the experience of television across nations "it is clear that the technology as such was in no way determining" (Williams 1990, 26). His inspections shows that the form technology takes in society is determined by socio-historical circumstances. I have argued from a multidirectional approach to VR technology, with specific attention to the conditions in which it takes shape. This position can thus be allied with Williams, who argues that we should assert critically how we understand the relationship between technology and society: "[t]he most precise and discriminating local study of 'effects' can remain superficial if we have not *looked into the notions of cause and effect*, as between a technology and a society, a technology and a culture, a technology and a psychology, *which underlie our questions* and may often determine our answers" (Williams 1990, 1, my emphasis).[28] It is the frameworks of thinking in and about technology, society, culture, and science underlying our questions about VR that I have tried to lay bare. The attention paid to the contemporary issues here could be understood as a critical middle ground against the dystopian and utopian categories that are fallen back on all too easily. Whatever shape VR takes, its meaning will always be a mediation between its technological and its cultural form.

[28] The page continues: "It can of course be said that these fundamental questions are very much too difficult; and that they are indeed difficult is very soon obvious to anyone who tries to follow them through" (Williams 1990,1).

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APPENDIX A - Respondents overview

Creative director at Triple IT, a company that among other things sells straining simulations for both gamified rehabilitation environments as well as recorded VR simulations of soccer matches.

Physiologist Chair of Vestibular Motion at VU University Amsterdam and researcher at TNO. TNO, or the Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek, is an independent research institute which investigates the application of scientific research in collaboration with Dutch universities and commercial companies. Institutes like these have a long history of involvement in R&D processes of science and technology and are actively involved in monitoring and stimulating developments in technological applications. The respondent has over 20 years of experience in the field of simulation production under his belt.

360 video producer responsible for the post-production at Purple Pill, a 360/VR production company based at the VRBASE Amsterdam. This production company has presented work at various film festivals, such as IDFA, and is supporting one of the productions selected for the Venice film festival competitive VR section 2017.

CEO of a VR co-working space CEO of VRBASE Amsterdam, a co-working space and entrepreneurial hub for VR projects. The VR BASE was launched in the summer of 2016 to become a cluster of VR related companies, thus functioning as an 'accelerator' for this emerging technology sector. Some of the big local cultural institutions such as Eye, IDFA and Muziekgebouw aan het IJ are involved in this effort.

Interaction Designers at a Dutch multinational consumer technology firm [3 designers] at the Philips Experience Lab, design interaction interfaces for health care appliances, based on the High Tech Campus in Eindhoven. Philips is a major Dutch company selling products in various technology sectors worldwide. Historically they have been involved in the production of many massively adopted technologies such as light bulbs, television and music distribution systems.

Independent developer independent developer who designs and programmes virtual environments, based at the VRBASE. As designer and programmer of the simulated environment, he described his role in the production process as being the "how does the player navigate the environment, how do objects react to a player, what is the interaction on the player: can they grab, shoot or throw? All that behaviour is what I do, that is my main function, designing behaviour, and often I assemble the environment."

CFO of a Dutch VR-software startup co-founder and CFO of Yado VR. Yado VR offers a platform, based on their IP protected algorithm, that translates LIDAR scans into 3-D models and is based on the High Tech Campus in Eindhoven.

APPENDIX B - VR news waveS

VR newswaves

	Lexis nexis search results
year	search term: virtual reality in: newspapers number of results:
1988	0
1989	17
1990	80
1991	256
1992	800
1993	1526
1994	2161
1995	2957
1996	2751
1997	2624
1998	2614
1999	2784
2000	2484
2001	1831
2002	1551
2003	1570
2004	1233
2005	1118
2006	1279
2007	1510
2008	1429
2009	1300
2010	1457
2011	1399
2012	1384
2013	1389
2014	3419
2015	6947
2016	19049