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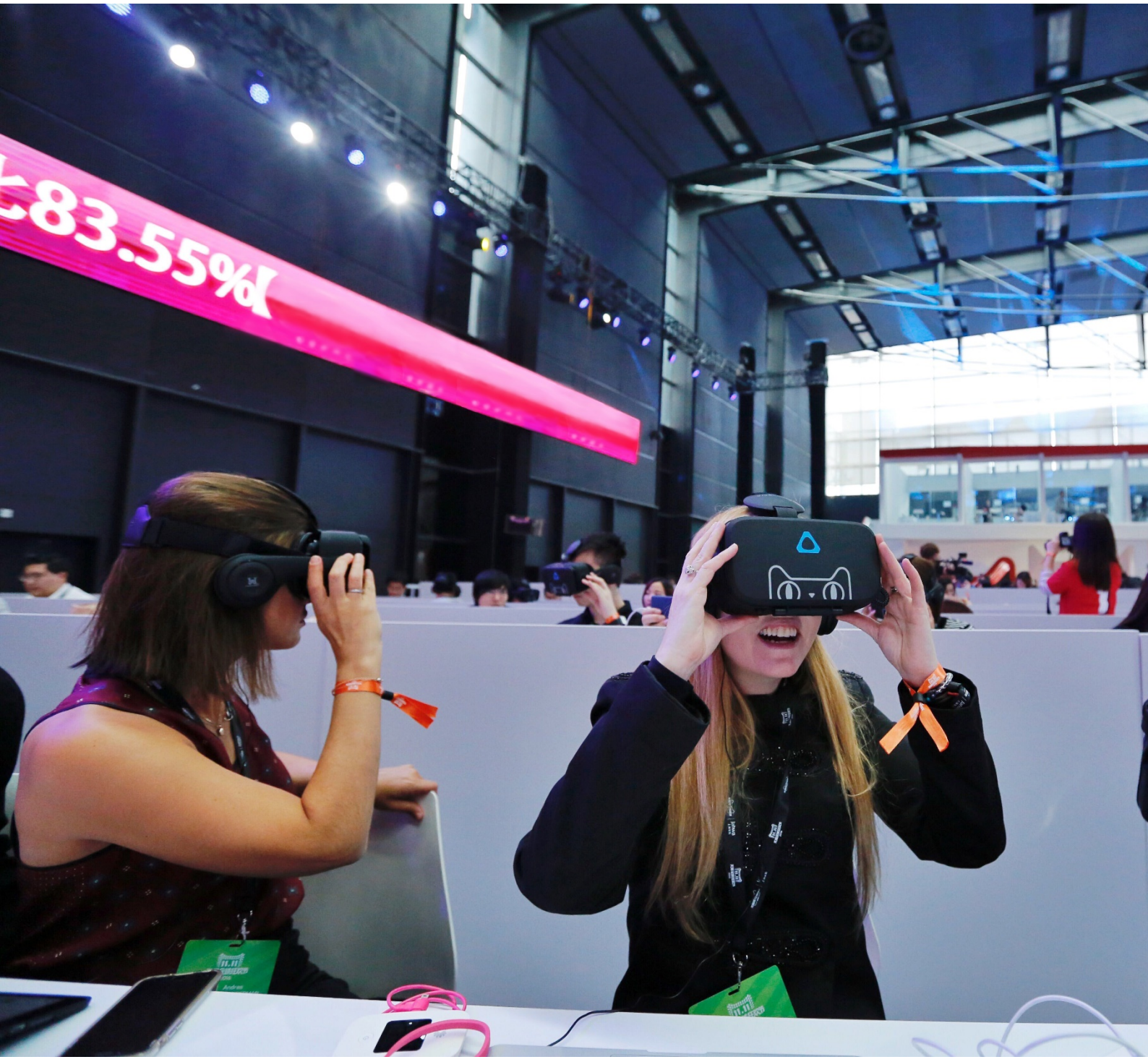
Responsible VR. Protect consumers in virtual reality



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Cover photograph
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Preferred citation:
Snijders, D., S. Horsman, L. Kool, R. van Est (2020). *Responsible VR. Protect consumers in virtual reality*. The Hague: Rathenau Instituut

Foreword

I recently watched an episode of the Netflix series Black Mirror, in which virtual reality (VR) plays a pivotal role. Two friends are playing a VR fighting game. Danny chooses a male character and Karl steps into the shoes of the seductive Roxanne. Danny and Karl are so absorbed in the game that they lose themselves in their virtual characters. Their fighting soon turns into an intimate entanglement. The question is soon posed whether a virtual sexual experience counts as adultery. Black Mirror asks us whether a VR experience that feels 'real' also has 'real' consequences.

This report shows that this question is not only posed in science fiction. Scientists, technology journalists and the VR sector itself are concerned about the way consumers are using VR. They are worried about social relationships, but also about the physical, mental and legal impact of VR. They wonder whether VR is so invasive that it should be regulated as a medical technology.

The literature on this subject also alludes to the possible abuse of market power, given all the data collected about consumers in this gaming environment. Facebook, Google, Microsoft and other tech giants have invested billions in developing VR hardware and platforms. More and more applications are available worldwide and in the Netherlands, and VR headsets are growing more affordable for consumers. VR is fast becoming an extension of existing social media.

Politicians and civil society must act to protect consumers and spark a debate on rights in the virtual world. The public needs clarification about the relevance of existing regulations, such as privacy legislation and consumer law, to VR. Other desirable steps are to provide information and place restrictions on the use of biometric data, and conduct more research into the long-term effects of VR.

This study aligns with one of the themes of our 2019/2020 work programme, i.e. 'Digital Society'. We chose this theme because we want to investigate new, immersive technologies that are transforming the way we interact with computers and the digital world. We are also investigating augmented reality and speech technology in this context.

Dr. ir. Melanie Peters
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Summary

Virtual reality (VR) is an immersive computer-generated three-dimensional, environment. Wearing VR headsets and using the accompanying accessories, users can move freely through this environment and interact with one another and objects. Facebook, Sony, Google, HTC, Microsoft and other tech giants have invested billions in this technology in recent years. As a result, VR has overcome many technical barriers and the devices now on the market are affordable and user-friendly enough and of good enough quality to be accessible to millions of people.

Virtual reality (VR) makes new digital experiences and forms of communication possible. It has been tested mainly in the professional world as a means of innovating transport, communication, education, healthcare, safety and product development. While the VR sector is excited about the potential of this new technology, there is less concern about its risks and the ethical issues surrounding its use by consumers. That is the focus of the present study. There has been little political or public debate, whether in the Netherlands or elsewhere, about VR technology (Kool et al., 2018) and very few VR-related policy measures, case law or ethical codes have emerged. What we do see is a growing list of academic publications addressing the key public and ethical issues involved. This study therefore analyses these publications and proposes a framework for organising their content. We summarise the most important ethical and public issues associated with VR in the consumer domain and note a growing challenge, as politicians continue to ignore VR despite the need to develop frameworks for integrating VR technology into society. We identify actions to resolve this dichotomy. Our study marks a starting point for an urgent public and political discussion of consumer use of VR in the Netherlands and Europe.

What's new about VR?

While VR resembles existing media technology, for example gaming and social media, in that it can function as a communication platform that connects people, it differs from that technology in two important respects.

First of all, VR is an **immersive technology** that submerges users entirely in a computer-generated environment, making it impossible for them to interact physically, in real time, with their real-world environment. VR sets cut users' senses off from the outside world. The sets make use of powerful computer simulations and headsets, headphones and gadgets to immerse users in a new, virtual world. The aim is to create a 'sense of presence', i.e. a subjective feeling on the part of users

that they are actually inhabiting the computer-generated environment in the here and now.

Second, VR is an **intimate technology** in which sensors in the VR headset collect large volumes of personal biometric data. By tracking user motion, including users head and body movements, eye movements, facial expressions and gestures, the technology collects information on a person's personality and preferences. Such biometric datasets can be used to create unique profiles of consumers, also known as 'kinematic fingerprints'. The fingerprints, in turn, can be used to identify and analyse specific individuals, both in the VR environment and beyond, by combining them with data obtained in other environments.

Overview of public and ethical issues associated with VR
This study reveals that the immersive and intimate nature of VR raises a multitude of ethical and public issues, for example with regard to privacy, autonomy, physical and mental integrity, informed consent, and access to technology. We differentiate between four clusters of risks pertaining to VR: physical and mental risks, social risks, abuse of power, and legal risks (see Figure 1).

1. With respect to **physical and mental risks**, there are serious questions about addiction and the long-term consequences of VR use. Some users experience a high level of emotional engagement with and even a disproportionate sense of attachment to virtual characters, virtual entities and the VR world. They run the risk of losing touch with reality, leading to feelings of confusion and loss of control because they cannot distinguish between real-world or familiar experiences and experiences in virtual reality.

2. VR may also pose **social risks**. Like the internet and social media, the rise of VR may well change the way we interact with others. In extreme cases, this can lead to people becoming estranged from their social environment. The immersive nature of VR means that extreme content poses risks, such as in the case of sexual and/or aggressive images that could lead to inappropriate behaviour in the physical world. Whether murder and other behaviour that is unlawful in the physical world should be permitted in VR is a question that must be taken seriously in light of VR's immersive nature. One telling sign is the increasing number of reports of sexual assault, defamation, stalking and other forms of threatening and aggressive behaviour in the virtual world (e.g. in online games).

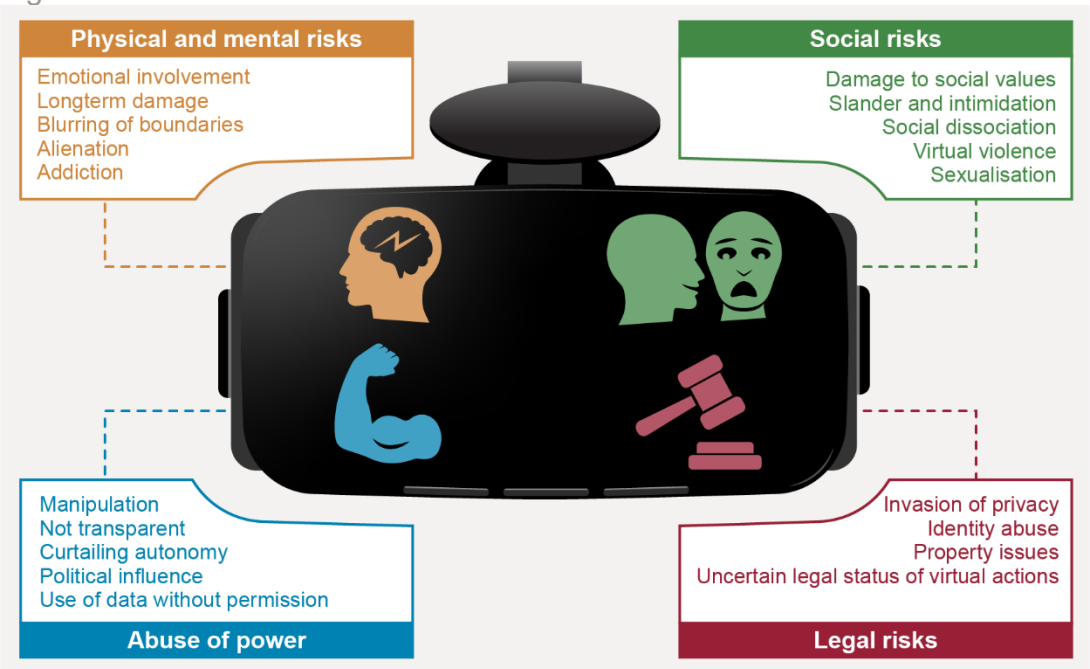
3. **Abuse of power** refers to the ability of developers and users to influence user behaviour by manipulating virtual worlds, objects and avatars without the user knowing or agreeing. User data (including personal data) can be manipulated or misappropriated for purposes of profit or political or other influence,

undercutting personal autonomy, freedom from social control, freedom of choice and self-determination. This is particularly relevant because VR systems can collect all types of intimate biometric data from users, giving VR companies information on a person's personality, behaviour and preferences. A related issue is that virtual spaces offer numerous opportunities for targeted advertising that keys into a person's desires, preferences and choices on a direct and subconscious level.

We also note that the tech giants are extending their current unique concentration of power. A small number of major tech companies are developing the hardware, software, content and infrastructure of the virtual world, leading to an unwelcome concentration of power. For example, there are no VR spaces outside the control of tech companies where people can interact without being observed.

VR represents a grey area in which several legal and legal-philosophical issues converge and this entails a number of **legal risks**. What does privacy mean in the virtual world? Can damage to virtual entities be equated with damage to real entities – and if so, to what extent? These issues must be clarified for the protection of users and their virtual possessions.

Figure 1 Four risk clusters in consumer VR use



Source: Rathenau Instituut

Regulating VR

As it seems that VR could be entering the consumer market on a massive scale in the coming years, and since the technology raises many public and ethical issues, we note a growing dichotomy between the lack of political interest in VR on the one hand and the need to develop frameworks for integrating this technology into society on the other.

The most fundamental question is to what extent VR should be seen and regulated as a biomedical technology. As computers, cameras, biometric sensors, VR headsets and the human body become ever more closely integrated, it is growing easier to influence individuals in real time without their noticing. Politicians and the authorities must respond to the development of intimate technology without delay and move to establish appropriate and effective frameworks for integrating VR into society. Politicians can do this by building on existing regulatory frameworks that deal with personal data protection and biomedical technology.

To curtail the public and personal risks posed by VR, we propose the following four measures:

1. **Launch a national/international debate on the ethics of VR**
2. **Establish frameworks for integrating VR into society**
3. **Inform and protect VR consumers properly**
4. **Study the long-term effects of VR**

1. **Launch a national/international debate on the ethics of VR**

   In addition to informing consumers, it is important to have a public and political debate on abuses of power and the physical, mental and social risks of VR. Over the past two years, there have been numerous attempts worldwide in scholarly, business, civil society and government circles to scrutinise the ethical aspects of and regulate social media, robotization, AI and other digital technologies. Debates on such new technologies not only raise public awareness of risks, but also lead to the development of normative frameworks that are then used and refined by those working in academia, industry, civil society organisations and government bodies. The specific issues surrounding VR will require much more public and political consideration worldwide in the years to come.

2. **Establish frameworks for integrating VR into society**

   There are various regulatory frameworks that can be applied to consumer use of VR, including privacy legislation and consumer law. It is important to clarify what such existing frameworks mean for VR and to what extent VR calls for specific adaptations, for example rules pertaining to the sharing of specific

biometric data. Within the framework of competition law, governments must keep a close eye on the possibility of tech giants dominating the market and abusing market power, and ensure consumer protection. The fact that companies are now increasingly able to link up data streams, profile users in fine detail, and influence their behaviour makes it both necessary and urgent for them to shoulder the responsibility for secure data management and privacy and for user health and wellbeing. The most fundamental question is to what extent VR should be regulated as a biomedical technology as well as being subject to consumer law.

3. **Inform and protect VR consumers properly**
   Research suggests a long list of VR-related risks (see Figure 1). It is therefore essential to properly inform consumers about and protect them against the possible harmful effects of VR. Following the example of the medical sector, this could take the form of leaflets, professional guidance or information campaigns. VR users hand over their most intimate data and become vulnerable to commercial parties, but also to other people. Consumers need to be informed about the personal and intimate data they generate in VR and how this data can be used to infringe their privacy and autonomy. VR platforms are neither public nor private spaces; rather, they are markets in which money and data change hands. Both supply and demand are mediated not by a neutral platform but by a private facilitator that makes the rules. This comes down to a case of 'information asymmetry', with consumers not knowing exactly what happens to their personal data, even if they consent. Because certain data are so personal and intimate that they make the individual vulnerable to abuse, whether by governments, hackers, commercial parties or other users, legal restrictions should be imposed on the collection, combining and sharing of data in VR.

4. **Study the long-term effects of VR**
   Because consumer VR is a recent phenomenon, there is insufficient knowledge about its risks and virtually no understanding of its long-term effects. VR researchers have drawn attention to the many empirical questions related to VR that should be addressed in the short term. For example, what impact does immersion in VR have on users? Which VR experiences have disruptive and negative effects on users? As in the case of new drugs with cognitive side effects, longitudinal research is required to identify the long-term effects on different groups.

The absence of hard evidence concerning the possible secondary effects and harmful consequences of VR is currently slowing down its use in healthcare. meanwhile VR companies are increasingly marketing their applications as self-

therapy products for which a medical prescription is not required, thus circumventing the expensive and time-consuming investigation process involved in marketing medical products. This study argues that the immersive and intimate nature of VR gives it intrinsic biomedical effects, even if they are unintended (side effects), and that its use may pose a variety of physical and mental risks, such as addiction, depersonalisation and dissociation. It is important for the scholarly community to do more research into the effects of VR and to identify its long-term risks.

Inhoud

1 Introduction

1.1 Emergence and potential of VR

Virtual reality (VR) has long fascinated us. Researchers first began exploring how technology can manipulate our senses to make it seem as if we are escaping from physical reality in the 1950s. Increasingly, VR developers are making this dream come true. Whether we imagine being on Mars or occupying the body of someone of a different gender or race, developers claim that the only limits to virtual reality are the limits of the human imagination.

The pace of progress in VR has quickened in recent years. When Facebook acquired the VR company Oculus for more than two billion dollars in 2014, VR attracted fresh public attention. Since then, other tech giants – including HTC and Valve (Vive), Microsoft (HoloLens) and Sony (Morpheus) – have invested billions in VR technology. Research firm Statista estimates that the VR market will be worth more than 200 billion dollars in 2022.[1] Large investors predict that VR, like the smartphone, will soon become a mass-market commodity. The first technically adequate and easy-to-use VR headsets were launched in 2016. Although VR headsets account for only a small share of the VR market today, that share is expected to grow in the years ahead as a new generation of cheaper and more comfortable headsets is introduced.[2]

Potential of VR

When Teegan Lexcen was born with a heart defect in 2015, one of the surgeons at Nicklaus Children's Hospital in Miami, Florida, used an inexpensive VR set to prepare for the necessary procedure.[3] Being able to study a three-dimensional model of the child's heart in VR helped the surgeon to perform a successful operation that the baby survived. VR makes all sorts of new things possible. For example, it is used as a training tool in classrooms and allows pupils to go on virtual excursions. Employees use it to learn how to manage risks, workplace situations or unfamiliar experiences. VR is an inexpensive and safe way to prepare drilling platform workers and fighter jet pilots for their high-cost, high-risk work. In order to let people experience what life is like for Syrian refugees, the United Nations launched the VR documentary *Clouds over Sidra* (Robertson, 2016). Psychologists

1 See: https://www.statista.com/statistics/426469/active-virtual-reality-users-worldwide
2 The hope is that the mobile 5G data network that will be rolled out in the Netherlands starting in 2020 will also improve the quality and mobility of VR technology.
3 See: https://www.geek.com/news/surgeon-practices-heart-surgery-using-google-cardboard-before-saving-girls-life-1643237

Banakou et al. (2016) designed an experiment that changed the user's skin colour in VR and demonstrated that VR simulations can help combat discrimination. In healthcare, VR is used in virtual therapy sessions to treat patients with arachnophobia or post-traumatic stress disorder (PTSD). VR also supports effective communication, allowing doctors to treat patients remotely and eliminating the need for physical travel. In the judicial context, VR applications have been developed to prepare prisoners for their return to society, to help offenders change their behaviour, or to train professionals to deal with difficult situations (Cornet et al., 2019, 28-33).

1.2 VR as an immersive and intimate technology

VR technology's power lies in its 'immersiveness', i.e. the experience of being immersed in another world. VR users often feel as if they are actually present in the virtual world. Users who make frequent and prolonged use of VR may find it increasingly difficult to distinguish between their VR experiences and their lives in the real world. They may come to identify with their virtual bodies and even start to believe that they are their actual bodies. Such optical illusions can lead to changes in their behaviour, attitudes and perceptions. VR technology is 'intimate' in that it penetrates users' perceptions by manipulating their senses in a way that goes beyond traditional media technology.

Intimate technology

VR is an excellent example of what the Rathenau Institute has termed 'intimate technology' (Van Est, 2014). VR takes the merger between human and technology further than other technologies. VR headsets are worn over the user's head and block signals in the physical surroundings from reaching their eyes. VR technology is therefore connected directly to the human biological cognitive system and feeds it images, sounds and other stimuli. It 'captures' the user in three ways:

1. The VR set uses numerous biometric sensors to track the user in a variety of ways.
2. It uses this biometric data to profile, monitor and analyse the user.
3. It gives the user a unique, personalised, virtual world to see, hear and feel.

Previous research by the Rathenau Institute showed that digitisation and technologisation go hand in hand with a political and economic battle that raises numerous social, ethical and political issues (Van Est 2014). In addition to questions about privacy and security, digitisation can also raise ethical issues about autonomy, control over technology, human dignity, physical and mental integrity, equity and equality and the power balance (Kool et al. 2017). VR technology makes it possible to collect all kinds of intimate biometric data from the user, to profile the

user in all kinds of ways, and to pre-programme what the user sees. We expect VR to raise the following ethical issues: To what extent can the identity of users be manipulated in VR? What are the psychological consequences of immersive VR experiences? What can companies do with the huge quantities of intimate biometric data generated by VR experiences? And who in fact owns the data?

While the VR sector is excited about the potential of this new technology, there is less concern about its risks and ethical issues. Politicians and civil society in the Netherlands and elsewhere have so far tended to refrain from debate on VR technology (Kool et al., 2018) and very few VR-related policy measures, case law or ethical codes have emerged. In the past ten years, however, we have seen researchers grow increasingly alarmed about the potential risks of VR. In this study, we discuss a number of these ethical issues and propose specific measures for managing them properly.

VR for consumers
Dutch consumers are rapidly embracing VR in various ways, even though the risks and ethical issues have not been addressed. This study focuses on VR practices in four specific consumer areas:

- de VR gaming sector
- the VR porn industry
- VR therapy
- social media platforms.

In doing so, it examines the most important developments in virtual reality. We have chosen the entertainment sector, because in this area, the market potential of VR has already proven itself: gaming and porn are currently the largest VR industries' (Takahashi, 2018). In addition, the Netherlands is seeing an increase in VR applications in the healthcare sector. Health insurers now (partly) cover some of these therapies. We also look more closely at VR social media platforms, which first induced Facebook and other tech giants to invest in VR and which are now reaching maturity. We describe trends and applications in these areas in more detail in Chapter 3.

1.3 Research questions

The purpose of this study is to clarify the technical status of VR and the ethical and public issues surrounding the consumer use of VR so that the resulting framework can form a basis for a public and political discourse on the integration of VR into Dutch society. The main questions are:

1. What is the current status of VR technology?

2. What are the most important current consumer VR applications and what can we expect in years to come?
3. Which ethical and public issues, or risks, may be associated with consumer use of VR?
4. How can the worlds of politics and government guide the development of VR from a public interest perspective?

1.4 Method

To address our research questions, we carried out a systematic literature review combined with desk research. To answer sub-question 3, on the ethical and public issues or risks that may be associated with consumer use of VR, we combed through scholarly articles published between 2010 and 2019 by searching Google Scholar, Springer, WorldCat, SagePub, PhilPapers, JStor and Web of Science. We searched these digital libraries using the keyword 'virtual reality' in conjunction with at least one of the following terms: 'ethics', 'ethical', 'moral', 'morality'. Our search yielded 65 articles. We then looked at the full texts of these articles and whether, for our purposes, they sufficiently addressed ethical and public issues surrounding VR. This led to a final list of 34 articles (see Appendix 1). Many were originally published in the fields of philosophy of technology and psychology. Some are themselves literature reviews or scholarly surveys. We identified the ethical and societal issues related to VR in each of the 34 selected articles. Our analysis yielded a set of twenty issues that we divided into four risk clusters:
1) physical and mental risks
2) social risks
3) abuse of power
4) legal risks.

These four risk clusters provide the structure for Chapter 4 and are discussed in more detail there.

Given the relatively recent development of VR and the absence of a long research tradition in this field, we decided to consult 'grey literature' in addition to scholarly publications. Grey literature is literature that is not distributed through traditional academic publishing channels, such as news items, journalists' reports and private-sector publications.

1.5 Reader's guide

Each of the subsequent chapters addresses one of our research questions. Chapter 2 examines the first question, concerning the current status of VR technology. We discuss the definition of virtual reality and the history of the field and analyse the technology that creates virtual experiences.

Chapter 3 zooms in on four consumer sectors in which VR is particularly prominent: gaming, pornography, virtual self-help and social media platforms. In addition, we consider how VR is evolving and in which areas we expect to see growth.

Chapter 4 looks at which ethical and public issues are associated with consumer use of VR. We use the results of our literature review to identify four risk clusters:

1. physical and mental risks
2. social risks
3. abuse of power
4. legal risks.

Chapter 5 summarizes the most important findings and identifies four actions that are necessary to integrate VR into society. Because VR will soon be accessible to millions of people, we consider it urgent to launch a public and political debate about the impact of VR on society and to establish frameworks based on the outcomes of this debate.

2 What is the current status of VR technology?

What is virtual reality (VR)? And how does VR technology relate to other immersive technologies, such as gaming and augmented reality (AR)? This chapter begins by considering such matters of definition and scope. We sketch a brief history of VR and then describe how the main components of modern VR headsets work and how VR experiences are generated. We also discuss the latest state of technology and reflect on the technical challenges that the VR sector faces. We conclude the chapter by anticipating future developments of VR.

2.1 What is virtual reality?

As early as 1999, Philip Brey of the University of Twente defined virtual reality (VR) as a three-dimensional computer-generated environment in which users can immerse themselves (Brey, 1999, p. 5). VR headsets and accessories allow users to navigate and interact with objects in this computer-generated environment. Most VR sets are designed to completely shut users off from the physical world and use sensory stimuli to immerse them in a different, virtual world (Amer, 2012). The aim of VR is to create a 'sense of presence', i.e. a subjective feeling on the part of users that they are actually inhabiting the computer-generated environment in the here and now (Coelho et al., 2006). Ideally, users forget that they are participating in a simulation and that their artificial world does not really exist.

In a sense, presence is not unique to VR; it also applies to reading a compelling book, watching an exciting film, or playing a computer game. Where VR differs from other media, however, is that the immersion depends less on the user's imagination and that the technology makes it easier for users to interpret the content of the medium as real (Sherman & Craig, 2018). Besides mental immersion, VR sets also offer physical immersion by creating sensory feedback. The special gloves, suits and treadmills that generate sensory stimuli – visual, auditory or tactile – may make it more difficult for users to distinguish between VR and real-world experiences. The extent to which VR succeeds in creating a sense of presence depends, among other things, on the quality of the sensory data, but also on the individual user (IJsselstein, 2002).

Immersive technology: a spectrum

There is a spectrum of immersive technologies and it is important to understand how VR relates to other technologies in this category. We present this spectrum in Table 1 and, to make the distinctions clear, describe the features of the different technologies.

Table 1 Spectrum of immersive technologies

	Virtual world via computer	Augmented reality		Virtual reality	
		Simple Head Up Display (HUD)	Complex Mixed Reality	Simple 180° or 360° videos	Complex Animated VR
Image	Computer-generated images.	Information layer projected on field of view.	An amalgamation of computer generated images, virtual objects ,and the physical world.	Static film images that are often recorded with a omnidirectional camera.	Computer-generated images.
Medium	Computer screen	Projection of information on a lens, screen, or glass plate.	Smartphone or AR headset, controllers and / or other haptic technologies.	VR-headset.	VR headset, controllers and / or other haptic technologies.
Interaction with design	A user controls the world indirectly via secondary hardware systems such as a mouse and a keyboard.	There is no interaction with the information layer.	Via GPS, accelerometers, and head tracking there is interaction with the environment. This interaction can be made more realistic by using controllers or other haptic gadgets.	Videos adapt immediately to the head movements of the user, thereby creating physical interaction with the environment.	By means of head tracking, physical interaction with the environment takes place. This interaction can be made more realistic by using controllers or others haptic gadgets.
Physical experience	In many cases users feel a certain distance to their avatar, but it is possible that users start to identify with the body of their avatar.	With a HUD a user has the experience of his / her own body.	In AR environments a user usually has the experience of his / her own body. Their body or parts thereof, can, however, also be virtualized, causing dissociation with their own body.	Because of a specific way of filming, 360 ° videos can be experienced from the field of vision of a person, which could generate the illusion that the body in the video is the user's body.	In VR, it is possible to create a fully embodied experience of an avatar, by using virtual embodiment. to suit. For this, a sensory suit is necessary.

Source: Rathenau Instituut

First of all, VR differs from computer-generated virtual worlds such as *Second Life* that allow for *minimal* interaction with the environment (see Figure 2). Users experience these virtual worlds indirectly and in two dimensions on a computer screen. They control the virtual world with secondary hardware, such as a mouse, keyboard or touchscreen.

Figure 2 An avatar in Second Life

Source: Embervoices, Flickr.

Augmented reality (AR) layers computer-generated, virtual elements on top of a physical reality. A broad range of applications fits this description. To identify the most important differences, we distinguish between simple and complex versions. Simple versions, such as head-up displays (HUD), project a small amount of information directly onto the user's field of view. The military has been

experimenting with HUDs since the 1940s (White 2007, p. 207). Early models were designed to allow jet fighter pilots to fly without constantly checking their instrument panels. Today, HUDs are common in cars and lorries, with route information being projected directly onto the windscreen.

As digital technology advances, the virtual layers of augmented reality are becoming more dynamic, realistic and interactive. The latest versions of AR connect virtual elements spatially to the geometry of the physical environment. Users interact with an enhanced version of reality, in many cases using a smartphone or headset equipped with cameras. Such complex interactive forms of AR are often referred to as mixed or merged reality (MR).

VR differs from virtual worlds and AR in that it immerses users in a fully computer-generated environment. We differentiate between two types of VR:

1. *180- or 360-degree videos*
   180- or 360-degree videos project images that are not computer-generated in real time. 180-degree videos project a 180-degree field of view, which is less expensive to develop. Films can be viewed in a computer-generated theatre or framework within which the film is set. 360-degree videos allow users to look all around, heightening their sense of presence.
2. *Animated VR*
   Animated VR immerses users in a fully computer-generated environment that allows for more dynamic interaction.

2.2 History of VR technology

VR visionary Morton Heilig developed what is regarded by many as the first VR system, the Sensorama, in 1957. At a time when people were only familiar with black and white television, Heilig created a booth in which users could ride a virtual motorcycle. He used 3D image, sound, wind, vibrations and smells to make the experience as realistic as possible. Although the Sensorama was not a huge commercial success, Heilig's vision was clear. He wanted to create a system capable of influencing users' senses and making them believe that they really were inhabiting a virtual world.

His vision was shared by Ivan Sutherland, who created the first VR headset, called the 'Sword of Damocles', in 1968 (see Figure 3). For the first time, a virtual image adapted continuously to the user's head movements. Despite its relatively simple graphics, the system is still regarded as a significant forerunner of current VR headsets (Lanier, 2017). Sutherland believed that VR's ultimate purpose was to let

users walk around in a virtual environment and interact with virtual objects as if they actually existed.

Figure 3 Sword of Damocles, the first VR headset

Source: Ivan Sutherland

After several decades of research, technology pioneer Jaron Lanier coined the term ‘virtual reality’ in 1986. It became a true hype, giving rise to films, books and conferences about VR and with companies turning their attention to the underlying technology en masse. Expectations ran very high. Nicholas Negroponte, founder of the MIT Medialab, predicted in 1993 that in five years’ time, 10 percent of people would wear a VR headset when taking public transport (Negroponte, 1993). The technology was not advanced enough to be commercially viable, however. Computer systems could not produce a fluent VR experience, causing many users to experience motion sickness. Systems that were powerful enough cost tens of thousands of dollars. The years that followed are known as the ‘VR winter’, a lengthy period in which there was sparse investment in the technology and VR headsets were sold only to specialist researchers (Bailenson, 2018). Only a few universities and companies worked on taking VR technology to the next level and on making it viable for healthcare and for military training purposes (Lanier, 2017).

Thanks to advances in today’s smartphone technology, VR has improved significantly in recent years and the costs have dropped sharply. The development of the smartphone has led to better and cheaper small high-resolution displays, processors and motion-tracking sensors (Kelly, 2016b). In addition, the number of transistors in microchips has doubled every two years in recent decades. As a

result, it has now become possible, for the first time, to design VR headsets that are affordable enough for consumers and comfortable to wear, without annoying wires.

2.3 VR-hardware

The first VR headsets hit the consumer market in 2016. They had to be connected by wires to a powerful computer or game console. Users needed a pricey computer or game console with a good graphics card, and the wires restricted their range of motion in the virtual environment. VR headsets powered by smartphones were introduced around the same time (for example Google Daydream and Samsung Gear VR). These were primarily head mounts for smartphones that offered only a limited VR experience. The first stand-alone headsets, e.g. the Oculus Go and other headsets that did not need to be connected to secondary hardware, were launched in 2018. Table 2 lists the most popular VR-headsets around today.

	Smartphone	**Game computer**	**PC**	**Standalone**
Popular VR headsets	Daydream (Google) Gear VR (Samsung)	Playstation VR (Sony)	Oculus Rift (Facebook) Vive (HTC) Odyssey+ (Samsung)	Oculus Go and Quest (Facebook) Vive Focus (HTC)

Source: Rathenau Instituut

VR gadgets

Whereas Heilig tried to mimic all five senses with his Sensorama, current VR headset manufacturers focus mainly on mimicking auditory and visual perception (Lanier, 2017). Advanced VR headsets also mimic a simplified sense of touch using vibration-generating controllers, so that users feel as if they are physically touching objects in the virtual world. This is known as haptic technology (see Figure 4). Companies are now developing various wearables that will mimic the sense of touch more realistically. For example, start-ups such as VRGluv and Noitom are working on haptic gloves, and start-up Teslasuit announced in 2018 that it was developing the first full-body haptic suit.[4] It will be made of smart textile with integrated motion capture and climate control that can adjust the temperature inside the suit to match the virtual environment.

4 See: https://www.digitaltrends.com/gaming/teslasuit-experience-ces-2019

Figure 4 Haptic VR gloves

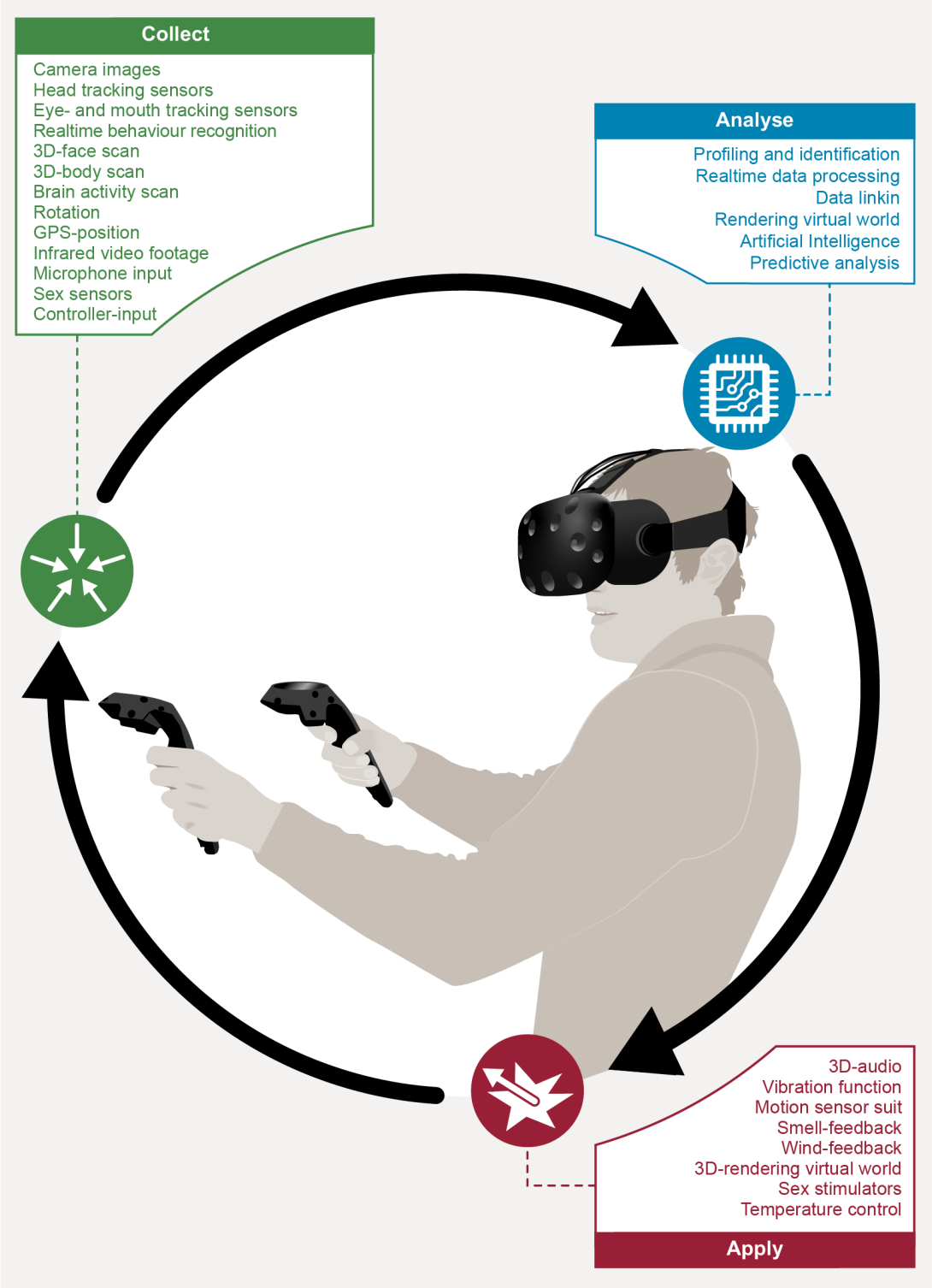
Source: Engadget

2.4 How VR-technology works

We can explain the interaction between VR hardware and user by referring to the cybernetic feedback loop (Kool et al., 2018). This model revolves around three steps (see Figure 5): data collection (tracking people), data analysis (profiling people), and application of data analyses (influencing people's behaviour). The process does not stop at application but goes back to square one whenever new data are collected.

We explain the three steps in detail below. It should be noted that our reasoning is based on the relationship between the VR system and the user. 'Input' is the information that the system collects *from* the user, while 'output' is the feedback that the system then provides *to* the user. Figure 5 identifies the technical features that play a role at each step of the cybernetic feedback loop.

Figure 5 The cybernetic feedback loop as it applies to the technical features of VR



Source: Rathenau Instituut

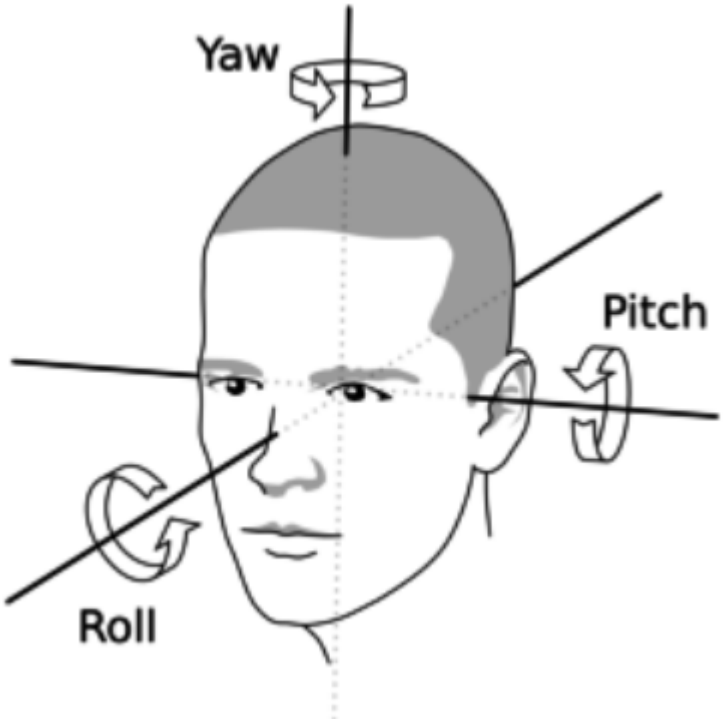
Collecting biometric data

VR headsets have dozens of built-in sensors, including cameras, microphones, speakers and head-motion tracking sensors (including gyroscopes, accelerometers, magnetometers, structured light systems and eye tracking sensors), as well as physical buttons and sensors on the gaming controllers. The input for the VR system is the user's intimate biometric data, which the sensors in the headsets and gaming controllers collect and store during use. Users do not control VR with a mouse and keyboard, the customary interfaces for standard computers; instead, they use the gaming controllers or a biometric system that converts eye and face movements and body gestures into virtual actions. As a result, VR requires other and above all more data to be collected as input than in standard computer use. For example, almost all VR sets track the user's head movements to establish and update his or her point of view in the virtual world in real time. The sets use two techniques to do this. The first is tracking of the rotational motion of the head, known as pitch, yaw and roll (see Figure 6).[5] The second is tracking of the position of the body: forward/backward (surge), up/down (heave) and left/right (sway). In addition to tracking rotational motion, advanced headsets use infrared sensors to track head movements, giving users the freedom to navigate and move around in virtual environments.

Relevant controllers track hand movements, while other haptic gadgets track movements of fingers or limbs or, for example, body temperature. There are headsets available that track other intimate user data, such as eye movements and/or brain activity (Leprince-Ringuet, 2019; Metz, 2017). For example, the Fove is the first headset to integrate eye tracking, making the visual experience more realistic. Because the headset renders peripheral images in lower resolution (mimicking weak human peripheral vision), it also uses much less computing power. In addition, we now have the first generation of headsets that combine VR with a brain-computer interface that senses brain activity. Researchers and game developers can use the data these headsets collect to examine what users experience in a VR simulation, or to develop an advanced form of neurofeedback training (a method aimed at changing brain activity). Some speculate that brain-computer interfaces will someday make it possible to control virtual objects with the brain, for example simply by thinking about something (Metz, 2017), although the technology has yet to be proven.

5 For an explanation, see: https://simple.wikipedia.org/wiki/Pitch,_yaw,_and_roll

Figure 6 Tracking of rotational motion in VR based on pitch, yaw and roll



Source: Jantunen et al. (2016), p. 850.

Analysing and processing data

All of the sensory input can serve to create a user profile. Combining all motor function data results in a 'kinematic fingerprint', a completely unique profile that can be used to identify and analyse specific persons (Kopfstein, 2016; Madary and Metzinger, 2016). It is important to understand that this kinematic profile is not only suitable for VR purposes but can also be used to detect people in public spaces, by uploading their profiles into smart surveillance cameras and other sensors. It is also possible to link user profiles to other, existing profiles based on their internet search histories, online behaviours and interactions, online purchases and communication and other digital actions.

Data analysis and processing proceeds in several steps. The application simulates the virtual world and digitises and processes the input (i.e. the data collected from the user), allowing the system and the software to calculate the current status of the virtual world for each timeframe. It repeatedly calculates the exact location of the virtual objects and users and establishes which actions are taking place. The newer headsets also establish where users are in physical space and furnish them with feedback. Rendering is the process of converting raw data into a digital representation that users can understand. All sensory data, i.e. visual, auditory and haptic data, is subject to this process. The time it takes to adapt the generated

image to the user's head movements is crucial, since any reaction time of more than a few milliseconds may render the illusion unrealistic. In many cases, an excessively long reaction time will also cause motion sickness in the user.

Applying data
The output is the representation of the virtual world as perceived by the user. The most important output is the image: a continuous representation of virtual reality in three dimensions. Stereoscopy – a technique in which both eyes see slightly different two-dimensional images that the brain then merges into a single, three-dimensional image – is used to create the illusion of depth.

At present, VR is experienced primarily by wearing a VR headset. It is also possible to generate a VR experience using a CAVE (a virtual reality projection room) or a powerwall (an ultra-high resolution display).[6] Three-dimensional audio is usually generated through headphones that minimise any background noise as much as possible for the user. Users experience touch by means of vibrating gaming controllers or haptic gadgets or through vibrations in the haptic suit that they are wearing. Systems, for example that generate wind or scent, may also be added to the user's physical environment to provide additional sensory feedback.

2.5 Technical challenges

Although VR has made great technical strides in recent years, the question is to what extent the technology will be embraced by the general public in the foreseeable future. Some journalists believe that VR will always remain a niche market (see for example Topolsky, 2018), while others are confident that VR will soon catch on with the general public. The tech giants mentioned above have invested billions in VR technology for this reason. Research and consulting firm Gartner expects that it will take another five to ten years before VR technology has reached a 'mature level'.[7] Nevertheless, our research reveals a number of technical challenges.

First of all, VR headsets are often cumbersome devices that completely block the users' view. The latest headsets solve this problem by integrating multiple cameras, allowing wearers to see the real-world as well as the virtual environment. Even so, user-friendliness remains an issue. Some users still suffer from 'virtual reality sickness', similar to motion sickness, and VR can also cause eye strain because users' eyes never get any rest (Takeuchi et al., 2018). Hardware firms will be

6 Since these options are very expensive and therefore unaffordable for consumers, they do not form the focus of this study.
7 See: https://www.gartner.com/smarterwithgartner/3-reasons-why-vr-and-ar-are-slow-to-take-off

working to make the necessary technical adjustments in the years ahead, for example to reduce the delay between input and output (Bailenson, 2018). Currently, VR manufacturers such as Oculus recommend taking ‘at least a 10 to 15 minute break every 30 minutes, even if you don’t think you need it.’[8]

In addition, technology firms intend to work on improving control of avatars (digital alter egos that represent the user) in virtual worlds. This includes the ongoing development of haptic gadgets beyond mere gaming controller vibrations to mimic the sense of touch (Lanier, 2017). Haptic technology is not yet able to do this realistically. Since we use our hands in all kinds of ways, for example to determine the hardness, shape, texture or weight of objects, VR developers are exploring how best to simulate all these experiences in the virtual world.

Figure 7 Facebook’s Codec Avatar scanning system, with an image of the real-world subject on the left and the avatar on the right.

Source: Facebook

In addition to enhancing the tactile nature of the virtual world with haptic technologies, developers are also using 3D scans to improve the representation of the physical world in the virtual world.[9] VR avatars do not look very lifelike at the

8 See: www.oculus.com/warnings

9 For an idea of how objects are scanned for use in VR, see: https://www.**youtube**.com/watch?v=7g-5hgWPMVQ

moment, but several firms are using artificial intelligence (AI) to simulate faces more accurately and to create realistic avatars. As a result, the visual difference between the VR version of a person and that person in the flesh is growing smaller (Rubin, 2019). Facebook, for example, is developing the Codec Avatar scanning system (see Figure 7), which is not yet ready for the market. Carnegie Mellon professor Yaser Sheikh, who is involved in the Codec Avatar project, says that its purpose is to allow communication between people in the real world to be fully simulated in the virtual world, replacing almost all telecommunication.[10] This means extending face scans to full body scans, but this requires the researchers to work around 'extrinsics', i.e. disruptions and other unintended experiences that interfere with the user's sense of presence. The technical challenge lies in keeping the avatar's movement as smooth as possible, without hiccups or failures even if it's dark or a good scan is not possible.

10 See: https://www.wired.com/story/facebook-oculus-codec-avatars-vr

3 VR for consumers

Pioneer Jaron Lanier has been claiming since the 1990s that virtual reality is a new art form not limited to existing media (see Lanier, 2017). While that may be true, current consumer applications do often build on existing media, two prime examples being computer games and porn films. However, the number of different applications is expanding rapidly now that the group of VR users is increasing. According to Statista researchers, there were 171 million active VR users worldwide in 2018, and they expect this number to rise significantly in the coming years.[11] Film festivals feature more and more VR films and documentaries, artists often experiment with VR, and companies use VR to innovate shop concepts. IKEA, for example, has launched its 'Store Experience that never closes', allowing consumers to browse through a VR store at any time of the day or night.

In this chapter we discuss the current status of consumer VR applications in four sectors where they are popular: gaming, porn, self-help and social media. We chose gaming and porn because they are the largest growth markets in the VR domain, with both the highest level of investment and largest number of users. We chose self-help because it is an important consumer market for VR in the Netherlands; in fact, insurance companies now reimburse a number of VR health applications. We chose social media as our final case study because it was the reason that Facebook, Microsoft and other tech giants originally invested in VR. This last case is relevant for our study because the social media domain is not about individuals but rather about a shared social experience, the aim being to create a shared VR world in which millions of users can interact. We describe how VR is used in each of these sectors and how it could develop in years ahead.

3.1 Compelling video games

Besides hardware, VR is all about content. Content today mostly comes from the USA or China and encompasses porn videos and games (Takahashi, 2018). The gaming industry is the most visible platform for VR content and a logical starting point for our study. Some very popular games have emerged in the past year. One of these was Beat Saber,[12] which was downloaded 100,000 times within a month of its release in May 2018 and recorded a turnover of USD 2 million.

11 See: https://www.statista.com/statistics/426469/active-virtual-reality-users-worldwide
12 See: https://uploadvr.com/beat-saber-passes-100000-copies-sold-in-less-than-a-month

The difference between VR and traditional video games is that in the former, the user's body movements and orientation are part of the game, enhancing one's sense of presence. Shelstad et al. (2017) say that users rate the overall experience of playing games with a VR headset more favourably than playing the same games on a traditional two-dimensional computer screen.

Sony, HTC and Facebook/Oculus are the top three commercial parties in hardware development and game distribution. Sony has its own game platform, the Playstation 4, while SteamVR is the most popular distribution platform for users of the HTC Vive and the Oculus Rift. A market survey conducted by Juniper shows that the VR gaming industry expects sales of $8.2 billion in 2023, with most of the revenue still being generated by sales of hardware.[13] At the moment, both the big hardware companies (such as Oculus) and the smaller VR gaming studios (such as Owlchemy Labs) are developing VR games. Most companies devote a relatively small part of their time to game development because the return on investment remains negligent (due to the small number of users and their reluctance to pay more for applications).

In addition to home-based entertainment, many gaming companies use location-based VR, with people having a VR experience in a cinema, a shopping centre or an amusement park, for example (Rubin, 2018c). China now has more than 3,000 VR gaming centres (Streiber, 2017), and several 'experience centres' have also opened in the Netherlands in recent years (e.g. VR Arcade in Amsterdam and VR4Play in Rotterdam). They focus mainly on attracting busines in the form of company outings and activities with other large groups and also offer VR versions of existing games, such as laser tag or an escape room. The Dutch market is modest but expected to grow (Ammelrooy, 2019). Investors' current top priority is to attract consumers who have never tried VR before (Roettgers, 2018). Investors who believe that masses of consumers will eventually purchase VR headsets draw parallels with the video entertainment industry: at first, people only watched films in cinemas, but now they do so mainly at home.

3.2 VR pornography

Alongside the gaming industry, the porn industry is at the forefront of developing VR content. It also led the way in the past by creating content for such new electronic products as the video cassette, the computer and the iPad (Johnson, 1996; Gross, 2010). This pioneering role was reconfirmed in 2017 when porn website Pornhub

13 See: https://www.businesswire.com/news/home/20190115005064/en/Juniper-Research-Virtual-Reality-Games-Revenues-Reach

announced that its VR porn videos were getting 500,000 views a day (Pinto, 2017). According to the CEO of VR porn company BaDoink, the first content people test a new media technology with is porn: 'Whenever you become comfortable with a new platform or piece of technology, the first thing you look for is porn' (Hussey, 2017).

The porn videos currently labelled VR porn are 180- or 360-degree videos (see Table 1, Section 2.1) and, to a much lesser extent, animated VR. Users have the illusion of experiencing the sexual encounter depicted first-hand, as if they were one of the characters (a technique known as Point of View or POV). The videos are shot with special cameras that are set up in the right places using scaffolds. In 2018, the company VR Bangers announced that it was developing a sex helmet with seven built-in cameras and 3D audio recording equipment that will make VR porn videos even more compelling in the future (Christian, 2018).

Most VR porn videos today target heterosexual white males. Only limited content is available for other groups. Some sites make users pay for VR porn, while others (such as Pornhub) make the videos available for free and earn money from website advertising. Simon and Greitemeyer (2019) investigated the difference between a non-VR and a VR experience of pornography in 60 male participants. Their findings showed that the subjects felt greater physical excitement and had a stronger subjective experience watching a porn video with a VR headset than watching one on a 2D or 3D computer screen.

Although it is a small market, there is a lot of discussion of haptic technology in the porn industry. Haptic technology can intensify the user's physical experience and make the sex seem more realistic. It includes the use of 'teledildonics' (Evans, 2018), i.e. sex toys that can be controlled remotely via an internet or Bluetooth connection. Some of these toys are synchronised with VR porn videos to provide physical stimulation during viewing, making the sexual experience even more lifelike for the user.

Despite its commercial potential, VR porn has several enemies. The big VR hardware companies (Sony, Samsung and Facebook Oculus) have rejected it and refuse to allow VR porn on their platforms (Ng, 2018).

3.3 Virtual therapy

Researchers have noted growing interest in the use of VR applications in medicine in recent years (Rizzo & Koenig, 2017). Studies have focused on using VR therapy to diagnose mental disorders and to set up virtual therapy sessions for patients suffering from depression or anorexia. In the Netherlands, for example, a number of

VR applications have been used in the mental healthcare sector to provide cognitive behavioural therapy, with medical insurers covering at least part of the costs. In 2016, at least twenty healthcare institutions began offering virtual reality exposure therapy (VRET) as a treatment for agoraphobia, social anxiety or claustrophobia.[14]

Even so, most VR health applications are not currently in use in Dutch healthcare practice. This is largely because there is limited evidence of how VR therapy works, because it is unclear how VR compares to existing practices, and because no one really knows whether VR applications may have detrimental effects or side effects. Dutch and EU law requires an application to be effective and safe, and there is often no evidence that these applications are either.

New technologies can be implemented in healthcare only after a lengthy process of investment, decision-making and research. It takes an average of 17 years before new medical technologies are incorporated into daily clinical practice (Bailenson, 2018). If a clinical trial involves human subjects, then a medical-ethical review is necessary, as well as the informed consent of the subject before the outcomes can be used. Ethical reviews are required not only for biomedical interventions but also for clinical trials in the behavioural sciences. There are also certain rules pertaining to medical use. For example, information leaflets must be included in the packaging, certain groups of users may be ruled out based on personal characteristics (e.g. age), and there may be constraints on the sale of the products.

To circumvent the expensive and time-consuming process of clinical trials, companies are increasingly introducing simplified versions of medical VR applications on the consumer market. The first VR self-help applications have consequently become available online in recent years. Most self-help applications are developed by small companies, lack any certification and, in the opinion of their developers, are straightforward and not very invasive. For example, the Arachnophobia application promises to help people overcome their fear of spiders, while Virtual Speech claims to help people get over stage fright. Applications such as Guided Meditation and Calm Place aim to reduce stress and Self-knowledge VR promises to augment the user's self-awareness through psychological testing. Swedish researchers (Lindner et al., 2019a; 2019b) investigated several self-help applications and concluded that VR headsets can in fact help users to overcome stage fright and to alleviate stress.

Some self-help applications involve working with a 'virtual therapist', an avatar that counsels users. This may be particularly effective for patients who are unable to

14 See: https://www.emerce.nl/wire/twintig-zorginstellingen-bundelen-krachten-vrplatform-vrendle

visit a therapist in person, for example because they suffer from social anxiety or live in remote areas (Temming, 2018). However, Temming concluded in 2018 that virtual therapists were not sophisticated enough to have real conversations with patients, although communication with virtual assistants is generally improving.

3.4 VR social media platforms

At the moment, it is quite a complicated matter to create a VR experience that involves several people simultaneously. Most VR content currently available is therefore geared to individual experiences. However, Facebook began investing in VR in 2014 because it thought it had potential as a social platform. Facebook CEO Mark Zuckerberg's goal was to have a billion people using VR on Facebook and other social platforms (Lee, 2017). He believes that VR will 'change the way we work, play, and communicate' (Kiss, 2014). Microsoft acquired the VR social media platform AltspaceVR in 2017 and has been developing social VR for the same reason ever since. In addition to the tech giants, a number of VR start-ups are also involved in creating social media applications.

VR social media platforms serve different purposes. For example, the best-known, VRChat, is a virtual meeting space where users socialise but also take classes, play games or attend events.[15] In October 2017, Zuckerberg demonstrated Facebook's VR communication platform by travelling in virtual reality to the moon, to his home, and to a region in Puerto Rico that had been devastated by Hurricane Maria (see Figure 8). In the days thereafter, he received harsh criticism for promoting disaster tourism and for opportunistic advertising. He apologised, giving the following explanation: 'When you're in VR yourself, the surroundings feel quite real. But that sense of empathy doesn't extend well to people watching you as a virtual character on a 2D screen' (Kastrenakes, 2017)

Facebook Spaces resembles VRChat, but is based on Facebook profiles linked directly to the virtual platform (Rubin, 2019). Oculus Rooms and Oculus Venues allow users to chat and attend events virtually, including sports matches, concerts and/or comedy shows projected in 180- or 360-degree video. Another VR social media platform, Rec Room, saw the first wedding in 2018 of two users who met in VR and fell in love (Rubin, 2018b). Horizon, Facebook's largest VR platform to date, will be rolled out in 2020. Once it is up and running, Facebook will pull the plug on Facebook Spaces and Oculus Rooms.

15 See: https://www.businessinsider.nl/vrchat-explained-2018-2/?international=true&r=US

Figure 8 Mark Zuckerberg's cartoon avatar visiting hurricane-devastated Puerto Rico in VR during the launch of Facebook Spaces

Source: Facebook

In VR, embodiment is achieved through the use of avatars. Games like Second Life (launched in 2000) or Habbo Hotel (from 2003) allowed users to create their own avatars and interact with others in a digital world. VR social media platforms take this a step further. Wearing a VR headset makes the virtual 3D world more lifelike, while haptic technologies allow users to experience materials, touch and body movements in the virtual world. Users can have their avatars dance or play sports using such applications as VIVE Trackers, a feature that has attracted.[16] In addition, more and more platforms incorporate technology that tracks and copies users' emotions and other facial movements virtually (see also Section 2.5). For example, the Veeso headset announced in 2016 uses infrared cameras to capture users' facial expressions and transfer them to their avatars. Social interactions from our everyday lives are transported to VR, blurring the boundary between virtual and physical interaction.

16 See: https://www.vrfitnessinsider.com/vrchats-full-body-tracking-pole-dancers/?fbclid=IwAR0YqM7SZE90XY-ezETMe9DHPkvU5pty0s5S0nJgTeaAVVuvEPT9R03_kZA

Philip Rosedale, the creator of Second Life, is using his open source platform High Fidelity to experiment with 'scanning' people to create realistic avatars (Rubin, 2019). The platform is supported by blockchain technology,[17] a new digital method for storing and validating data, making it possible to assign virtual assets (such as avatars, worlds and creations) to users and to verify and protect those assets. While the companies that create virtual worlds now often own the content, applications of this kind will allow users to manage and trade digital assets themselves (Bonasio, 2017).

17 See: https://cryptoinsider.21mil.com/philip-rosedale-second-life-blockchain-virtual-world

4 Four clusters of VR risks

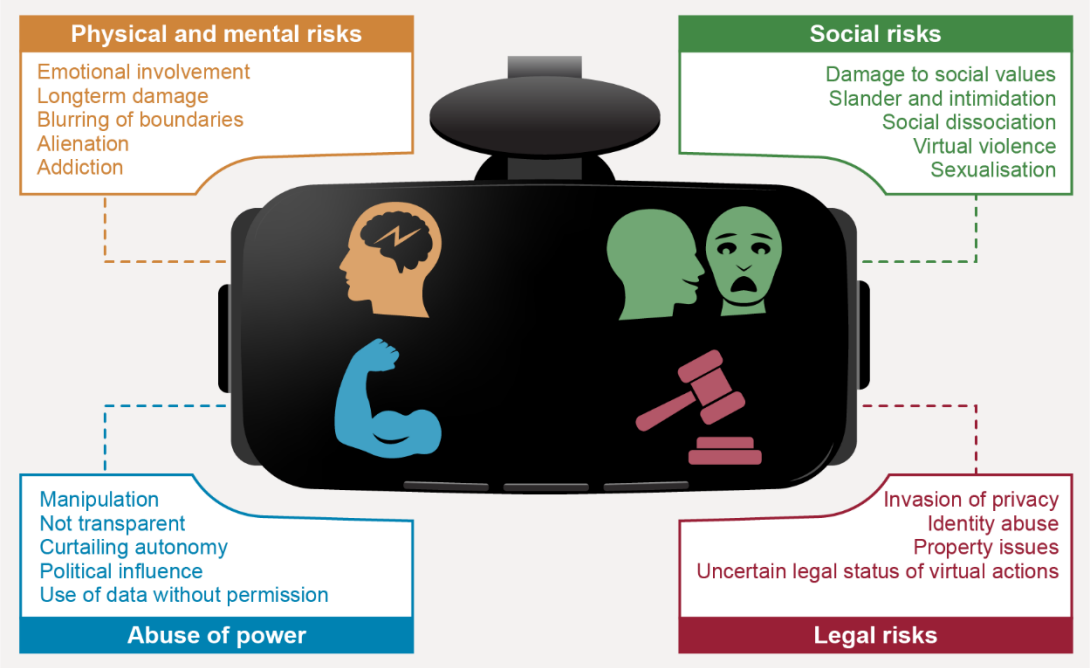
In our introduction we argued that VR raises various ethical and public issues because it is an intimate technology. Drawing on the cybernetic feedback loop (Figure 5), we showed in Chapter 2 that VR users relinquish a considerable amount of intimate biometric data and can be profiled in all sorts of ways on the basis of this data. Everything presented to them in the virtual world is, by definition, pre-programmed. Data can also be used to manipulate and mislead consumers. Despite all this, there is as yet very little political or public discussion of VR technology, whether in the Netherlands or internationally (Kool et al., 2018). In the past ten years, however, we have seen a growing concern about the potential risks of VR among researchers.

This chapter draws on scholarly articles that address the ethical and public issues associated with individual and collective use of VR. To understand these issues, we conducted a systematic literature review by scanning articles published between 2010 and 2019, ultimately selecting 34 for our review (see Appendix 1). The articles mention several issues, which we have divided into four clusters of risks:

1. physical and mental risks
2. social risks
3. abuse of power
4. legal risks.

We identify and elaborate on the key issues in each risk cluster. They are shown in Figure 9.

Figure 9 Four risk clusters in consumer VR use



Source: Rathenau Instituut

4.1 Physical and mental risks

German philosophers Metzinger and Madary predict that if VR technology continues to evolve, the risk of users suffering psychological trauma will increase steadily (2016, p. 19). The scholarly literature has already noted such physical and mental risks as addiction, depersonalisation, dissociation from a person's familiar physical or social environment (Cheshire, 2010; Dodig-Crnkovic, 2013), and the blurring of lines between real-world and virtual experiences (Pan et al., 2011).

Addiction and depersonalisation

Researchers have been studying internet addiction since its introduction in the early 1990s and proposed to classify it as a mental disorder comparable to other forms of addiction (Gedam et al., 2017). Since then, there has been a growing realisation that intensive gaming and social media use can lead to addiction among some adolescents, resulting in a decline in psychosocial well-being and school performance. According to Eijnden et al. (2018), 5 to 10 percent of young people meet the criteria for Social Media Disorder (SMD) and 3 to 9 percent of adolescent online gamers have Intensive Gaming Disorder (IGD). Young people who have these disorders are consumed by social media or games almost around the clock. The immersive power of gaming can be so strong that users are unaware of what is happening to their bodies.

Because VR technology makes gaming and social media even more immersive, several researchers argue that it has the potential to be highly addictive (see e.g. Young et al., 2010; Kelly, 2016b). According to Bailenson, VR is even more addictive than social media (in Hijink, 2018). Some individuals report having spent 24, 48 or even 168 consecutive hours in the virtual world.[18] Madary and Metzinger (2016) expect those who do to develop symptoms resembling depersonalisation disorder. The key hallmark of this disorder is that people feel detached from their body, identity or personal psychological processes. To date, there has been no research investigating the impact of days-long immersion in VR or longitudinal studies exploring the impact of VR.

Dissociation from familiar physical or social environments

A related syndrome is derealisation disorder. A person with this disorder experiences their familiar environment as alien or surreal. Various researchers believe that frequent VR users become less and less able to distinguish between their virtual and real-world experiences (Young et al., 2010; Pan et al., 2011). Bailey and Bailenson (2017) found that it is difficult for people – and children in particular – to distinguish between virtual and 'regular' experiences. In their study, children had their VR avatars swim with orca whales; later, the children believed they were remembering an actual, real-world experience. An inability to distinguish between virtual and real can lead to dangerous situations, with people coming to believe that they can do in real life what they have done in the virtual world (ibid).

The speculative issue here is to what extent VR will replace reality in the future. Will realistic VR environments replace our classrooms, hospitals and pubs? Proponents of VR point out that communication using VR technology and accessories will increasingly resemble physical communication by mimicking both emotions and realistically embodied interaction between avatars. Critics, such as Sherry Turkle (2017), believe that human interactions are always more nuanced and complex than computer-based interactions. Turkle believes that moving social interaction into the digital domain will jeopardise important human values, such as in-depth conversations and intimacy.

18 Thorston Wiedemann spent 48 hours in VR as an artistic experiment and did not experience motion sickness, headaches or eye strain (Bolton, 2016). Jack Wilmot of Disrupt VR spent a week in VR without any such symptoms. See: https://www.youtube.com/watch?v=BGRY14znFxY

4.2 Social risks

Is murder permissible in virtual reality? How about rape? Various authors are concerned about the intense experiences in the VR domain triggered by violent, sexist or otherwise shocking content (Madary and Metzinger, 2016; Spiegel, 2018). As improvements in the technology make it increasingly difficult to distinguish between the virtual and the real world, the question is to what extent users should be protected from potentially damaging experiences and to what extent shocking content encourages inappropriate behaviour. A further issue is whether standards and values in the virtual world could undermine those in the physical world. For example, many VR games are based on the extermination of living beings and fellow players. Madary and Metzinger (2016) have called for a ban on murder in the virtual world.

Aggression
A common worry with regard to violent video games is that they provoke more aggressive behaviour in their users. It is very difficult to establish cause and effect here because violent behaviour is also associated with other factors. A comprehensive meta-analysis by Anderson and Bushman (2001) showed that children and adolescents who play violent video games have more aggressive thoughts and feelings, but there is no empirical evidence linking violent VR games to aggressive behaviour. Nevertheless, there are valid reasons for concern. For example, Brey (1999) argues that a VR gamer is not a spectator but an actor who plays a more active, embodied role in virtual combat scenes than in traditional video games, and that this is more likely to lead to aggressive behaviour in the physical world.

That is why Bailenson, in an op-ed for CNN in 2018, argued that VR games should not be too realistic and that game developers should curb their shooter games. One of his proposals was to have players operate a virtual gun by bending their elbows instead of pulling a trigger in the normal fashion. This would prevent them from building muscle memory that carries over into the real world and real guns. Some game developers do not agree with this criticism and complain that such proposals restrict their creative freedom (in Hijink, 2018). According to Madary & Metzinger (2016), those who defend violent content argue that people play these games precisely because they can push the boundaries and ‘blow off steam’ in the virtual world.

Sexualisation
Some researchers fear that VR pornography could lead to an unhealthy sex culture and contribute to the sexualisation of society, in part because of the aforementioned manipulation and the digital cloning of persons (Wood et al., 2017). The growing

popularity of 360-degree porn videos is heightening existing concerns about the porn industry, one of which is that VR porn videos mainly target white heterosexual males (Evans, 2018). Because VR content is almost always presented from the man's point of view, Evans (2018) argues that VR pornography can reinforce problematic concepts of sexuality such as 'heteronormativity', i.e. the idea that heterosexuality is the standard and the male gender dominates the female. In an interview with *The Independent*, researcher Madeline Balaam of Newcastle University worried about a growing obsession with having a perfect sexual experience: *'We are already obsessed with body image and the digital industry is no different, creating the perfect virtual woman from Lara Croft to sex-robots. VR porn has the potential to escalate this'* (Griffin, 2017).

Defamation and harassment

Slater and Sanchez (2016) look at VR behaviour within the context of 'proxemics', the branch of knowledge dealing with the amount of space that people maintain between themselves and other people and objects in their intimate environment and how people experience the presence or absence of physical contact. They argue that although VR users are separated physically, the proximity of other users in the virtual world can feel like harassment and an encroachment on their personal space (Slater and Sanchez, 2016).

The problem of online harassment is widespread and has surfaced before in such virtual worlds as Second Life and Habbo Hotel. Various forms of inappropriate behaviour have also cropped up in virtual reality, such as digital defamation and harassment. Users of VR social media platforms such as Rec Room and VRChat are often anonymous, allowing them to harass others with impunity (Evans, 2018). This problem has led to many users feeling unsafe on these VR platforms in recent years. There have been many instances of sexual harassment within VR applications as well as reports of racism and other threats (see Outlaw, 2018). Rec Room, VRChat and other developers take these problems seriously and warn users (before they go online or during their VR experiences) to abide by the platform's code of conduct.[19]

In VR, however, it is also possible to programme the rules and interactions. After users complained, the developers of QuiVR added a 'personal bubble' to the game that offers players a safe haven from other players (Henriksson, 2018). This did not fix the problem, however. A journalist wrote that, despite the bubble, she had been groped in the game's VR environment: *'Suddenly, BigBro442's disembodied helmet*

19 In its Code of Conduct, Oculus prohibits users from promoting sexually explicit, offensive or obscene content, from encouraging violence or illegal activity, and from harrassing other users. See: https://support.oculus.com/1694069410806625

faced me dead-on. His floating hand approached my body, and he started to virtually rub my chest.'[20] Following publication of her critique, the developers updated the game to include an expanded 'personal bubble' that they believe will prevent future gropings.[21]

Social dissociation

Another concern that emerges from the literature is that VR is changing our personal interactions and undermining social relationships. The concept of 'escapism' plays a major role in this discussion. Escapism refers to a behaviour whereby persons who have unsatisfying life circumstances abandon the reality in which they live on a cognitive and emotional level (Vorderer, 1996). Escapism is a well-known and well-documented phenomenon that can be exacerbated by VR technology. According to Sherry Turkle and other critics, escapism can undermine relationships between users, their families and friends and cause them to neglect their social obligations. In an interview in *The Atlantic*, Stanford psychiatrist Aboujaoude argues that virtual reality may change a person's social and emotional needs over time, making real social interactions feel foreign (Kim, 2015). Escapism is not necessarily a bad thing, notes psychology professor Blascovich in the same article: 'Who is to say that a virtual life that is better than one's physical life is a bad thing?'' (idem).

4.3 Abuse of power

A VR headset captures large quantities of biometric data that it can then analyse and use. Combining these data with the immersive quality of VR makes it possible to manipulate the user's experience in subtle ways. For example, by tracking eye movements, changes in pupil dilation and facial expressions, VR companies can identify what users are looking at and how long they are focusing on a given virtual object and assess their physical and emotional response to it. By combining different intimate data, VR platforms and companies can profile user behaviour in fine detail. For example, Facebook tracks what users watch in 360-degree videos to find out what interests people most (Robertson, 2018). As is the case on the internet, companies can also monitor and test consumer behaviour continuously in virtual reality. Analysing various data yielded by VR can reveal a great deal about users, including how they behave, what their interests are, and when they are most alert or impressionable. A company can then analyse these data to improve future VR experiences, or sell the data to third parties for commercial purposes. VR is

20 https://www.mic.com/articles/157415/my-first-virtual-reality-groping-sexual-assault-in-vr-harassment-in-tech-jordan-belamire#.2cdAUlHKo

21 See: https://uploadvr.com/dealing-with-harassment-in-vr

interesting to advertisers and data brokers precisely because it offers them information and opportunities of this kind. Lawyer Emil Henriksson (2018) warns that the intimate and immersive nature of VR can thus lead to advertisements becoming even more persuasive and having an even bigger impact on consumer behaviour.

Restrictions on autonomy

VR makes it possible to influence people in all kinds of ways. It can be used constructively in education or in therapy to teach people how to cope with a new situation. However, manipulating a user's perception can also seriously restrict their autonomy or self-determination (see e.g. O'Brolchain et al., 2016). VR technology can be used to influence the knowledge that a person acquires and their freedom to act and think. For example, it is possible to programme an avatar so that it appears to be making continuous eye contact or imitating the user's body movements. This can influence someone's attitude towards another and manipulate the user to consider the other person more likeable or, at the other end of the spectrum, more suspicious or frightening. In 2014, Facebook, already one of the largest companies in the VR sector at that time, made headlines because it had conducted a psychological experiment on 689,003 users, manipulating their news feeds to assess the effects on their emotions (Meyer, 2014). VR can also be used in political campaigning or for commercial purposes (Blascovich and Bailenson, 2011). Scanning, digital cloning and other VR processes make it more difficult for users to distinguish between real news and fake news, causing them to be even more vulnerable to manipulation.

Another invasive form of manipulation is the impairment of the user's sense of agency, i.e. their experience of freedom of choice (Madary and Metzinger, 2016). As we described above, many VR applications work with avatars that allow users to navigate in the virtual world. Users may feel as if they control the movements of avatars, but in fact those movements are being manipulated by an underlying programme. In addition to controlling the user's avatar, the programme can influence entire VR worlds, including other avatars and their behaviours, resulting in possible infringements of autonomy. O'Brolchain et al. (2016) warn that the convergence of VR and AI can lead to users being 'nudged' into accepting certain ideas or views. For example, AI-controlled avatars can be programmed to smile at one idea and frown at another. The researchers argue that this persuasive technology will be even more effective and convincing if it makes use of data and knowledge about the emotional responses of users acquired through eye movement trackers and other emotional data capture (idem, p. 15).

4.4 Legal risks

The literature that we reviewed identifies various legal risks in the field of VR. Here, we discuss issues of ownership, privacy and identity, as well as ambiguities concerning the legal and moral status of virtual actions.

Ownership issues
Many legal questions of relevance to VR remain unanswered. Will there be a shared VR world that, like the internet, is basically accessible to all? Who will create this world and therefore control what it is like? What precisely does it mean to 'own' a virtual space or object? And how do we ensure that people have fair access to the virtual world?

There is, as yet, no shared virtual world with shared protocols that enable free movement and establish user rights. VR companies are locked in fierce competition and applications today are platform-based, meaning that they are not accessible to all VR headset owners. The concept of 'ownership' is less clear in the virtual world than in the offline world (see e.g. Moore, 2017; Zhou et al., 2018). Right now, the companies that develop software initially also own the VR content. According to Zhou et al. (2018), the interaction between content and platform causes confusion in ownership questions. This interaction currently works to the advantage of the VR companies that build the platforms. They specify user rights, data and content ownership rights and commercial rights in End User Licence Agreements (EULAs). At the same time, the virtual world is undergoing a process of juridification and economisation as companies increasingly file to patent their VR designs and techniques.

Privacy issues
Mass storage and processing of VR data raises new questions regarding user privacy (see e.g. Metzinger & Madary, 2016; Spiegel, 2018). Integrating more sensors into VR technology has made it possible to capture more, and more intimate, user data. Today's consumer headsets track in fine detail how users move physically in virtual environments. Future models will be even better at capturing brain activity, eye movements and facial expressions. Their manufacturers will therefore be increasingly able to 'see the world through the user's eyes' (Susskind, 2018, p. 135). For example, Oculus's privacy policy states that the company collects information on users' 'physical movements, and dimensions' to personalise and customise their experiences based on their online activities and 'to market to you'. The company reserves the right to share that information with third parties, such as its parent company Facebook, and to retain it, for example to detect and prevent fraud or other illegal activities (Kopfstein, 2016).

In the European Union, the collection of personal data is regulated by the 2018 General Data Protection Regulation (GDPR). Much of the data captured in VR consists of biometric data. These are subject to especially stringent rules under the GDPR (Henriksson, 2018), which defines biometric data as 'personal data resulting from specific technical processing relating to the physical, physiological or behavioural characteristics of a natural person, which allow or confirm the unique identification of that natural person'. The Dutch GDPR Implementation Act essentially prohibits the processing of biometric data for the purpose of identifying a person, unless such processing is necessary for authentication or security purposes.[22] Some of the data captured in VR is new, for example data on how someone moves their head. Existing legislative frameworks, such as the Dutch GDPR Implementation Act, should be used to ascertain the type of data that can be captured and how to handle such data responsibly.

Public debates feed these discussions and ensure public awareness of the need for such regulatory frameworks. For example, mass violations of privacy by large IT companies (such as in the Cambridge Analytica scandal) have made the public more aware of the consequences of data abuse. There was much commotion in the VR domain about the Oculus privacy policy and the device's default 'always on' settings. Users and journalists were especially critical of the blanket clause that allows Oculus to share VR data with the Facebook group of companies and third parties (Russell, Reidenberg & Moon, 2018; Robertson, 2018). Henriksson (2018) warns that the debate about privacy will become even more crucial as we increasingly identify with our virtual avatars and virtual objects. He predicts that the popularity of VR will blur the line between our physical and virtual identities, making it ever more necessary to protect VR data.

One pertinent example of a new VR application centred on personal data is the psychological testing of users. For example, in the games Dungeon Scrawl and Wasabi Waiter, players are required to solve puzzles developed by a team of scientists to reveal the player's personality. VR researchers (Peck et al. 2013) have found that Knack and other game manufacturers can deduce quite a lot about people's personalities and their ability to cooperate and problem-solve by studying how they play a VR game. According to Guy Hafteck, the founder of Knack, 20 minutes of game-play generates several megabytes of data that offer more insight into a player's personality and intelligence than any existing personality tests. The data reveal how people solve problems, how they learn and what their IQ is, and can therefore be useful for assessing their suitability as employees (Peck, 2013). The more social interactions migrate to VR social networks, the more opportunities

22 See e.g.: https://autoriteitpersoonsgegevens.nl/nl/onderwerpen/identificatie/biometrie

the technology will offer to conduct psychological experiments on people (Kool et al., 2017).

Moral and legal status of virtual behaviour

A final point about the legal risks of VR concerns the moral status of actions in a virtual world. For example, there is a growing amount of distasteful content showing illegal acts. Like video footage of the same practices, such content is considered criminal. Even so, the question of exactly which rules apply in the virtual world is largely unanswered (Gooskens, 2010; Stoiber, 2014).

One example is virtual cloning. 3D facial or full-body scanning is becoming easier (see Section 2.5), and there have already been experiments in which porn stars were virtually cloned for sex purposes (Van Egmond, 2018).[23] This raises questions, including what consent means in the virtual world. Do you need to have a person's permission to have sex with their virtual clone? Are you allowed to abuse or kill someone's virtual clone? VR allows cloned avatars to do things that their real-world counterparts would never do. For example, several authors point out that VR is enabling new forms of revenge porn, making it easy to distribute sex videos featuring the VR versions of real-life people (Griffin, 2017; Wood, Wood & Balaam, 2017). An unanswered question raised in earlier research by the Rathenau Institute is: how can VR users retain control over their own image, and how can identity theft be prevented? (Kool et al., 2017).

23 See: https://www.vice.com/en_us/article/3bjwpy/behind-the-scenes-of-tori-blacks-virtual-reality-porn-debut

5 Urgently required: frameworks for integrating VR into society

5.1 The merger between human and machine

The merger between human and machine becomes almost complete in VR and that is what makes it the ultimate intimate technology (Van Est, 2014). VR headsets are worn over the head and block signals in the physical surroundings from reaching the senses while simultaneously collecting and using intimate personal data. What distinguishes VR technology from existing media technology is its pronounced immersive nature. It holds the user captive in a digitally modified virtual world. VR immerses users almost completely in a computer-generated environment, allowing real-time embodied physical interaction with that environment. The point is to create a sense of presence, i.e. a subjective feeling on the part of users that they are actually inhabiting the computer-generated environment in the here and now (Coelho et al., 2006). In Chapter 2, we used the cybernetic feedback loop model to describe the way in which VR technology captures users digitally. As we explained, it does so in the following three steps.

In the first step, the VR headset uses numerous biometric sensors to track the user in a variety of ways. It tracks user motion, eye movements, emotions and gestures, thus generating detailed information about the user's personality and preferences. In the second step, the technology profiles the user based on this intimate biometric data and adapts the virtual world accordingly. VR developers are not only able to adapt images in virtual spaces but also to modify the behaviour of other users and control avatars and the user's own avatar digitally. In the third step, the technology gives the user a virtual world to see, hear and feel. VR thus offers numerous data-driven ways to track, test, analyse and manipulate user behaviour.

Authors such as Lanier (2018) and Zuboff (2019) describe the internet today as a utopia for tech companies that want to monitor, experiment with, profile and manipulate people on a mass basis. What VR can do, as described above, bears a strong resemblance to existing media technology and the way in which the tech giants currently use it. Viewed from this angle, it is understandable for authors such as Madary and Metzinger (2016) to fear that combining big data, AI and VR could lead to 'Big Nudging' strategies, influencing people's behaviour on a mass scale. For example, using kinematic profiles – i.e. profiles based on all captured motor data – it becomes possible to programme avatars to respond to users' facial expressions, gestures, emotions and desires (O'Brolchain et al. 2016).

The immersive and intimate nature of VR raises the issue of how this far-reaching merger between human and machine should be interpreted and regulated. Given that VR collects, analyses and uses all kinds of biometric personal data, existing privacy regulations clearly apply. However, in the case of high-risk drugs and medical devices that have a biological impact on the human body, such as implants and pregnancy tests, manufacturers are required to follow a strict procedure before they can market their products. One fundamental question is whether the risks that VR technology poses for users are serious enough to consider and regulate it as a biomedical technology.

Based on our exploratory study, this final chapter first describes the status of consumer VR applications. We examine the technology, applications, use by consumers and the role of developers. We then briefly review the many ethical and social issues raised by the intimate and immersive nature of VR technology. Finally, we consider how the worlds of politics and government can guide the development of VR for the benefit of the public. In doing so, we question what is already being done and whether it suffices. As it appears that VR could be entering the consumer market on a massive scale in the coming years, and since the technology raises many social and ethical issues, the Rathenau Institute notes a growing dichotomy between the lack of political interest in VR on the one hand and the need to develop frameworks for integrating this technology into society on the other.

5.2 Status of consumer VR

In Chapters 2 and 3, we looked at the current status of consumer VR. What is the state of the technology, which applications can be found in the consumer domain, to what extent are consumers embracing VR, which companies are active in the field, and which revenue models are they using?

The development of VR has led to new and popular gaming concepts and realistic pornographic content, and it also has enormous potential in areas such as education, healthcare, safety, product development, entertainment, and creativity. The immersive nature of VR opens up many possibilities. VR enables new forms of digital experience and telecommunication, with a growing number of applications being developed to spur changes in society, for example in healthcare. Developers are also working on a VR version of social media platforms. Although it is uncertain whether these platforms will attract large audiences, they could nevertheless have a major impact on the way we communicate (digitally).

Facebook, Sony, Google, HTC, Microsoft and other tech giants have invested billions in VR development since 2014. As a result, developers have overcome

many technical barriers so that the VR devices currently on the market are affordable and user-friendly enough and of good enough quality to attract millions of consumers. There is therefore a good chance that VR will enter the mass consumer market in the coming years. Market research by Multiscope shows that in early 2018, about 5 percent of Dutch consumers had a VR headset at home,[24] amounting to some 650,000 headsets. Considering the small number of tech companies developing the hardware, software, content and infrastructure of the virtual world, VR market penetration will allow the tech giants to extend their current and unique concentration of power (Zuboff, 2019).

At the moment, the VR sector generates revenue by selling hardware, content and software. Although investment in software is increasing, Huawei (2017) and other companies expect to earn most of their VR revenue from hardware in the years ahead. The sectors examined in Chapter 3 – gaming, porn, self-help and social media platforms – have relatively few VR users at the moment, who pay little or nothing for VR content. According to the CEO of BaDoink, the porn industry is the only sector to date that has a profitable revenue model for VR (Cornish, 2017). It remains to be seen whether creating VR content will be profitable for the other sectors. There are a number of successful games and applications on the market, but VR companies are currently investigating how many users are willing to pay for VR content, and to what extent they can rely on advertising revenue (Llamas, 2018).

Indeed, companies are increasingly experimenting with the economisation of virtual spaces by permitting advertising, offering personal services for a fee, and selling user data or metadata. According to Metzinger (2015), commercial virtual spaces create new opportunities for targeted advertising. It is a well-known psychological phenomenon that consumers tend to find people who are similar to themselves more trustworthy. Madary and Metzinger (2016) explain that advertisements in VR can be made to project images of users while using specific products. The virtual world also makes it possible to track and test people psychologically in a variety of new ways. By analysing the behaviour of VR users, insurers could, for example, establish that they are suffering from certain illnesses and amend their policies or exclude them from insurance on the basis of such information. Needless to say, such matters raise a series of ethical issues.

24 See: http://www.multiscope.nl/persberichten/ruim-650.000-vr-brillen-in-nederland.html. Consulted 29-5-2019.

5.3 Public and ethical issues

In Chapter 4, we divided the most important ethical and social issues into four risk clusters (see Figure 9):

1. physical and mental risks
2. social risks
3. abuse of power
4. legal risks.

Physical and mental risks

With respect to physical and mental risks, there are questions about addiction and the long-term consequences of VR use. Some users experience a high level of emotional engagement with and even a disproportionate sense of attachment to virtual characters, virtual entities and the VR world. Various studies have raised the risk of dissociation. First of all, there is the risk of detachment from one's body and social environment. Second, there is the risk of becoming estranged from familiar physical reality. Users feel confusion and a loss of control because they find it difficult to distinguish between real and virtual experiences.

Social risks

VR may also pose social risks. Like the internet and social media, the rise of VR will change the way we interact with others. In extreme cases, this could lead to people becoming estranged from their social environments. The immersive nature of VR means that extreme content poses risks, such as sexual and/or aggressive images that could lead to unlawful behaviour in the physical world. Experts say that VR differs so much from other media that the question of whether murder or other inappropriate behaviour should be permitted in VR must be taken especially seriously. Another significant indicator is the reports of assault, defamation, stalking and other forms of harassment and aggression in virtual worlds.

Abuse of power

Abuse of power refers to the ability of developers to influence user behaviour by manipulating virtual worlds, objects and avatars without the user knowing or agreeing to them doing so. User data (including personal data) can be appropriated for purposes of profit or political or other influence, undercutting personal autonomy, freedom from social control, freedom of choice and self-determination. This risk is real because VR systems can collect all types of intimate biometric data from users, giving VR companies information on a person's personality, behaviour and preferences. A related issue is that virtual spaces offer all kinds of opportunities for targeted advertising that keys into a person's desires, preferences and choices on a direct and subconscious level. We note that the tech giants are extending their current unique concentration of power by investing in VR. A small number of tech

companies are developing the hardware, software, content and infrastructure of the virtual world, leading to an unwelcome concentration of power and the absence of any VR spaces outside their control.

Legal risks
Virtual rights represent a grey area where a number of legal and philosophical issues converge. What is required is to clarify ownership in the virtual world, ask who the virtual world and virtual entities belong to, and how to register and transfer ownership. Can damage to virtual entities be equated with damage to real entities (and if so, to what extent)? What does privacy mean in the virtual world? It is important for users to retain control over their virtual characters, actions and the capture of personal data.

Many of these issues are familiar to us from the public debate about digitisation that has unfolded in recent years, particularly in response to the rise of social media, digital platforms, robotisation and AI (cf. Kool et al. 2017; De Jong et al. 2019). This debate shows that modern digital technologies, such as VR, not only involve issues of privacy and security but also such public values as autonomy and human dignity, control over technology, justice, and an equitable balance of power.

5.4 VR as a biomedical technology

Based on an analysis of relevant literature, this study reveals a generally poor understanding of how VR connects our biological, digital and socio-cultural worlds. This connection has implications for our bodies, our social relationships, our perception of reality, and our law enforcement practices. Because the VR market is largely in the hands of a small number of technology companies, they will be able to use VR to extend their technological, economic and social dominance. In that sense, VR is a combination of platform technology, big data and artificial intelligence. The VR headset establishes a new kind of connection between the user and the computer, a connection that collects and analyses the user’s biometric data in a variety of ways and then decides what the user sees on that basis. VR thus leads to even closer interaction between human and machine and between people’s private worlds and the economic domain. That is why it is important to research the phenomenon of VR more closely, to engage in public discussion about it, and to reflect systematically on how it is used in our society. With VR soon being accessible to millions of people, a public and political debate about such consumer applications has become urgent. That discussion should lead to frameworks for integrating VR into society.

VR technology is still often perceived as a gadget that should be categorised as entertainment. To date, there has been virtually no public and political discussion of VR, and users are largely at the mercy of industry self-regulation when it comes to being protected from the above risks. A number of VR developers have drawn up codes of conduct warning about physical risks and laying down rules signalling that they will not tolerate inappropriate behaviour on their platforms. Others have altered their designs to prevent improper behaviour on their VR platforms, sometimes in response to user complaints. Self-regulation of this kind is a positive development, but in our view, it does not go far enough.

First, the codes of conduct are often patterned on codes for existing media, such as television or the internet. This study shows that the immersive and intimate nature of VR makes it different from existing media in significant respects. VR creates a stronger connection between our biological, digital and socio-cultural worlds. The technology is much more invasive in that way and has greater consequences for users and their data. VR permits real-time manipulation to a much greater extent than existing social media or games controlled by a keyboard and mouse.

Second, this study shows that existing research not only examines inappropriate behaviour but points towards a whole list of risks, including physical and mental risks, social risks, abuse of power, and legal risks. It is important that users of all VR platforms are made aware of all these risks and not just the select few identified by some developers. Previous publications by the Rathenau Institute concerning power relations and platform technology remain relevant in this respect.[25]

Given the growing dichotomy between these risks on the one hand and the lack of political interest in them on the other, there is an urgent need to develop moral and regulatory frameworks for integrating VR technology into society. To resolve this dichotomy in good time, at least the following four actions are necessary:

1. **To launch a national/international debate on the ethics of VR**
2. **Establish frameworks for integrating VR into society**
3. **Inform and protect VR consumers properly**
4. **Study the long-term effects of VR.**

1. Launch an international debate on the ethics of VR

Since the first technically acceptable VR sets were introduced in 2016, they have penetrated the Dutch market to such an extent that more than 5 percent of Dutch consumers now have a VR headset at home.[26] There is, however, very little public and political discussion of VR. This is different with other new technologies, such as

25 See e.g.: Rathenau Instituut, 2017; Frenken et al., 2017; Smink et al., 2018.

26 See: http://www.multiscope.nl/persberichten/ruim-650.000-vr-brillen-in-nederland.html Geraadpleegd op 29-5-2019.

social media, robotics and AI. Over the past two years, there have been numerous attempts worldwide in scientific, business and government circles to scrutinise the ethical aspects of AI, for example. Such debates raise public awareness of opportunities and risks and can also lead to the development of normative frameworks that then serve as signposts for the way in which the sciences, industry, civil society organisations and government bodies should develop the technology. It would therefore be beneficial for the public and politicians to take a greater interest in VR in the coming years, both in the Netherlands and internationally.

This study shows that there is a need for debate about moral boundaries, given that consumer VR applications may involve a wide range of social and ethical issues.

2. Establish frameworks for integrating VR into society

Because VR will soon be accessible to millions of people, it has become most urgent to establish frameworks for integrating it into society. Normative frameworks that result from public discussion can help in creating new regulatory frameworks, such as guidelines and legislation. However, development of such frameworks has now become a matter of some urgency, and this is why it is essential to act quickly to clarify what various existing regulatory frameworks might mean in the case of VR. There are various regulatory frameworks that can be applied to consumer use of VR, including privacy legislation and consumer law. It is important to agree on what such existing frameworks mean for VR and to what extent VR calls for specific adaptations, for example rules pertaining to the sharing of specific biometric data made available through VR (see e.g. Brey, 1999, Ramirez & LaBarge, 2018, Spiegel 2018).

VR platforms can capture all of a user's motor function data, both voluntary and involuntary, and such platforms claim the right to share these data with third parties for marketing purposes and to personalise experiences accordingly. Interactions in VR require devices and infrastructure provided by private companies, which make them subject to contracts and terms and conditions that users may never read, but which may infringe their freedom and rights (Lemley and Volokh, 2018).

New ownership issues are emerging in the virtual world, and rights to virtual objects and characters are still a grey area. The digital cloning of persons and objects and the management and trading of virtual entities are becoming increasingly common. These trends raise legal questions about how to prevent defamation and identity theft in VR and how to organise fair international virtual markets. Within the framework of competition law, government must keep a close eye on the possibility of tech giants dominating the market and abusing market power, as well as on consumer protection. The fact that companies are now increasingly able to link up

data streams, profile users in fine detail, and influence their behaviour makes it both necessary and urgent for them to shoulder the responsibility for secure data management and for user privacy. They should also take responsibility for users' health and well-being.

Because VR technology poses potential physical, mental and social risks, the most fundamental question is to what extent it should be regulated as a biomedical technology. Experience in the biomedical sector shows that we need a responsible approach to investigating, regulating and integrating VR into society.

3. Inform and protect VR consumers properly

As in the case of films and games, the Dutch entertainment industry uses the Kijkwijzer classification system to inform consumers about the harmful nature of VR games. With so little being known about the possible physical and mental impact of VR on young children, many manufacturers recommend a minimum age of 12 or 13 years. The question is whether this method of information provision is adequate. In the first place, research shows that users older than 13 can also suffer from harmful effects. Second, the literature has identified a long list of VR-related risks (see Chapter 4). It is essential that consumers are properly informed about these risks and protected from them. One way would be to follow the example of the medical sector and provide consumers with information leaflets, but other methods are also possible. Consumers should also be informed about the intimate biometric data that companies collect in VR and how their privacy and autonomy could be compromised. VR platforms are neither public nor private spaces; rather, they are bilateral markets in which money and data change hands. Both supply and demand are mediated not by a neutral platform but by a private facilitator that makes the rules. It comes down to a case of 'information asymmetry', with consumers not knowing exactly what happens to their personal data, even if they consent. Because certain data are so personal and intimate that they make the individual vulnerable to abuse, whether by governments, hackers or commercial parties, it is vital that compliance with legal restrictions on data processing, sharing and use is strictly supervised. Equally important are the sector's own efforts to fulfil its duty of care towards consumers.

4. Study the long-term effects of VR

Although VR itself has a long history, consumer use of VR is a new field of research. Given the relatively recent development of consumer VR and the absence of a long research tradition, we know little about the risks associated with VR use and have almost no data on its long-term effects. The literature identifies several urgent and largely unanswered research questions, for example what impact exposure to VR immersion has on users and which VR environments are most disturbing for users. As with new drugs that have cognitive side effects,

longitudinal research is important to chart the long-term effects on a broad population.

In Chapter 3, we explained that the absence of hard evidence is curtailing the use of VR in healthcare. There is no evidence that it is effective or safe and its side effects or detrimental effects are as yet unknown. On the other hand, VR companies are increasingly marketing their applications as self-therapeutic products, allowing them to avoid the expensive and time-consuming investigation process involved in marketing medical products. Our study shows that the immersive and intimate nature of VR entails the risk of biomedical effects and that its use may pose a variety of physical and mental risks, such as addiction, depersonalisation and dissociation from the social and physical environment. It is important to conduct more research into the long-term effects and risks of VR and to use the findings as input for tightening up our regulatory frameworks.

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Appendix 1: literature review ethical and societal questions regarding VR

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