EUDAIMONIA
FORGING THE FUTURE OF WELLBEING

VIRTUAL WORLDS AND WELLBEING
LAB ON A CHIP
FERTILE GROUNDS FOR SCIENCE AND TECHNOLOGY
FUNNY SOCIAL ROBOTS
SUSTAINABLE ENERGY
AN INQUIRY INTO ENERGY GENERATION AND MANAGEMENT
Enschede, University of Twente
April 2015

Design: Manon Jurgens

Image (pg 3): Virtual worlds for wellbeing: RAFTWET Jewell
ACKNOWLEDGEMENTS

Dear reader,

this High Tech Human Touch magazine features four different technologies, all promising and emerging in their own respect. These technologies are Virtual Reality and Wellbeing, Lab-on-a-Chip - Fertile Grounds for Science and Technology, Funny Social Robots, and Sustainable Energy - An Inquiry into Energy Generation and Management. These topics all came about after an inquiry into the research done at the University Twente. All the writers of the articles in this magazine have therefore aimed to present a closer look into the current research projects and to present a broader overview of the implications of the technology in society. By investigating the technical, philosophical, and social scientific aspects of the technologies, we were able to bring together a wide variety of aspects revolving around the key topics of our study program - Philosophy of Science, Technology and Society.

The title we chose for this 2015 edition of the High Tech Human Touch magazine is Eudaimonia, the central theme of our project, representing our focus on the importance of technology for wellbeing. All four technologies are connected to this theme in their own way, for instance as a central theme in the technology itself, or less evidently along the sidelines representing a possible implication of the implementation of the technology.

To be able to present these technologies to you with the broader approach they deserve, we happily made use of the help that was kindly given by our interviewees. We would like to thank them for their help, as well as Olaf Stokkers and Karin Middelkamp for their help in finalising the printed product. We owe special thanks to our professor, Mieke Boon, who guided us in our process of writing the articles and who gave valuable commentary to keep us on track.

With this magazine, we hope to inspire you to see technology's bigger picture!

The writers of the magazine,

Chirag Arora, Jerfy ter Bekker, Jan-Yme de Boer, Harm Bult, Nolina Doud, Ana Fernandez, Iris Huis in 't Veld, Jurjen Idskes, Verna Jans, Manon Jurgens, Jannis Marinakis, Christian Pauli, Peter Segers, and Thijs Slot.

Enschede, April 2015
It is my pleasure to introduce the HTHT Technolab Magazine edition 2015, which has been written by four multi-disciplinary teams of MSc students in the Philosophy of Science, Technology and Society (PSTS). This High Tech – Human Touch Magazine addresses techno-societal trends to which diverse research-groups of the University of Twente contribute. This year, the PSTS students have chosen Well-Being as the general topic of their investigative journalism.

The PSTS master program aims to educate philosophers that bring philosophy into practice – philosophers who are capable of analyzing and interpreting current societal trends of which technological developments and societal responses are an inherent part. One of their tasks as professionals in PSTS will be to clarify and critically analyze important aspects of such trends to other stakeholders. This involves skills such as indicating various relevant perspectives and understanding the complexity of issues related to these trends. Notably, it requires the ability to understand how academic disciplines study their topic and come to conclusions. Writing such a rich and deep analysis of techno-societal trends must not only describe the trend, but also explain how scientific research aims to contribute to the technological development and how societal responses are studied. This task is intellectually challenging, as it involves the ability to become at ease with disciplinary perspectives that go beyond their own expertise. On top is this, some of the issues that emerge from these kinds of analyses must be lifted to a philosophical level for further study, which may result into relevant new perspectives on the techno-societal trend, thereby transcending the common view-points of distinct disciplines.

Studies on broad techno-societal topics related to current scientific research projects, such as presented in this magazine, is one of the ways in which PSTS professionals may contribute to the mission of the High Tech, Human Touch University of Twente in research and education. The promoted vision is inter- and multidisciplinary research aiming at high-tech solutions for the grand societal challenges, and education that prepares students for such tasks. HTHT solutions are not technocratic – no, HTHT research aims at technologies that are valuable for society by anticipating successful implementation and suitable uses. The word-cloud on such HTHT research and education endeavors presents us with buzz-words such as Problem-solving, Science, Innovation, Valorization, Entrepreneurship, Multi-disciplinarity, Questions, Research, Progress, Sustainability, and Solutions.

Nevertheless, fleshing out such a High Tech, Human Touch profile is a challenge. Advertising this vision is one thing – doing it is another. According to the HTHT mission statement, students
and researchers are challenged to look beyond the boundaries of their own field and establish links with other disciplines. But do we know how to work inter- or multidisciplinary? And do we know how to combine research, design and organization? Believing that behavioral and social science research must play a vital role in technological innovation does not necessarily mean that we understand how to do that. It appears that many professionals educated in the engineering sciences do not even have a clear picture of what the social science disciplines have to offer. They often lack insight in the kinds of problems that may emerge when ignoring the so-called soft-side of technology and they do not have a clue of the kinds of questions that should be asked in a thorough HTHT approach. Conversely, researchers in the behavioral and social sciences often lack understanding of technological research and do not have a clear picture of how they may interact or contribute to technologies that supposedly stimulate change, renewal and progress in society. Bridging this gap by facilitating productive exchange between the engineering sciences and the social sciences in projects that aim at genuine HTHT contributions to techno-societal trends, may be one of the future roles of PSTS professionals.

The HTHT Technolab Magazine series presents appealing and significant examples of opportunities that often remains unnoticed, that are brought to the surface by PSTS students’ journalistic investigations. Therefore, it is written for those who are curious, and for those who are skeptical, and especially for those who would like to learn by means of examples about these unknown dimensions of HTHT research. Each quire of this magazine has been written by a multi-disciplinary group of PSTS students holding a bachelor degree in the engineering sciences or in the social sciences. These students have chosen challenging technological developments with clear significance for society. Two magazines have appeared already. The HTHT Technolab Magazine of 2013 covered a wide range of topics, such as Smart grids, Blue energy, Human-brain interaction, Tissue regeneration, and Data storage. In 2014, the students addressed Pammography, the Exo-skeleton, and In-vitro meat. While this year, the PSTS students have chosen to explore four techno-societal topics relevant to Well-Being: High-tech and low-tech sustainability, Virtual worlds for well-being, Social robots with humor and Medical laboratories on a chip. Each of these quires entail different perspectives relevant to an advanced understanding of the topic. For creating this magazine, the students have studied relevant scientific and professional literature in different fields. More importantly, they have interviewed several UT researchers at the University of Twente, to whom we owe much gratitude, since these researchers have helped opening black-boxes in which we found the secrets and the pleasure of doing scientific research, but also the constraints. In this manner, PSTS students have created a number of new examples of what multidisciplinary High Tech, Human Touch research might look like.

The PSTS students have done a great job in writing this magazine. They bring together many relevant aspects such that we learn to better understand the challenges of technological design, engineering sciences, social sciences and philosophy, and also, how this gives the full picture of technological innovations and techno-societal trends.

Mieke Boon,
Enschede, March 23rd 2015.
## Virtual Worlds and Wellbeing

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VIRTUAL WORLDS AND WELL-BEING
Virtual Worlds and Well-being - An Introduction

Virtual worlds strike a futuristic, utopian note in many people. The idea of being immersed into a world without ever leaving your armchair certainly speaks to a sense of adventure without the danger, a view without a presence. It stands for a dream and a promise of experiences that would otherwise not be available, and all at your leisure. The modern conception of virtual technology traces its origins back to the 1950s, but at that time it was not persuasive enough to make the concept take off. Virtual worlds have, however, continued to feature in science fiction literature and movies, familiarizing people with the concept and the potentiality of the technique. These works of fiction may have painted pictures of a fantastical horizon, but often bear little resemblance to the actual developments. This set of articles will move beyond the laymen’s intuition, and introduce the reader to the broader applications of virtual reality and virtual worlds for well-being. The overarching idea is to inspect this connection in a threefold manner, covering the technology itself, the philosophy behind it, and the societal impact it currently has. The three domains are not separated in any strict sense, but instead interwoven, enhancing one another in both width and depth, providing background and supplementing understanding. The topic and scope of this set of articles fits neatly in the ‘high tech, human touch’ orientation at the University of Twente. Combining fresh academic research with practical, real-life applications, we will see how the latest insights are being employed to meet society’s needs.

Beginning with a brief history of virtual reality and virtual worlds, the reader will attain a sense of the baby-steps of these technologies, as well as being acquainted with the current state of the art. In this section, a couple of examples of how the technologies have shifted and progressed will be provided, to allow the reader to gain a recognition for the diversity and richness of possibilities. Moreover, the authors have spoken to researchers currently engaged with improving the quality of virtual worlds significantly in the context of the VIEWW, currently part of the largest ICT-project in the Netherlands. Improving the quality of virtual worlds is essential, since for most purposes the ‘realness’ was insufficient. Through the overview thus obtained, a number of existential questions will arise, bringing to the fore not only the one-sided, optimistic way of seeing virtual worlds, but also problematizing user-experiences and authenticity. It opens up a debate that brackets the dreamy, quixotic vision and heads towards a more serious appreciation of the nuanced consequences of virtual technologies. Furthermore, it will become apparent that research into virtual reality does not exist in a vacuum, and is
influenced by factors external to the actual research objectives. This has ramifications for the connection between virtual reality and well-being, as the latter is often left implicit and vague.

To follow up on this tangent, the philosophical part will consist of two main elements. First, user-experiences will be analyzed in a variety of philosophical traditions. This aids in coming to grip with a range of answers to the questions posed in the previous articles. Following a Heideggerian and postphenomenological line of thinking, the perhaps surprising argument is made for the point that virtual experiences can be as real as non-virtual experiences, only in an altered shape. The second aim of the philosophical angle is to focus on the notion of well-being itself. Rather than simply taking the abstract idea of “well-being” for granted, the concept will be philosophically dissected and explored. With this, we arrive at a nuanced idea of the contemporary thoughts of what constitutes and contributes to well-being. This more elaborate approach opens up the space for the introduction of positive psychology, a rather recent development that focuses on what makes life worth living, backed up with rigorous empirical research.

Tying the concepts of positive psychology’s insights into well-being with actual technologies is the next logical step. The advent of the internet entailed an expansion of the possibilities for people to connect – both with one another and with virtual worlds – and engage in myriad ways previously unavailable. Whether they contribute to a sense of well-being, however, is an entirely different matter, and will be the focal point in one of the articles. Positive technology looks into this specifically, combining psychology and technology in a way that directly relates to the world. It helps the reader in pinpointing both what positive psychology’s contributions could mean in everyday life, as well as highlighting some of the technological advancements that are already fulfilling such a niche. Zooming in on virtual techniques once again, a number of practical applications will be examined. Virtual worlds are now being utilized for the treatment of patients in a number of medical settings, including treatments for cerebral palsy, stroke-recovery, and reducing the fall-risk in people suffering from Alzheimer’s. Contrary to other research areas, here we will find a number of objective measures of the effect of virtual reality. The article dealing with this will show that rather than being a far-fetched dream, virtual worlds are already contributing to well-being in a sense that exceeds the oft-associated use for recreational games. This conclusion urges forward, hopefully inspiring the reader to continued interest in these developments.
VIRTUAL WORLDS AS A TECHNOLOGY

History, Developments and Applications of Virtual Worlds

In this article we give a summary of the developments in virtual worlds. We start by giving a brief, historic overview of the most important discoveries and events that led to the emergence of virtual worlds. After this, we take a closer look on the way in which virtual worlds are used today. In the last part, we discuss how current and near-future developments regarding virtual worlds can influence our well being.

History of Virtual Worlds
The development of Virtual Worlds has been influenced by different branches of industry. Important contributions to the modern-day nature and possibilities of virtual worlds originate from training programs, such as flight simulators, the gaming industry, the emergence of LAN- and internet connectivity and sub-sequential social network sites. One of the earliest steps towards virtual worlds was the development of the head-mounted display by Sutherland near the end of the 1960's (Sutherland, 1968). This was a helmet-shaped device designed to immerse the user in a virtual, three-dimensional environment. The first text-based, multi-user, virtual world was created in 1979 (Bartle, 2004). In text-based computer games, a world is described to the player, after which the player can type in commands in order to move around and complete objectives. The creation of Maze War (Damer, 2008), led to a number of significant advancements regarding virtual worlds. The game was originally created in 1973, with developments and improvements continued until the 1990's. Maze War was a computer game in which players would walk through a maze and try to find and shoot each other. The creation of this game was important because of three significant aspects of virtual reality. Firstly, the game could be played with multiple players over a peer-to-peer connection, contrary to earlier multi-player games on which players controlled the world through the same system. Secondly, the game was important for the use of avatars, a graphical representation of the user that could be observed by others as well. In this particular game, every player was represented as a floating eyeball. Thirdly, it was the first video game that provided its users with first-person view, meaning that the player would seemingly look through the eyes of the avatar. It was during this period that online chat was developed, with Maze War as one of the first products in which it was implemented. This resulted in people just logging in to chat with one another. One of the main problems of Maze War, and other virtual
worlds and games, was that it could only be played on computer systems owned by research facilities or companies related to computer science. The emergence of the personal computer, such as the Commodore 64, and access to the internet in the late 80's resolved most of these complications. The improvements that were made on both the personal computer and internet connectivity caused for increased power and speed while the costs decreased, making it available for more people. These advancements resulted in the emergence of Habitat (Morningstar & Farmer, 1991), the first large scale, multi-user, social, virtual world with graphical representations of each user. Habitat contained all the major requirements of a virtual world. One of the most important being the continuation of the world in the absence of the user. This means that the virtual world still exists and functions when a user is not logged in. This makes a huge difference in experience compared to an environment that is depending on the user to be present. These type of environments are not entirely considered to be worlds. The continuation of the world in the absence of a single user is of course caused by the multi-user nature of the virtual world. This changes the influence and experience of a single user entirely, through interaction with an active and alive environment.

Popular, modern-day applications of virtual worlds
The continuation of improvements in computing power of personal computers and internet speed led to more possibilities. More players can join in on the same sessions, the virtual worlds are visually more realistic due to increased graphical capabilities and more freedom is allowed to users, such as the implementation of user-created content.

The most popular type of virtual worlds are those that are aimed on entertainment; video games, and those that are aimed for social interaction. World of Warcraft is one of the most famous online communities. The users of this online game are part of a fantasy world in which quests and objectives ought to be completed. In the beginning of the game, the user has to shape his or her own avatar. When enough objectives and quests are completed, an avatar gets more powerful, creating a bond between user and avatar. In this virtual world, users can interact with one another, cooperate with each other and fight against other users. Groups and communities can be formed, either temporary or permanent until dissolved. Games like World of Warcraft are often referred to as MMORPGs; Massively, Multiplayer, Online, Role-Playing Games. In order to be a part of World of Warcraft, one must buy the game, plus optional additions to it, and pay a monthly fee to be able to log in. The price of this fee is somewhere between 10 and 15 euros, depending on what part of the world the user lives. The amount of members has been well over 10 million for several years, this shows the financial potency of virtual worlds.

Second Life is a good example of a virtual world that focuses mainly on social interaction and the formation of communities. In contrast to most other popular
virtual worlds, Second Life tries to imitate the real world as precisely as possible. A user creates an avatar out of a large selection of characteristics and joins the virtual world. In the virtual world, users can socialize, explore the world, construct things, attend conferences and participate in group activities. Second Life has an effective economy with internal currency, which makes it possible for users to trade services and virtual property.

**Future applications and well being**
New technologies to improve the experience are in continuous development. An example of an exciting new device is the Oculus Rift, a virtual reality head-mounted display. Devices like these aim to enhance the experience by making the virtual world appear more real. This should make it easier for users to relate to the virtual world and intensify the virtual experience. The Oculus Rift has the capabilities to be beneficial in psychological treatments, such as creating a lifelike representation to confront someone's fears. It is because of these exciting new developments that virtual worlds are becoming increasingly more popular. Popular virtual worlds, such as World of Warcraft and Second Life, show the eagerness of people to be part of virtual worlds for various reasons, such as; entertainment, sense of accomplishment or for communication and social contact. Devices that allow someone to be a part of a virtual world have become smaller and easier to bring along, making it possible to be part of a virtual world seemingly whenever someone desires to. The main focus of this magazine is to assess the relation between virtual worlds and the well being of the user. In order to make a valid evaluation, we need to have a solid idea of what well being entails and have knowledge about how and why virtual worlds can have an effect on well being. In the following parts of this magazine, the relation human beings can have with virtual worlds is examined and the concept of well being is explained. Applications of virtual worlds that aim to increase well being, and their effects, are discussed. After this, we assess how virtual worlds can be most effectively used to boost someone's well being.

Sources
Devices that bring imagination to reality

Virtual Reality (VR) hardware or gear are one of the most talked about technologies in the current market. Primarily these include headsets which cross the limitations of 2-D screen to make the user experience an actual 3-D world, close to what we are used to in our daily lives. While Oculus Rift, a virtual reality gear recently acquired by Facebook for over US $2 Billion, has grabbed much media attention, it is certainly not the first such technology. This article will look at some of the VR gear from the past, their problems and how they may have been improved in current technologies.

Virtuality
Virtuality was a line of VR gear produced by Virtuality group that was founded as a result of Dr. Jonathan Walden’s PhD research on VR and funding support from IBM in 1985. The set-up included a stand-up arena like system with a hand held controller and a headset. Virtuality became very popular in many arcades by the early 90s and had a series of successful games developed for their gear. This included the famous game Dactyl Nightmare which allowed players to shoot one another while a Pterodactyl attacked them. The major problem with Virtuality was the cost as individual customers could not pay the high price. The graphics, while great for the time, are not near enough the standards in the present era.

iGlasses
As much as the name may suggest, this product wasn’t from Apple. This was a headset developed BY Virtual I/O and was capable of stereoscopic 3D with color and head tracking- the image moving as the players move their heads. The device had a cost of less than $1000 and could be used with a PC. While the product was exciting, gamers and gaming companies, the prime
target for VR devices, did not find the experience good enough to make it a hit.

**Nintendo Virtual Boy**
Coming from the gaming industry giant, this product caught many eyeballs. It could be found in many video stores in the mid 90s. However, Virtual Boy didn’t last long as it lacked quality graphics as well as a head tracking system.

**Cybermaxxx and VFX -1**
Cybermaxxx was one of the impressive VR gears to be released in the 90s. It was developed by Future Vision Technologies. Cybermaxxx had many improvements over the previous devices with a stereoscopic color 3D, head tracking and a price below $1000. It also had support for a number of games on consoles and PC. VFX-1, developed by Forte, not only matched Cybermaxxx but seemed better in graphics quality as well as offered ability to play games that weren’t actually supported by the technology.

**Oculus Rift and Morpheus : Dawn of a new era**
Yet, none of these were a success in the market which seemed to suggest that VR wasn’t a good area for business investment. Therefore, the following decade did not see any major VR gear developments. However, with the Oculus Rift launched through the Kickstarter campaign in 2012 and now supported by Facebook, with competition from Sony’s Morpheus as well as Microsoft and Google getting into VR gear, it seems that VR is finally getting into mainstream. Moreover, the improvements in graphics quality, resolutions, field of vision, simulation complexity, etc. due to superior processing power available these days as well as understanding of user experience in earlier VR technologies, the experience offered by these upcoming devices is much superior to that of in the 90s. The new devices have also overcome the motion-sickness feeling associated with some of the earlier devices and give a much more realistic, coherent and engaged experience to the user.

Images
Virtuality system in Arcades Photo : Dr. Jonathan Waldren
Oculus Rift Photo : Rebke Klokke
THE AUTHENTICITY OF VIRTUAL REALITY EXPERIENCE

An examination through tools within Philosophy of Technology

Introduction to the next three articles

Computers have dramatically altered our lives. With technologies like the internet, an increasing part of our experience is lived out through a virtual medium. This has exposed us to doubts regarding the authenticity or reality of our experiences. While some of these existed even before the internet age, such as “is this true love?”, the internet has certainly added a few more – “Is she really my friend?” , “What is my real identity?” and so forth. If this was not complex enough, virtual reality does make it so. With technologies, such as Oculus rift, allowing the user to immerse herself into a computer simulated world, the boundaries between real and virtual seem blurry. Indeed, claims are often made, by people from a diverse range of identities – policy researchers, philosophers, parents, journalists, that virtual reality deprives us from the offerings of real life. That while virtual reality may offer some temporary gratification, it does not deliver the authentic experience of life itself. This set of articles will attempt to refute this claim against authenticity using the arguments within Philosophy of Technology tradition. The authenticity of virtual reality, this article will explicate, stems from a physical ontology, made possible through similarities between virtual and non-virtual world, and a relational ontology, as laid out through the phenomenological tradition within Philosophy of Technology. The section contains three articles that explicate three conceptions of how reality might be experienced through Virtual Reality: A classical conception, phenomenological conception and Postphenomenological conception. While all three have limitations, it will be argued that Postphenomenology provides the best tools to understand how an authentic experience is achieved through Virtual Reality technologies.
Physical Simulation of Reality

One of the ways in which virtual worlds attempt to give a realistic experience is by making a representation of the physical world we live in. There are, however, some virtual worlds which draw their inspiration from the world of fantasy. These can have objects, or beings, that may not have a correlation with the actual physical reality. However, there are still some fundamental characteristics which the virtual worlds share with the physical world. The most basic of these characteristics is the three dimensional nature of space and apparent objects within it. Thus, even if a virtual world is comprised of Unicorns, which even though are not real, their physical simulation is based on characteristics that treat them as real (Soraker, 2010: 96). Therefore, in many cases, shared characteristics between the virtual and the real world go beyond the three dimensional space to other physical mathematically describable properties such as mass and density. Furthermore, the events in a virtual world are modelled on causality as experienced in the real world. In Kantian terms, this is an extremely important feature as causality is a category of understanding without which the world wouldn’t make sense for us (Wilkerson, 1976:46). This characteristics allow the virtual world to be realistic, at least by appearance. However, there are still fundamental ontological differences between virtual world and the physical world. For example, virtual entities have no actual location in space-time, no actual physical mass and therefore, no mechanical causality relations with the real world (although their underlying physical states, such as in the electronic circuitry, may form such relations). Is the similarity in appearance of any use in making the virtual worlds as real and authentic? To answer this question, we will look in Heidegger's hermeneutic phenomenology to see what constitutes reality in terms of experience in the world, or ‘being’ in the world.

Sources
Soraker, J. (2010). The Value of Virtual Worlds and Entities (PhD). University of Twente.
PHENOMENOLOGICAL APPROACH TO UNDERSTANDING REALITY

Heidegger and problems with contemporary experience of reality

According to Heidegger, the contemporary conception of reality has fundamentally changed over the course of history and is starkly different from the ancient experience of reality, for example, that of the ancient Greeks. This change in the experience, in Heidegger's terms, has its roots in what he calls the "essence of technology". The Fundamental Greek experience of reality, according to Heidegger, involved a responsiveness to what was presencing the Greek Man. He openly received what spontaneously met him (Heidegger, 1977:131-132). Reality, thus, was a process of 'coming forth' or 'revealing' called as poeisis. This 'bringing forth' manifested itself in all of Physis, or nature, rising from the thing itself. Techne, the etymological root for the word Technology, was also a bringing forth (Heidegger, 1997:12-13). However, in Techne, or art and craftsmanship, man participated in 'bringing forth' of nature by transforming an aspect of it. While this seems to suggest a positive view of technology, where it plays a role of 'revealing' nature and thus, man himself, for Heidegger, this process gets forgotten over the course of history. The Philosopher Man began to seek a grasping of reality, what it might be underneath, so as to truly reveal what it was. Precisely, in so doing, according to Heidegger, he distanced himself from Being (manifested in the presencing of all particular beings), as he not only sought to unconceal but also to control. Here, to Heidegger's thinking lies the origin of modern technological thing and the essence of technology. Still Philosophy was a techne in its own way and by considering reality made it manifest in its Being. The shift in its approach is most significant with man becoming a determined centre of reality, a subject to behold truth, without relating himself to the Greek way of presencing before everything that met him. The historicity of this thought, in Heidegger's thinking, can be traced in the metaphysical traditions related to Christian theology and its influence in the middle ages. After this period, where Man was involved in determining his relationship with God, Man found himself in need of security, doubting everything that was before him. This doubt and the corresponding solution is embodied in Descartes' work, following which Man found the security he sought within himself (It is, therefore, not a surprise that the virtual worlds attempt to share the features of physical reality described by Descartes and referred to as "Res extensa") (Soraker, 2010:112). The new task for man was, therefore, not to be involved in un Concealing 'truth' by presencing in its presence but to represent it to himself, as it appeared, as an object of thought. With a continuation of that tradition, modern man arrests reality, objectifies it and modern
in terms of experience. As long as the virtual worlds are able to achieve similarity in appearance and virtual events can demonstrate regularity (In Kantian terms fall within the categories of understanding such as causality), human experience will qualify them as real rather than non-real.

However, so far we have only proved that virtual worlds are internally congruent, that is, once a user is immersed in them, the experience would be that of a real world experience. However, for virtual worlds to become a meaningful part of the user's reality, they should also have consequences that stretch beyond the domain of the virtual. This is an important criteria because the user might still be conscious of the fact that the virtual world he is experiencing is a constructed one. In other terms, for the user to count an experience of the virtual world as "real" and authentic, virtual worlds need to be externally congruent and enter into relations with the physical world of the user. In order to answer whether or not virtual worlds are able to achieve this, it is useful to use Don Ihde's postphenomenological concepts which illustrate how technologies in general act as mediators between human and the (actual) world. However, before we begin to understand Ihde's concepts we need to look at the context in which his philosophy is situated. This is particularly relevant for this set of articles as the said context involves the inquiry of epistemological relation between a knowing subject and known reality.

**Knowing Subject and Known Reality**

In the 19th century, two important epistemological movements developed – Idealism and Realism. According to Idealists, all knowledge of reality is a product of consciousness, that is, reality appears as consciousness produces it. By contrast, Realists claimed that consciousness had direct access to reality, that is, our knowledge of reality is that of the world itself. Phenomenology arose as a concept to solve the dichotomy between these two approaches. Husserl, credited for establishing phenomenology, stated that when human beings encounter the world, they bracket off the question of whether the world is outside of them or articulated by them (Verbeek, 2005:109). Instead, what we are left with are appearances, or 'phenomena', and the consciousness directed towards these phenomena. Therefore, human consciousness does not exist in itself but is always consciousness of
something, directed to something. In phenomenological terms this directedness is called intentionality. However, consciousness, as knowledge of the objects in the world, forms only a part of the human relation to the world. This shortcoming was addressed through Heidegger's philosophy of 'being-in-the-world' described previously. He characterizes the intentionality towards the world as having a structure of care (sorge), with which human beings shape their existence in relation to the things in the world (Verbeek, 2005 :111). Reality was, according to Heidegger, formed in relation between humans and the things. However, he claimed that by forgetting this relation contemporary man lived an unauthentic alienated life as reality remain concealed. Moreover, Scientific discourse of reality is, thus, not a disclosure of 'reality itself' (Verbeek, 2005 :105). However, a conclusion from this is that true reality is always illusive and therefore, reality is lived in a specific way through a relation to the objects. Thus, rather than concerning philosophy with nature of 'reality itself', more important question would be how this reality is lived when objects present themselves to the human. However, this questions seems to create a dichotomy between subjects and objects. The lived experience of reality is not just about objects being interpreted and put into language by a subject, but in fact the subject itself is also realized through this relation. This aspect of understanding the relation between the world and Humans comes from the existential tradition (one of the central tenets of existential thinking was that humans don't just exist but rather have a relation to their existence. Therefore, for them being-in-the-world is not about relations to the world but rather a realization of human existence within that world (Verbeek, 2005: 119) as opposed to the hermeneutic relation which is the origin of the first relation pointed out by Husserl and refined by Heidegger. Together these two relations can be characterised as taking a form of mediation (Verbeek, 2005 :122). Postphenomenological theory arises out of this understanding and tries to analyse how the intentional relation between humans and the world is extended through mediation by artefacts. With the help of this developed understanding we can say that virtual reality is able to conceive a lived reality by presenting itself to humans and giving rise to relations to the world through its presenting. Postphenomenology, solving the dichotomy of subject and object, also informs us that this relation does not have a directionality from human to the world, rather, the two are simultaneously constituted through it. The next article will therefore, apply Ihde's postphenomenological analysis to understand how virtual reality mediates the relation that constitutes human existence and the world experienced by the human being.

Sources
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Image
Le Jour Ni L’Heure
Understanding Virtual Reality as a mediator of relations between Human and the World

The relation that co-shapes humans and the world becomes localized in the form of experience. Therefore, Ihde approaches his conception of phenomenology by referring to experience. As stated in previous articles, in phenomenological terms human experience has an intentional structure, that is, it is always experience of something. There is always a link between the experiencer and experienced (Verbeek, 2005: 126). Therefore, it does not make much sense to search for 'reality in itself' or the 'world in itself' because just as beings are understood only in relation with reality, similarly, reality itself can only be understood in relation to humans. Ihde introduces a technological dimension in this human-world relation. In contemporary technological world, human relations with the world are mediated by technology. This can range from seeing objects in front of us through glasses to looking at stars. Virtual worlds are such a mediator. A user in a virtual world such as 'Second Life' is not only looking at a simulation of physical reality but is in fact forming a relation to the world through that simulation. Ihde distinguishes between four different ways in which technologies mediate the relation that constitutes humans and their world. These are: Embodiment, Hermeneutic, Alterity and Background. The following sections will discuss each
of those starting with the less relevant ones to the more relevant in terms of applicability to virtual technology.

Background Relations
(human (→ technology - world))
In this kind of relation, humans do not directly relate to the technology nor via a technology to the world, rather technologies are involved in shaping of our experience which we do not consciously perceive. Example of this relation include technologies like the thermostat. While a thermostat is responsible for giving us an experience of a warm room, the stability in temperature results in the technology taking a 'background' role where we scarcely notice it. This type of relation is not applicable to virtual reality as a Virtual reality user is actively and consciously engaged in the task.

Alterity Relation
(human → technology (→ world))
In alterity relations humans are related to a technology while the world takes the background. In this kind of a relation the technology behaves as quasi-other. While it is tempting to see them as the 'other', they remain quasi-other as technologies can not be seen as a true person. The technologies appear in alterity relation as they appear to be independent, that is seem to have more than mere 'objectness', yet they give rise to an 'interaction' between humans and the technology (Verbeek , 2005: 127). Examples of technologies that enter into this type of relation include robots and ATM machines. While they are technologies, humans 'interact' with them as quasi-others while the world is in a distance. It is quite tempting to classify virtual reality as an example of holding such a relation with humans. However, while it maybe true of some virtual environments, virtual worlds cannot be considered to be in alterity relation with humans. This is because while humans do interact with virtual worlds, the world is not bracketed off. Infact, within the virtual world a human encounters other human 'alters' and forms a relation with them through the technology.

Embodiment Relations
((human → technology) → world)
In this relation, technical artefacts become an extension of the body or in other terms, they are taken into experiencing of the world and hence, broaden the sensitivity to the world. Typical example of a technology that manifests such a relation are eyeglasses which allow us to see the world through them. Moreover, once the act of perceiving through the technology has been done enough to become automatic or 'constituted' (Ihde, 1990:73) – for example seeing with glasses, hearing with aids or walking with a cane- the technology becomes transparent to the user. It withdraws leaving only an 'echopresence' behind. At first glance, it seems that virtual reality also allows an embodiment relation with the human user. In fact, Ihde in Technology and Lifeworld writes:

“The experience of one's "body image" is not fixed but malleably extendible and/or reducible in terms of the material or technological mediations that may be embodied.” (Ihde, 1990:74)

This seems to allow a body image in the form of avatar, the virtual surrogate for a user's body, and suggest that it is a form of embodiment. However, there is one major difference that doesn't allow applicability of this relation. Ihde's description of embodiment relation is about how one experiences the real world through a technology. As the illustration depicts the world is outside the human -technology relationship. In virtual reality however, the experience of the real world is eclipsed and the body is immersed
in a world of virtual images and perceptions. However, this relation is still of importance to our discussion. This will become more clear after the discussion on hermeneutic relation, the fourth relation described by Ihde.

**Hermeneutic Relation**

(human ---> (technology – world)

In this relation too, like the embodiment relation, humans are related to the world via an artefact. However, in this case, the artefact does not ‘withdraw’ or become transparent. Rather the artefact provides a representation of the world that has to be interpreted, hence, the name hermeneutic. The user of the technology looks the instrument and is dependent upon it to get access to the world. Ihde writes:

“Perceptually, the user’s visual (or other) terminus is upon the instrumentation itself. To read an instrument is an analogue to reading a text. But if the text does not correctly refer, its reference object or its world cannot be present.”

Verbeek (2005 :127) gives an example of a thermometer to illustrate the hermeneutic relation. When one reads a thermometer, one is not involved with the instrument itself, but rather with the world. The thermometer allows the reader access to one of the aspects of his world, namely the temperature. It is important to note that the reader does not sense the temperature but rather is given access through a representation of it.

But is our relationship with Virtual reality hermeneutic? Ihde, in Technology and Lifeworld, writes (Ihde, 1990 :87):

“Through hermeneutic relations we can, as it were, read ourselves into any possible situation without being there.”

This may seem to suggest that we are in fact in a hermeneutic relationship with virtual technology, since they allow us to be in a situation without actually being there. However, Ihde's further description of hermeneutic relationship seems to suggest otherwise. He adds, “In science, in contrast to literature, what is important is that the reading retain some kind of reference or hermeneutic transparency to what is there” (Ihde, 1990 :87). Virtual reality, however, does not refer to 'what is there'. It does translate a physical state in the real world into an interpreted one, but it does not allow the user access to that physical state of the real world.

However, one way to understand the relation realized by virtual reality is to look at it as a combination of hermeneutic and embodiment relation. Virtual reality first represents the physical states of electronic circuits in a readable form for the user. Once the user is able to read herself into a situation, she perceives, through an embodiment relation, herself into a virtual one. The strength of this embodiment relation is strengthened by the sharing of the accessed world by multiple users. To illustrate this point with an example, imagine a user in the virtual world of second life. The artefacts that she perceives within this world are representation of a computer code which in turn is a representation of the electronic states of the server. This is how the technology allows the physical electronic state to be represented to the user as something other through a hermeneutic relation. Then, say this user picks up an object, example a knife inside that world and passes into another user within that world. The user is able to do that through an embodiment relation with the knife within the virtual world. It is important to note that the user knows that the knife is a virtual one and is in fact a set of codes or electronic states. However, the user is still able to perform this task without absurdity because the other user is also in a hermeneutic and embodiment relation and is perceiving the world in the
same representation as the first user. To refer to the discussion in the earlier section, this combination of the two relation allows the virtual worlds to be externally congruent and hence, conceive a subjective reality and an authentic experience for the user.

Concluding Discussion
Virtual reality and virtual worlds are often seen as making real life bereft of life's offerings. The experiences in virtual worlds is therefore, often labelled as inauthentic. This section tried to refute this claim by de-covering the human relation to virtual reality and its relation to human relation to the world in general. First, it was established that one of the ways through which virtual worlds are able to create a sense of reality for the user is through simulation which resemble physical reality seen in everyday life. This is made possible by the fact that human world is composed of objects with mathematically describable properties, which can thus be represented in the virtual world through lines of computer codes. Secondly, the section followed a phenomenological approach to understand how reality is conceived by humans. While encountering the world, human beings bracket off the questions about 'reality itself' and are rather engaged in a relation with the world. This relation with the world, along with the realization of human existence within the world through this relation, makes up the lived reality of a human being. This relation moreover, is established by an intentional directedness towards the world (or objects perceived in the world). Don Ihde's introduction of a technological component within this relation enables us to understand that in contemporary technological world, the relation constituting human existence and the world around him is mediated by technology. That is, the notion of lived reality for humans is realized through artefacts. This is made possible in a variety of relations such as perceiving the world through artefacts, interpreting the world through instruments, interacting with the artefact as a quasi other and even an unconscious effect of the artefact on the perceived world. This understanding makes clear the notion that human beings don not have a final contact with reality but rather reality is always conceived as a lived one through a mediated relation to the world. Virtual reality is also another mediator of this human relation to the world and therefore, questions about its inauthenticity are not the right ones. What is of more importance is to look how this mediation is made possible by virtual reality. To this end, it was found that while the ways in which technologies in general achieve this, as postulated by Ihde, can be problematic when applied directly to virtual reality, they do help in conceiving a better understanding for the particular case of virtual reality. Finally, we established that virtual realities form a rather unique combination of hermeneutic and embodiment relations through which the human user is first given access to the world through a representation and is then allowed to perceive that representation through an embodiment within the created representation (virtual world, for example) via the technologies associated to virtual realities, thus conceiving a subjective reality.

Sources
The VIEWW project

Introduction
Virtual reality and virtual worlds are predominantly used in the entertainment industry. There are, however, several academic research groups that are attempting to increase well-being with the use of virtual reality. One of these groups is VIEWW (Virtual Worlds for Well-Being)[1]. We have used this project as the starting point of the magazine. In this article, we describe the VIEWW project as an example for academic research aimed to use virtual worlds in order to increase well-being.

VIEWW project
The VIEWW research group is concerned about the lack of an emotional experience in current virtual worlds. The research group is part of COMMIT/[2], a program that brings (non-)profit organizations and academic research together. In total, COMMIT/ supports sixteen different research projects, of which the VIEWW project is one. The main goal of the VIEWW research group is to develop a way to create affective virtual worlds in which users can have a rich and rewarding experience. Existing virtual worlds have detailed graphics that can accurately represent an environment. However, there is a lack of emotional and social interaction due to a lack of possibilities to express emotions in avatars. This limits the affective and emotional bond that can be formed with a virtual world. In order to increase well-being, it is necessary that these bonds are formed. The VIEWW research group attempts to research new technologies that can measure intended behaviour and emotions in a user and translate those to the avatar.

The VIEWW project faces multidimensional challenges. There are, for example, programming related issues regarding the design of avatars and more psychology related challenges in an attempt to make a model to measure well-being. Henceforth, the project is divided between multiple research groups with different academic backgrounds. There are four main research categories; animation, sensing emotion, tangible interfaces and creating environments. A separate group will be responsible for defining the requirements and integration. The findings of the research will be tested and reviewed by four different pilot work packages.

Research Categories
The project for realistic animation and sensing of emotions in virtual worlds are both divided in three different research topics. Tangible interfaces and
creating environments each consist of one research topic.

Animation:

ANI1: Affective Body Animation
Attempts to combine motion and emotional expressions for affective character animation.

ANI2: Social Animation
Investigates new techniques to improve the quality of realistic movements and animation.

ANI3: Biomechanical Animations
Attempts to use computational methods to assess someone’s physical well-being based on existing musculoskeletal models.

Sensing Emotion:

SEN1: Sensing Emotion in Video
Extracts emotional information about people based on analysis of video sequences.

SEN2: Sensing Emotion in Music
Tries to find knowledge about identifying the emotional and semantic parameters in music, and implement these in a computational model.

SEN3: Socially Aware Sensing from Videos
Aims to develop new technologies to measure the emotional state and behaviour of human beings.

Tangible Interfaces:

TAI: Investigates new input devices with smart, tactile interfaces.
Creating Environments:

ENV: Investigates techniques that can help developers of virtual worlds to create a more affective environment.

Pilot Work Packages
Prototypes of products will be designed based on the outcome of the different fields of research. The aim of the pilot work packages is to test these prototypes on real users and interested parties. As mentioned, there are four different pilots.

Monitor pilot:
The aim of this pilot is to develop and test system that can monitor the activity of groups of people. The system uses wearable sensors and video analysis to measure activity. The idea is that this leads to the prospect of making an analysis of the effects of the environment and atmosphere on well-being. With this information, the effects of individual parts of the environment and the atmosphere can be altered to increase well-being. This technology can be adapted in public places and elderly homes.

Play pilot:
in this pilot, a framework to make realistic, affective character animation. Next to this, a mechanism is developed to create an interface with which users can control the emotions of the virtual character. With this, they aim to increase emotional bonding with a virtual world and its characters. This technology enhances virtual interaction and can be applied to reduce the sense of loneliness by isolated people.

Exercise pilot:
This work package attempts to introduce a demonstrator to keep interaction with virtual worlds fun and engaging. The demonstrator is an virtual motivator to boost the performance of a user in order to achieve pre-set goals. One of the adaptations of this technology is to use it in rehabilitation or boost exercise activities in elderly homes.

Touch Pilot:
The touch pilot is concerned about the fact that elderly are less socially connected because of their inexperience with the use of modern communication technologies. The goal is to develop tangible interfaces that allow elderly people to be more socially active.

Together, the research groups and work packages should lead to virtual reality products that are able to increase well-being.

Interview
In order to get some more in-depth information about the VIEWW project, we interviewed Merel Jung and Gijs Huisman, both are PhD students and part of the research department. Ms. Jung is working on a touch
recognition system for artificial interfaces. This could, for example, be applied to robots so that they are able to know how someone is feeling based on touch. In this research, machine learning is used to teach the system how to differentiate between fourteen different kind of touches, such as stroking and tapping. Ms. Jung has a background in psychology and was not so much a part of the development of the machine learning system. She is responsible for the psychological research of different touch patterns on the robot arm by participants of the project. She told us there was a lot of communication within the work group she worked with, but there was not much communication with the other work groups. The reason for this is that the whole research project contained a lot of diversity between the different groups.

Mr. Huisman explained the communication between companies, institutions and the VIEWW project. There is some struggle between the research and the development of applicable products. However, there is a demand for the new technologies. For instance, companies have asked for specific applications of the developed technologies. Another example is a medical institution that was interested in a new way of communication between caregivers and patients that were both blind and deaf. Furthermore, the VIEWW project stimulates members of the various research department to come up with ideas to turn the new developments into products. Mr. Huisman mentioned there have been some problems about the question who actually owned the developed technologies. This was caused be the fact that the project was financed by the government as well as interested companies. This was the cause of another problem as well. Companies want release tangible products, whereas the university was concerned with academic publications. This indicates the partially conflicting interests by companies and universities.

Conclusion
The VIEWW research group attempts to develop new technologies and investigates new possibilities to make the virtual experience a more affective one. By doing so, they want to provide a framework for virtual worlds that leads to a strong and legitimate effect on well-being. The different research groups lead to a broad approach in which a lot of different aspects of the technology and its possible applications in society are covered. A lot of communication is required in order to find interested parties for not yet finished products. In the case of the VIEWW project, both companies and the university is funding the research. Companies are interested in products that are available to the general public. Universities prioritize research and publications. This demonstrates the difficulty of having investors from different fields of interest involved in the development. However, it is a good sign that interested parties from different backgrounds are willing to invest in technologies for virtual worlds. This shows that there are different fields in which the technologies can be employed and that there is a demand for the idea of virtual worlds for well-being. However, the field is new and there are a lot of improvements that still need to be made.

Sources
WHAT IS WELL-BEING?

Theoretical Approaches in Philosophy and Psychology

Wellbeing has been a traditional topic of concern in Philosophical study, and in recent years, it has become an important concern in other areas of research, notably Psychology and economics. Over the past few decades, attempts to use wellbeing and Happiness to guide social and economic policies have significantly increased. This article will introduce and discuss the study of wellbeing and Happiness in Philosophy as well as Psychology.

Philosophical Theories of Wellbeing
Wellbeing has been an area of interest in philosophy at least since the time of ancient Greece, particularly in the work of Aristotle. In modern philosophy, wellbeing and happiness are an important theme in utilitarian theories proposed by Jeremy Bentham and John Stuart Mill. In contemporary Philosophy, wellbeing has received increased attention in the past three decades. The following sections will introduce three major types of wellbeing theories in Philosophy: Hedonist, Desire-fulfilment and Objective (Parfit 1984, Griffin 1986, Sumner 1996).

Hedonism (and other Mental State theories)
Hedonist theories hold that only pleasure is intrinsically good while only pain is intrinsically bad. To have wellbeing is therefore to be able to accumulate pleasure while avoiding pain. This view was first advocated by Epicurus (giving origin to the word “epicurean” - devoted to pursuit of pleasure) circa 4th century B.C. Modern hedonism has its origins in utilitarian works of Jeremy Bentham and John Stuart Mill. Bentham and Mill, however, propose different types of hedonism, quantitative and qualitative respectively. Quantitative hedonism holds that the value of pleasure is determinant only upon its quantity (through parameters such as duration and intensity). Qualitative hedonism, as proposed by Mill, gives an objection to this view by claiming that some pleasures are more desirable and/or worthy than others. For Mill, “it is better to be a dissatisfied Human than a satisfied pig”. Some of these higher pleasures may include, according to qualitative hedonist, experiences of knowledge, companionship, art, contemplation, etc. A good life, for qualitative hedonists, thus, involves not just more number of pleasures but a good representation of higher pleasures.

Hedonism, in both its forms, has been criticized for not corresponding sufficiently to human intuitions of a good life. One particular and popular criticism has been from Robert Nozick, who uses a thought experiment to demonstrate this shortcoming.
Proponents of this theory take up a cognitive view of happiness, where happiness may be defined as a positive attitude to life as a whole (Brey 2012). Other views of happiness include the Hybrid view, which holds that happiness is a combination of positive feelings about and positive experiences in life, and hedonistic view, which views happiness as a purely hedonistic state.

**Desire Fulfilment theories**

Desire fulfilment theories came about prominently in 19th century with welfare economics. Desire fulfilment theories hold that wellbeing lies in fulfilment of one’s desires. They hold two advantages over the hedonistic or mental state theories. First, they can be measured objectively as opposed to mental states which can be much cumbersome to measure. Second, they can avoid Nozick’s experience machine dilemma since people can desire for real events which machine doesn’t fulfil. These class of theories can be said to be of three major types (Brey 2012).

Simple desire fulfilment theory holds that an individual is better off when more of one’s current desires are fulfilled. A major criticism of this theory is that often people hold desires that may be contradictory to their long term interests, for example, desires held during impulsive or reckless mental states. Reflective or comprehensive desire fulfilment theory give priority to one’s reflective preferences concerning life as a whole. For example, if one reflectively desires for a long and wealthy life then that trumps other desires. An objection to this theory is that it may also result in choices that may not be optimal for one. Consider the situation where an orphan wins a lottery. Now the orphan has two choices: remain in the orphanage and temporarily or permanently give up the prize or move out of the facility. While, life outside may enable the orphan to live a more fulfilled life, the orphan may choose the
former due to lack of information of what life outside may hold. Third kind of desire fulfilment theory, which attempts to counter this objection, is informed desire fulfillment theory. This holds that the best life is one in which all desires held if one was fully informed of one’s situation are fulfilled. Relevant information may include possible courses of action, objects and consequences of actions.

A general objection to desire fulfilment theories is that they tell us nothing about the sources of desires. It would seem that it should be the case that we desire things because they are good for us and not that they are good for us because we desire them. Yet, desire theories do not account for why some things might be good or desirable for us. Moreover, they do not account for defective desires such as poorly cultivated or pointless desires, which people may hold even after being informed. If this is indeed the case, then it cannot be concluded that desire fulfilment leads to well-being.

Objective List Theories
These theories hold that wellbeing is attained by possession of a number of objective conditions of persons rather than their subjective experience of pleasure or fulfilment of desires. The conditions are objective in the sense that they increase wellbeing irrespective of individual’s tastes, interests or traits. For example, Parfit (1984) proposes a list that includes moral goodness, rationality, having children, good parenting, knowledge and awareness of true beauty. Objective list theories not only differ in terms of items on the list but also if the items have a unifying element or not. The ones that do have such an element are known as explanatory objective theories while others as bare objective theories. Perfectionism is an example of an explanatory theory which holds that the objective conditions should be such that they result in perfection of human nature. Perfectionist theories define an intrinsic human nature which may stem from sources such as biology or divinity. An objection to objective theories is that they are paternalistic or elitist by claiming that things are good for people even if they may not value or desire them. Another criticism is that they deny the diversity within human beings.

Well-being in Psychology
The psychology of wellbeing and happiness began roughly in 1950s with an increasing number of psychologists taking interest in studying positive emotions and feelings in contrast to negative emotional states which had defined the field thus far. Psychology of happiness came into being as a rich field during the 1980s with the seminal work of Ed Diener and others. Diener coined the term “subjective wellbeing” and proposed methods to study it. Subjective wellbeing is an individual’s current evaluation of their happiness. In contrast to subjective wellbeing, objective well-being concerns with people’s real time positive sensations and feelings of happiness. Proponents of this view include psychologist Daniel Kahneman, who argues that psychology should concern itself with objective happiness. Methodologically, subjective wellbeing is much easier to measure and involves surveys and interviews through which people can report their experienced happiness, emotions, levels of satisfaction, etc.

With regards to the conceptual notion of happiness, research on wellbeing in psychology can be split into two categories; hedonic and eudaimonic. Hedonic approaches correspond with hedonist traditions in philosophy but may also include satisfaction as a parameter, thus, extending to desire fulfilment theories as well. Eudaimonic approaches hold that happiness includes objective factors that result in actualization of human potential. Therefore, this approach corresponds to the class of objective list theories in philosophy. A very influential eudaimonic theory is that of authentic happiness proposed by Martin Seligman, who is credited with initiating the field of Positive Psychology. Seligman’ positive psychology approach to authentic happiness holds that a good life should be a combination of three categories: a pleasant life,
engaged life and meaningful life. The pleasant life concerns with having positive feelings about past, present and the future. The engaged life is one in which the individual feels engaged and involved in their work, leisure and relationships. In engaged activities, one experiences ‘flow’ and loses the sense of time. The pursuit of engaged activities is enhanced through possession of character strengths and virtues, according to this theory. Finally, meaningful life corresponds to one in which one’s strengths are employed in the service of activities that one finds meaning in or bigger than oneself.

**Conclusion**

While there exist diverse and rival approaches to wellbeing both within Philosophy and Positive psychology, the recent decades have seen research with focussed aim to develop practices that can enhance human wellbeing, through learnings from these fields, and be applied in various forms such as at an individual level, institutional level, social level, etc. Concepts and data obtained through research on wellbeing and happiness, particularly in positive psychology, is increasingly been used to guide policy debates. Some countries have started to use happiness indices as a supplement or alternative to GDP as a measure of progress. Bhutan is the first country to use

![Bhutan: the first country to use happiness as an indicator of progress](image)

GNH or Gross National Happiness as the most important measure of progress through sophisticated surveys of its population’s wellbeing. Other countries that are using or considering using GNH include Canada, France, Australia, Thailand and United Kingdom. Attention through research in well-being is also being to use and design of Technology. The pervasive role of Technology in modern life has drawn scholars in psychology and philosophy to examine carefully the scope of enhancing wellbeing through technology. Virtual Reality technologies, through their potential to impact social relations, emotional states, personal development, make good candidates for such research. The next article will focus more attention on some of the research that attempts to propose ways in which Virtual Reality can be used for enhancing wellbeing.

**Sources**


**Image**

Bhutan: Ritwick Datta
Presence, Telepresence and the Design of Virtual Worlds

In order to make a legitimate claim about the relation between being a user of a virtual world and well-being, it is necessary to determine the intensity of the connection users have with the virtual world. In order to obtain a connection, it is important for the user to have a sense of presence in the virtual world[1]. In this article, we discuss what is essential for a human being to feel present in an environment. Next, we argue how this relates to virtual worlds and what the requirements are in the design of a virtual world in order to invoke the experience of presence.

Presence and Telepresence
In this article, when we talk about presence, we are focussing mainly on the feeling a person can have of being present in an environment. Next to this type of presence, there is also physical presence, which is just the existence of an object or being in a certain place and time. But since we are concerned with virtual worlds and environments, we will predominantly discuss the type of presence that is defined by a person's own interpretation. The definition of this type of presence is usually linked with the connection people feel with the environment they are in. But since it depends, for a great deal, on a person's own perception, it is difficult to give a clear definition. Because psychological and social factors are of influence on someone's interpretation, it is problematic to accurately measure presence[2]. In this article, two of the most influential philosophical theories about presence are discussed, the rationalistic view and the Heideggerian view. In doing so, we attempt to get a better view on what being present entails, and what is necessary for a human being to feel present in an environment. Even though both theories were developed and written down before the existence of virtual worlds as we know them now, they are still relevant in the analysis of modern-day technologies. In virtual worlds, presence is not the same as in the physical world. A human being can not physically exist in a virtual environment. The sense of presence is a remote one. The feeling of being present in a location where someone's body is not, mediated by technological devices, is called telepresence[3]. In virtual worlds, this is achieved through the use of technologies such as monitors and interfaces.

Presence in the Rationalistic View
The rationalistic view on presence is based on the dualism theory by Descartes, a hugely influential,
French philosopher living in the 17th-century. In this view, there is a clear distinction between res extensa; the body, and res cogitans; the mind. In the rationalistic view on presence, there is a gap between the physical world and the mental world. To close this gap, representations of the physical world are conceived in the mind. We can explain this by giving an example of someone that is observing a tree. The tree is an object in de physical world. In the mind of the observing person, the mental world, a representation of the tree is made based on the interpretation of the observed object, in this case, the tree. If the concept of presence is studied according to this theory, it becomes clear that presence is not determined by just one factor. There are two types of presence, objective presence; that what exists in the physical world, and a subjective presence, that what is conceived in the mental world. The extent to which someone is present, therefore, depends on a person's feeling of presence (subjective), and physical, observable presence (objective), the latter can be determined by estimating the ability to perform tasks.

Heidegger's View on Presence

Heidegger was a famous, 20th-century German philosopher. His view on the relation human beings have with the world is radically different from the rationalistic view[4]. According to Heidegger, there are two modes of existence a person can find him- or herself in. The first one, the primary mode of existence, is the one human beings spend most their time in. In this mode, a person focusses on the actions they perform. These actions can be all sort of things, such as; working, talking, running or cooking. In this mode, we interpreted our environment and the objects in it based on their functionality. If we want to cut a piece of paper with a pair of scissors, for example, we are not concerned with the colour or exact shape of the scissors. The pair of scissors is represented in our mind according to the task we want to perform, cutting the paper, and the ability of the scissors to do so. In Heidegger's view, for the large majority of the time, this is the type of relationship we have with our entire environment. In this primary mode, however, we can never acquire a full representation of our relationship with the environment and the objects in it. We only have partial and functional relationships with the environment. To get a full representation, we need to leave this primary mode of existence. If we detach ourselves from the functional relationship with the environment and we enter a non-primary mode of existence, we are able to get a full representation. If we take the example of the scissors, we lose the strictly functional relationship with the pair of scissors when we stop seeing it as just an object we use for cutting paper, for example, when the pair of scissors breaks.

If we relate this theory of modes of existence and relationships with the environment with being present, we come to some interesting conclusions. In the primary mode of existence, we only have partial, functional relationships with objects. We are not actively aware of our representation of the environment. In order to acquire this representation, and henceforth get an active sense of one's own presence, one must detach him- or herself from this primary mode of existence and enter the non-primary mode of existence. Only in this mode, it is possible for someone to estimate one's own presence. In the primary mode, human beings are unable to evaluate their own presence, and presence is therefore only defined by the functional relationship with the world. In other words, the only way in which we are able to not feel present, is when we leave the primary and enter the non-primary mode of existence.

Theories of Presence and Virtual Worlds

If we take these theories into account, we can make an evaluation about what is required in a virtual world to make a user feel actually present in that world.
In the rationalistic view, to achieve a sense of presence in a person, the mind must be able to produce mental representations of the physical world. This mental world must be formed in such a way that it serves as a functional representation of the physical world. A person must have a representation in such a way that his or her interpretation of objects and the environment make it possible to appropriately make use of these objects and the environment. In virtual worlds, this can be problematic because there is no real, physical world. It appears that a representation of the physical world in the mental world is therefore impossible. The concept of virtual worlds does not seem to fit in either of the two defined worlds in the dualistic view. Because they are clearly not part of the mental world as well. In order for this dualistic theory to make sense in virtual worlds, we need to replace the term physical world with something else. The physical world has always been related to things that are real, and the mental world with mere representations and is considered to be not real. Virtual worlds, however, are real in the sense that they exist outside of the mental, but they are not physical. We should therefore redefine the dualistic split in the rationalistic view. Instead of mental and physical world, we should be talking about a mental world and a extra-mental world. Everything that is not part of the mental world, and can therefore be shared by more people, is part of the extra-mental world. By using the definition of extra-mental world and not the definition of physical world, we are able to apply the rationalistic view on presence in virtual worlds. In order to feel present in the rationalistic view, mental representations should be formed accurately. For mental representations to be adequate, it is necessary that someone can make correct interpretations of the extra-mental world. The virtual world should consists of elements that make it possible for a human being to make a representation. This suggests that the virtual world should correspond with the real, physical world. For this is the world human beings are able to make functional representations in. Representations that make it possible to adequately perceive ourselves, other people and the environment. This entails visual and other sensory correspondence with the real world, but also a logical or functional one. This means that the virtual environment should respond correctly to actions of the user. These requirements do not necessarily mean that every aspect of the virtual world necessarily has to emulate the real world in order to have a feeling of presence, but imply that increased detail leads to an increased feeling of presence. In any case, the requirements should be met in such a way that the intentions a user has within a virtual world are adequately fulfilled. To summarize, in the rationalistic view, there are several requirements for a virtual world to make a user have a feeling of presence. The intentions of the user correspond with the purpose of the virtual world. The sensory features in a virtual world should resemble the real world in a way that the user can adequately choose actions to fulfill their intentions. The response of the virtual worlds on the user's actions should be logical and predictable so that the user can achieve his or her goals.

According to Heidegger, we are unable to not feel present when we are in the primary mode of existence, the mode in which we are carrying out tasks. This mode represents the state in which human beings are enrolled in for the majority of the time in real life. To put in in other words; if you keep someone occupied, he or she has no time to consider their presence, and are therefore always experiencing presence. So, what we need to achieve in virtual worlds, if we consider Heidegger's theory as our point of departure, are tasks that occupy the user. There are certain requirements for someone to be entirely absorbed into this functional mindset. As mentioned, human beings see objects for their functionality. Thus, objects in the virtual world must either visually represent those in the real world or shaped in such a way that it is clear for the user what function the object has. A second
requirement is that the task that is performed has to be met with an appropriate response. The result of the task must be logical, and preferably, be anticipated by the user. One can argue that when a user is occupied in a virtual world long enough, the functional view he or she has on the virtual world might change according to the rules of the virtual world. Objects can be identified with a new functionalities. Even unfamiliar objects, with unclear functionality at first, can be identified for their new functionality if the usage of this object leads to a logical and wanted outcome. The goals a user has with a task may change as well, as long as that goal has a function in the virtual world. In short, a virtual world needs to meet a certain set of conditions in order to acquire a real sense of presence by the user in a remote environment, telepresence. Initially, we need identifiable objects, at least in functionality, and tasks that lead to logical responses in the virtual world. If a user spends enough time in a virtual world, objects and tasks may become more easily recognizable, even if they do not represent the real world correctly. As long as the response to the usage of these objects and the performing of tasks lead to a satisfactory result. This is caused by a new set of rules the user has formed, leading to new evaluations of objects and actions.

Simultaneous Presence in Multiple Environments
With telepresence, human beings are able to get the experience of being present at a location were the body is not. The work of Helmuth Plessner, a 20th century, German philosophical anthropologist, is used to explain why it is possible for human beings to have this experience[5]. According to Plessner, human beings are excentric beings, and have the capability to be in a excentric positionality. In short, this means human beings, in contrast to animals and plants, are able to position themselves outside of their own body. Sometimes referred to as changing the centre of experience. A phenomenon that can be experienced when someone is daydreaming or caught up in a story. The difference with telepresence is that telepresence is induced by technological devices. Because human beings can position themselves outside their own body, they can have the experience of presence in a virtual body or world.

However, being present were the body is not, is a problematic concept. When a user is emerged in a virtual world, there is still a connection with the body. Two problems of a biological nature that occur when someone feels present in a location where the body is not. A user of a virtual world will still be able to feel his or her own body. A human being cannot turn off sensory perception. A user is, for example, still aware of temperature, can feel pain and has proprioception; a sense of position, movement and acceleration of parts of the body. There are also examples that are more related to the virtual experience itself; such as the sense of the user's hands on a controlling device. The second problem is that someone is still depending on functioning sensory organs. Even though users experience virtual sounds and visuals, they still need their eyes and ears to perceive this information. Users cannot completely disconnect themselves from their body when they are immersed in a virtual world. It seems, therefore, that there is some sort presence in multiple locations, one in the virtual and one in the physical body. There is no longer one centre of experience, but two. This concept of having multiple centres of experience is called poli-centric positionality[6]. This also entails the doubling of the perception of having a body. In the case of virtual worlds, someone would have a physical body and a virtual body. Because of the human being's ability to have multiple centres of experience, it is possible to have a a sense of presence within both their physical and virtual body.
Realizing the Experience of Presence in Virtual Worlds
In this part, we make a comparison between the rationalistic and Heideggerian view on presence. We attempt to determine the requirements of a virtual world in order to maximize the feeling of presence by the user. Both views on presence emphasize the importance of a recognizable world. In the rationalistic view, it is important for the user to make mental representations of the extra-mental world. In the Heideggerian view, a user should be able to identify objects and how to use them. Although both theories point out that the environment should be identifiable both sensory and functional, Heidegger's view prioritizes functionality to a greater extent than the rationalistic theory. As long as the user is occupied, according to Heidegger, he or she will have a sense of presence. The user has to identify objects for their functionality, after which the object can be used as a tool to perform a task. The activity of performing a task will lead to a sense of presence. In the rationalistic view, it is predominantly the recognizability of objects and the world that is important. It is the representation of the world itself that should cause a sense of presence. This leads to a somewhat different approach in creating a virtual world. In the rationalistic view, objects in the virtual world should be constructed in such a way that it is easy for the user to create mental representations of objects. In the Heideggerian view, occupation is key, and the world should be constructed so that users recognize objects for their function and performed tasks should lead to logical and satisfactory results. This concept is in line with that of 'flow', as mentioned earlier in the magazine. Flow is what someone experiences if they are involved in engaging experiences. The problem with the rationalistic view is that it attempts to make a distinction between what is real and what is not real. The theory accentuates the necessity for a virtual world to copy the real world. The required alteration in the dualistic division from physical world and mental world to extra-mental and mental world in order for the theory to make sense in virtual worlds, underlines this problem. In Heidegger's theory, there is no division between different worlds. The focus lies not on what is 'real' or what 'reality' is. Instead, it accentuates the importance of the intentions of the user and the user's occupation with tasks to fulfil these intentions. In this view, there is no clear distinction between virtual and physical worlds. A human being has the feeling of presence as long as he or she stays in the primary mode of existence. This might either occur in the virtual or the real world. Therefore, Heidegger's theory, and what it has to do with presence and telepresence, is better applicable to virtual worlds.

Presence and the Design of Virtual Worlds
The view by Heidegger allows for a genuine feeling of presence and fits better into the concept of virtual worlds. If we take a short look on how virtual worlds should be designed in order to realize the strongest possible experience of presence, Heidegger's theory seems to be the better choice as well. In the rationalistic view, the experience of presence is a subjective concept. Someone can feel more or less present at a given moment. This, in combination with the required similarities with the real world, makes the design of a virtual world complex. To enhance the sense of presence, seemingly endless adjustments can and, arguably should, be made to the virtual world. Not only has the virtual world to look and sound like the real one, other sensory stimulation is required as well, such as touch and smell. This is highly difficult to achieve and demands extreme amounts of detail. Another problem is that every virtual world should resemble the real world in a highly detailed fashion, whatever the purpose the virtual world may be. In
Heidegger’s theory, there is a binary division of the experience of presence. Someone either stays in the primary mode of existence and feels present, or someone leaves the primary mode of existence and is able to estimate his or her own presence. As long as someone stays in the primary mode, there is no need for a full representation of the world. The virtual world should provide the users with enough tasks and objectives to let them remain in the primary mode. This functional approach is less problematic for the design of a virtual world. The feeling of presence in a virtual world can be experienced solely based on one specific task. Therefore, virtual worlds can be designed for one specific purpose, such as communication or specific tasks for rehabilitation. A detailed and realistic representation of the world leads to a prolonged sense of presence. This also entails different types of sensory feedback such as visual, auditory and haptic. Perceived errors and inconsistencies by the user of the virtual world leads to a decoupling with the virtual world. This happens because the user leaves the primary mode of existence when decoupling takes place. The concept of policentric positionality states that when a user is engaged in virtual worlds, there is the experience of being present in two bodies, the physical and the virtual body. It is important that the user stays occupied and, consequently, remains in the primary mode of existence within the virtual world to maintain the experience of presence within the virtual body.

**Conclusion**

In this article, we discussed what presence and telepresence is and how to achieve a sense of presence in virtual worlds. Because of the capability of the human being to feel present in a location where the body is not, it is possible to experience a genuine sense of presence in a virtual environment. We compared two different theories of presence, the rationalistic view and the Heideggerian view. The theory by Heidegger is better applicable to virtual worlds. There are two main reasons for this. First, it does not make a distinction between real and not real. And secondly, it focusses mainly on the occupation and fulfilment of tasks. Therefore, in the design of a virtual world, it is important that the user is occupied with engaging tasks that lead to satisfactory outcomes. The world should be designed in such a way that it is recognizable in functionality and performed tasks should have a predictable and logical outcome.

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Virtual Worlds and Positive Psychology

The road to wellbeing

Introduction
This article will further explore Positive Psychology (PP) as introduced in the previous article. Far from being the only theory on well-being, out of the options discussed so far PP has as a major advantage in that the field is very thorough in its methodology, and has already been applied to contemporary technological advancements. Having explicated PP in more detail, the article will zoom in on how the insights obtained may be put to use in an analysis of virtual worlds, through a discussion on positive technology. With this we will begin to see the potential of virtual worlds, illustrated by a number of examples. In this sense PP will serve as a bridge between the theory practices and the technologies.

Positive Psychology
The contemporary field of Positive Psychology has emerged with the work of Martin Seligman in the late 1990s. Traces of its ideas, however, may already be found among the classical Greek philosophers, and more recently in the 1950s with Abraham Maslow naming a chapter specifically “Positive psychology” [1]. Nonetheless, its modern conception came about when Seligman and Csikszentmihaly – the two leading proponents of PP – initiated a renewed interest in this direction. The major difference with earlier humanistic psychological approaches is methodological in nature: It was claimed that the humanist approaches did not accumulate enough empirical evidence, and were thus prone to severe criticism [1]. To combat this, the field of PP has been outstanding in its methodological rigor [2], largely driven by the potential controversial nature of both their studies and findings.

In contrast to traditional psychology, which looks at which dysfunctioning and how to remedy this, positive psychology aims at facilitating a happier, flourishing life, looking at human potential and virtues. Moving beyond the hedonistic-eudaimonic divide, PP combines the two strands, attributing importance to both [3], but regards eudaimonia as contributing more to overall well-being. This dynamic is found across cultures, sex, and for all adult ages. In order to measure this happiness or subjective well-being, a combination of Experience Sampling Method and self-report measures (see textbox). Because neither method is perfect, a good indication is to what degree the measures correspond to each other, and the coherent relation to other factors that are being measured. Through these techniques, a variety of conclusions are drawn that characterize positive psychology.
Experience Sampling Method (ESM) and Self-Report Measures.

The Experience Sampling Method (ESM) uses a small device that researchers give to participants. At random, pre-determined intervals the device will make a sound. When this happens, the participants fill out a questionnaire that evaluates what they are doing, how they are feeling, what they are thinking and where they are. It is used as a tool in positive psychology to measure subjective well-being in the moment [3].

Self-report measures come in many forms, but often revolve around a survey or questionnaire. There are obvious objections regarding the validity and internal consistency of such tests, but there is a consensus that when properly applied self-report measures are reliable indicators.

Studies have shown that people have a happiness set point [3], to which people generally return even after encountering an event that is regarded as ‘life changing’. For example, people who have won the lottery do not report a higher level of happiness after a couple of years [4]. Roughly 50% of factors that contribute to this resting point are genetic in nature, with the remainder being made up 40% the person’s activities, and 10% of other circumstances. Obviously not aiming to alter the genetics and having fairly little influence on other circumstances (affluence, marital status, etc.) PP focuses on a person’s activities and engagements. This has led to the identification of three categories or pillars of PP that combined facilitate the ‘good life’ [3]:

a. Positive subjective experiences (happiness, pleasure, gratification, fulfillment)
b. Positive individual traits (strengths of character, talents, interests, values)
c. Positive institutions (families, schools, businesses, communities, societies)

These categories correspond respectively to the pleasant (hedonic), engaged (eudaimonic) and meaningful (social and interpersonal) life described in the previous article. Fostering elements in these categories corresponds highly with subjective well-being, and can be said to be, together, ‘paths’ to a happier life. Interventions in PP focus on finding people’s strengths, as well as fostering engagement and meaning.

How can PP Insights Contribute to Well-being through Technology?

An important element of PP specifically for technological advancements is the concept of flow, originally coined by Csikzentmihalyi. Moments in which someone experiences this, “usually occur when a person’s body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and
worthwhile”. During flow, one can become unaware of time, hunger and possible other discomforts, and even lose the sense of self-consciousness. It is important to note that it does not matter how difficult the activity itself is objectively, but rather that the person engaged in such an activity is challenged to his or her capacity. According to [2], [C]lear goals, immediate and relevant feedback, and an appropriate and continuously adjusted balance between skill and challenge” are important elements that need to be in place for experiencing flow. It should come as no surprise then, that flow is important for the positive individual traits, eudaimonic pillar of PP.

The leap from psychological insights to Positive Technologies (PT) has already been made [6] [7], and flow is a key concept in such a framework. In [6], PT is defined as the “scientific and applied approach for improving the quality of our personal experience with the goal of increasing wellness, and generating strengths and resilience in individuals, organizations and society.” To qualify for inclusion in PT, a technology should “manipulate the quality of experience to create well-being, strength and resilience.” [6]

Virtual reality, out of the very few of a technologies capable of such, is considered to be extremely effective at precisely such a manipulation. Through Mood Induction Procedures (MIPs), virtual reality has already been shown to have an impact on two of the

**The quality of experience as a function of skill and challenge**
three pillars of PP, to wit the hedonic and the eudaimonic. On the hedonic front, researchers have been able to improve moods and help people relax through the combination of virtual worlds with MIPs. Such improved emotions also influence other elements, opening up more space for other behavioral options and the forming of habits. Virtual reality has shown to have very high efficacy in producing the desired moods. On the eudaimonic level, immersive virtual reality experiences are considered the most capable of inducing flow [7], due to its flexibility, immediate feedback, and the possibility to personalize the experience. In a properly set up virtual world, the user will feel absorbed, and display all the elements of flow previously described. It is theorized that inducing flow experiences in people, especially in applications of positive mental health, will allow them to draw upon these experiences to create new possibilities for themselves. In this sense, their resilience and self-efficacy could be greatly enhanced. In the sphere of PT, then, virtual reality occupies a unique niche.

Concluding Remarks
In this article, we have seen that with the advent of positive psychology, a whole host of new possibilities was created that exceeded the original field. Its concepts and foundation are currently taken up by researchers working in the human-computer-interaction field, with obvious and robust results. Technologies, of which virtual reality is the clearest example, are indeed capable of qualitatively altering the ‘quality of experience’ of people. With this in mind, people now have more possibilities at their disposal to fulfill their potential and stretch their feeling of well-being more easily towards the higher regions.

Sources

Images
Factors influencing chronic happiness levels: Tesseract2 - Wikimedia Commons
‘Quality of experience’: Csikszentmihalyi (1997), as found in [2], p. 233.
APPLICATIONS OF 
VIRTUAL REALITY

Therapy, Games and Parkinson’s

Virtual reality (VR) offers the opportunity to contribute to well-being in a variety of manners. Often one thinks of entertaining games, primarily played during leisure time. However, the range of possibilities with VR and games is far larger than that. For example, researchers have been entertaining thoughts to apply virtual reality techniques in combatting feelings of loneliness among elderly people (Kanayama, 2003; Siriariaya, Ang & Bobrowicz, 2014), as well keeping the senior population active through so-called exergames (Brox, Luque, Evertsen & Hernández, 2011). In practice, VR is currently being investigated to help children with cerebral palsy, aid in the physical rehabilitation of people who have suffered a stroke, and applied to reduce certain risks associated with Parkinson’s disease. This article will explore the latter three of these applications, thus focusing primarily on the physical aspect of well-being, with a focus on the medical world. Building on the previous article, which discussed the angle of positive psychology on well-being, this piece will combine the mental- with the physical aspects, highlighting the scope of VR-applications.

Virtual Reality and Physical Therapy
In October 2014, the rehabilitation center Het Roessingh in Enschede opened a new room in their facilities, called the Novalab. This room is specifically designed to supplement traditional physical therapy with virtual reality-based elements. In this manner, patients can be treated while at the same time research on the efficacy and feasibility of VR’s role in therapy is being conducted. This research has entered the next phase with the Novalab, providing a dedicated space in which VR is utilized. For the purpose of writing this article, we spoke to Ms. Anke Kottink of the Roessingh Research and Development department to get a more in-depth view of the developments surrounding virtual reality-supplemented therapy.

One of the main advantages of VR in physical therapy so far, was described by Kottink to be a higher score on the Intrinsic Motivation Inventory (IMI; see textbox). The results indicate that patients have less trouble sticking to the treatment, a key aspect in the successfulness of physical therapy. Repetition and consistent effort are both instrumental in this process, precisely two aspects that are believed to improve with the aid of VR. To illustrate this and to highlight other advantages, let us look at two examples of Kottink’s own research of how this works in practice, focusing on “upper arm function in children with Cerebral Palsy” (Winkels et al., 2013) and “reach training on
Intrinsic Motivation Inventory

The *Intrinsic Motivation Inventory* (IMI) is a measure of intrinsic motivation, which relies on self-reported values. First developed to apply to the fields of sport and exercise (Markland et al., 1997), it has gained popularity since early publications in 1989. Subsequently, the IMI has been applied in a broader context, which also modified what this measurement represents. Originally consisting of a set of 27 questions with a 7-point Likert-scale, it measured 4 dimensions:

- Perceived competence
- Interest-enjoyment
- Pressure-tension
- Effort-importance

Modifications have taken place both in the amount of questions being asked (up to 45), as in the dimensions that are being measured. Modern versions often add 2 or 3 more dimensions, to wit:

- Perceived choice
- Value/usefulness
- Felt pressure

The choice to include or exclude any given dimension depends largely on the specific research. It is important to see that strictly speaking only the “interest-enjoyment” factor directly measures the intrinsic motivation. Contemporary applications include physical therapy and a range of cognitive tasks.

arm function after stroke” (Prange et al., 2015).

---The Nintendo® Wii™ in Therapy for Children Affected by Cerebral Palsy---

Cerebral Palsy (CP) is a neurodevelopmental disorder, often beginning to become apparent in early childhood. Among other characteristics, it “is the most common cause of physical disabilities in children in Western countries” (Winkels et al., 2013). To remedy some of the motor dysfunctions, physical therapy is often prescribed for the afflicted children. Relevant aspects of this therapy are that it should be motivating, repetitive, purposeful, and task specific, as well as that it should ideally integrate playful elements. VR satisfies these conditions, and has as an added benefit that it is quite feasible to offer training in groups and at home.

To empirically study the workings of a therapy enhanced with VR, a group of children between the ages of 6 and 15 years was selected to play on the Nintendo® Wii™ for 30 minutes, twice a week. The basic idea underlying these sessions is that movements that are typically challenging for children afflicted by CP would now be executed in a radically different, more engaging context. The main of the research was both to measure the effect of this type of training on upper extremity function, as well as evaluating the user satisfaction with this intervention. The results found a general “significant increase of convenience in performance of daily activities” (Winkels et al., 2013), with the important note that this result comes from a functional scale (ABILHAND-Kids), indicated

---Kids playing Wii™ Tennis---
by the caregivers of the children. Most children also reported enthusiasm, and a willingness to play together with other children. In general, the authors conclude that VR shows promise in these types of therapies, primarily due to its stimulating and motivating nature.

--Virtual Aid and Recovery from a Stroke--
People who have survived a stroke often find themselves presented with a partial loss of motor functions (Prange et al., 2015). To alleviate these losses, rehabilitation programs tailored to relearning certain body movements may be prescribed. Currently, such programs provide individual care, with only few opportunities for group therapy. This is largely due to the large variety in severity of stroke-induced impairments, making it difficult to give patients in a group the specific attention they require. Essential elements in the therapy are intensity, level of engagement, and task-oriented exercises. Whereas conventional therapy offers this, the benefits of “target group specific-designed rehabilitation games” (Kottink et al., 2014), or virtual environments (VEs), is that they allow for a further individualization to the training environment, as well as boosting the motivation and attention of the patient. These factors combined are theorized to improve the success rate in relearning motor skills.

In practice, Kottink et al. (2014) divided a number of recovering stroke subjects in their subacute phase into two groups: one receiving conventional treatment, the other one with a supplement of rehabilitation-games. Each group received three sessions of 30 minutes each week, for a total of six weeks. The evaluated variable was the functioning of the affected side of the body, which was to be trained through goal-directed motions. This measurement was taken on three occasions: a) before the therapy began, b) after the six weeks of training and c) a month after the training had ended. The results showed that both groups had improved significantly, but that there was no significant difference between the two groups, nor were there any other specific differences found. The results on the IMI showed that motivation was slightly higher for the group receiving treatment through rehabilitation games, but the difference was not
significant. However, the authors remark that this was possible the case because both groups received an unusual amount of attention. A related study (Prange et al., 2015) has in fact found that the IMI scores can indeed increase significantly using VR, which is highly conducive to a more positive outcome. In fact, the evidence that virtual environments at this point have been able to produce the same results is a very positive sign, since this opens up a lot of future directions.

A crucial remark at this point is that even while the score on the movement test itself has not increased, this is believed to be due to the time-constraints that were in place. The setup of the research was so that it compared time-matched conventional therapy with VR-enhanced therapy. Clearly, given the motivation patients experienced using the games, it is expected that once this restriction is lifted, an actual improvement may be observed, which was also anticipated by Ms. Kottink herself. Another aspect that should be mentioned here is that the game was not very immersive, which leads to a less engaging experience. A major benefit however is that it allows people to practice more, by for example providing them with artefacts that they can use at home. In an increasingly aging population, combined with a reduction of the number of caregivers, any initiative that motivates and enables people to work on their physical health by themselves should be welcomed. Virtual environments offer this, as well as the possibility to change the current practice of individual treatment towards group-oriented sessions. Hence, the efficiency of the operation is increased without decreasing the efficiency of the treatment itself.

--Developments--

As was mentioned earlier, the type of game that is being used during therapy makes a tremendous difference with regards to its effect. While popular, commercial gaming devices are good at piquing someone’s interest, they are designed for a healthy population, and therefore miss the fine-tuning and individual settings required. Paired with the issue that funding has been limited in the early stages, this has led Roessingh Research and Development to collaborate with students to develop a game that would include such possibilities. It was found, however, that these games coming out of projects with a more restricted budget, also resulted in a lower enthusiasm, effectively negating a lot of what VR has to offer during therapy. Currently, as funding becomes slightly less of an issue, contacts with professional game developing companies are being made, which is expected to remedy these problems. In terms of research, the constraints concerning the time spent on the therapy – that were required for the proper comparison – will soon be lifted, and an increase in effectiveness and efficacy is anticipated.

**Virtual Reality and Parkinson’s Disease**

Parkinson’s disease disrupts – among other things – gait and motor functions, increasing the fall risk of the affected people. In a study that was more academic than practical in nature (Mirelman et al., 2010), the researchers set out to evaluate the effect that VR-training would have the complex deficits that are associated with increased fall risk. The intervention would take place as follows: Twenty patients would receive three sessions a week, six weeks long, totaling in 18 sessions. During these sessions, the patients would walk on a treadmill, will being shown a virtual environment containing obstacles. The task was to avoid these obstacles, sometimes while performing other tasks simultaneously, where the distance between the foot and the obstacle was one of the key measurements. The position of their feet was indicated by sensors in specifically designed shoes. The final numbers came from three measurement-points; pre-training, post-training and a follow up after four weeks
post-training.

The results were uniformly positive. Both on the obstacle-avoidance as on other cognitive tasks, the participants scored significantly higher. Patients were better able to scan the surroundings and act accordingly, and scored higher on being able to divide their attention properly. In comparison with treadmill training that did not include VR, the results were generally far more positive. The ability to stay clear of objects, divide attention, paired with better planning abilities each reduce the fall risk. This evidently points to the benefits of the inclusion of VR. An even more optimistic note is that the learned strategies seem to be translatable to other daily activities, in that way promoting a more active and self-sufficient lifestyle, with a decreased risk of falls and the associated health threats.

Concluding Remarks
In this article we have briefly discussed some of the practical applications of virtual reality on the physical well-being of people. A wide range of possibilities is being explored at the moment, while there are many more applications being researched and developed. Perhaps the most promising element is that instead of having the popularly feared alienating, ‘couch potato’ effect, virtual reality has in fact been shown to have the potential to lead to greater involvement, increased enthusiasm, and a higher success rate during therapies and interventions. Even though these applications are still in their infancy, the positive results are certainly encouraging.

Sources
Few technologies have generated more attention than Virtual reality, which promises to transport people into mystical 3-D worlds while comfortably sitting in an armchair. While this promise and fantasy has been fueled through various cinematic and literary arts, the technology itself hasn’t reached levels of mass consumption. This association with fantasy and lack of integration in general use so far has led to very little detailed attention to technology, particular its philosophical and social dimensions. Yet, exciting new applications of Virtual worlds such as aids in psychological treatment are already in use in some clinics, thus, demanding closer observation. These set of articles attempted to acquaint the reader with virtual reality and virtual worlds as well as their applications towards well-being. Besides uncovering the nuances and evolution of technology, a deeper reflection, on philosophical and social levels, was presented. This reflection is critical, not just as a scholarly exercise, but also to support better design of technology and its introduction to society, which the University of Twente also aims to do through its philosophy of High Tech, Human Touch.

The initial set of articles took the readers through the doors of the technology itself, developing a better appreciation of what virtual reality and virtual worlds entail, and how they have evolved over time. This overview leads to various philosophical questions about technology particularly those relating to user experience and its authenticity. The next set of articles, thus, explicated philosophical analysis of these essential themes. By addressing through multiple approaches within the discipline of philosophy, namely classical, phenomenological and post-phenomenological, it was hoped that the reader will not only develop a better understanding of technology but also of the role of philosophy as well as its academic process.

Having developed a clear picture of the technology and its philosophical nuances, the path to the overarching theme of this set of articles, namely role of virtual worlds in well-being was ready. To elucidate how this role can be fulfilled, the reader was made familiar with the VIEWW project, currently part of the largest ICT project in Netherlands, aimed at improving the quality of virtual worlds with the particular goal of enhancing well-being through them. Another important objective of a look into this research was to throw light on practical challenges encountered in technical research, such as those related to finances, collaboration and social compatibility.

Technical research, however, can take ‘well-being’ for granted. In the subsequent article, a more discerning rumination of the concept of well-being as approached in philosophy and psychology was propounded. The latter subject opened the space up for positive psychology, a rather nascent discipline within psychology that employs scientific understanding and intervention to help in pursuit of a fulfilled life. The next focal point was to connect the insights of positive psychology with technology and its potential to bring about the aim of positive psychology. With these theoretical foundations in place, the final frontier was to illuminate how virtual reality and associated technologies are being employed in providing a better life through their use in treatments for cerebral palsy, stroke-recovery, and reducing the fall-risk in people suffering from Alzheimers. This final article is a fitting end to the theme, exhibiting that virtual reality’s contribution to well-being is not just an optimistic fantasy, but already a reality, ascending to greater frontiers.
INTRODUCTION

We are four students of Philosophy of Science, Technology and Society at Twente University. All with different backgrounds. Both Harm Bult and Jan-Yme de Boer have a background in medical technology. Harm has a degree in technical medicine and Jan-Yme in biomedical engineering. Verna Jans studied philosophy in Nijmegen and Iris Huis in ’t Veld has a background in social science because of her degree in communication science. With these different experiences we were able to learn a lot from each other and to lift our work to a higher level.

Before you lies our part of the TechnoLab magazine on which we have gladly worked for the past half year. We wanted to describe a technology we all wanted to explore in depth: technologically, biologically, socially and philosophically. We explored a research project, that had received some media coverage a couple of years ago, and which we were all passionate about: the fertility chip from the BIOS lab-on-a-chip group at Twente University. At the time the media had broadcasted it as a quick and accurate home testing application that should allow men to test their semen in the safety of their homes. A technology that made us wonder how it works, what ‘a chip’ is, how to understand fertility and ultimately where the technology currently stands and whether we had missed the bright future the media implied or that the reality of science is slightly more complicated than the media anticipated.

The sperm chip fits nicely into the overarching theme of well-being because conceiving a child has a positive influence on subjective well-being and is of fundamental importance to our human existence (Kohler, Behrman & Skythte, 2005). However, conceiving children is not without problems: about one out of six couples visits the hospital’s fertility department due to problems with getting pregnant. Though none of us has gone through that, we can imagine it to be a very stressful situation full of waiting and uncertainty. A technology that should be able to deliver fast and objective results, and is supposed to benefit the effectiveness of fertility therapy has a very evident position in this specific area of well-being by alleviating the burden on want-to-be parents and increasing the chances of conception.

As we dug deeper into the subject and explored the width of fertility and science, we found a lot of questions that intersected with our investigations of the sperm-chip, to which the answers quite often surprised us. Do we have a basic right to pro-create? Is artificial female-sperm desirable? How does the process from societal problem to scientific idea work and how can that idea become a product? Does the fertility chip fit in the current trend of self-quantification? How come science is so unpredictable and how does the fertility chip fit in with other nanotechnology projects?

We want to thank dr. Segerink, Bram de Moor, Ron Winkler, and Mieke Boon for the time they made available helping us through the process and providing us the answers we needed. We learned a lot from them and we sincerely hope they value our contributions as PSTS students.

Enjoy!

The team,
Jan-Yme de Boer, Harm Bult, Verna Jans & Iris Huis in ‘t Veld

Sources
Fertilization is the epic story of a single sperm facing incredible odds to unite with an egg and form human life. It is literally the story of our lives. Before we can introduce lab-on-a-chip technology to test fertility, the process of fertilization will be explained. What is fertilization and how does it work? What is infertility, when is someone considered infertile and how can one influence it?

**Fertilization: the birds and the bees**
The process starts with sexual intercourse. Sexual intercourse is the insertion of a male's erect penis into a female's vagina for the purposes of sexual pleasure or in this case reproduction. Male orgasm usually includes ejaculation, a series of muscular contractions that deliver semen containing male gametes known as sperm cells or spermatozoa from the penis into the vagina. With this ejaculation about three hundred million sperm cells enter the vagina. A part of it flows out of the vagina or dies in its environment but also many survive because of the protective fluids surrounding them.

First the sperm must pass through the cervix, an opening in the uterus. Most of the time the cervix is tightly closed but during the female ovulation, the cervix is open for a couple of days. Once inside the cervix the sperm swims to the uterus. Though millions will die trying, there is still a group that continues the journey. When the sperm is inside the uterus, muscular contractions help the sperm move to the egg. Resident cells from the immune system of the woman mistake the sperm for invaders and kill thousands more of them. After that half of the sperm enters the empty tube and the other half enters the tube with the unfertilized egg. Only a few thousand remain. Inside the fallopian tube, which is the tube with the unfertilized egg, the tubal fluid flows against the action of the cilia which want to push the sperm into the direction of the egg. The sperm has to swim against this motion of the tubal fluid which is a difficult task. Here still some sperms die mostly because they get stuck in the ciliae. The sperms that made it this far now get their heads covered in chemicals that cause them to change: the sperm becomes hyperactive so that it can swim harder and faster to reach its destination. And then finally, the sperm reach the egg.

The egg is covered with cells called the corona radiata and the sperm must push through this layer to reach the outer layer of the egg: the zona pellucida. When sperm reach the zona pellucida they attach specialized sperm receptors on the surface which triggers their
acrosomes to release special enzymes enabling the sperm to enter the layer. Inside the zona pellucida is a narrow fluid filled space just outside the eggcell membrane. The first sperm to make contact will fertilize the egg. This single egg attaches to the eggcell membrane. Within seconds their outer membranes fuse and the egg pulls the sperm inside. This event causes changes in the egg membrane that prevents other sperm from attaching too. Next, the egg releases chemicals that cause the other sperm to go away from the egg. As the reaction spreads outward the zona pellucida hardens. Outside the egg sperm are no longer able to attach the zona pellucida. Meanwhile, inside the egg the tightly packed male material spreads out. A new membrane forms around the genetic material creating the male pronucleus. Inside, the genetic material will reform into 23 chromosomes. The female genetic material, awakened by the fusion of the sperm with the egg, finishes dividing, which results in the female pronucleus which also contains 23 chromosomes. When the male and female pronuclea are formed, they are pulled together. The two sets of chromosomes join together completing the process of fertilization. At this moment a unique genetic code arises, instantly determining gender, eye color, hair color and hundreds of other characteristics. This new single cell, called the zygote, is the beginning of a new human life. Now the cilia in the fallopian tube gently sweep the zygote toward the uterus where he or she will implant, grow and mature for the next nine months until ready for birth (Wassarman, 1987).

Infertility
The process of fertilization is very complex. There are a lot of points where the sperm have to struggle and are not able to continue the journey. As you may imagine, there is chance of the sperm not making it to the egg at all with as a result that a couple is unable to conceive. One is considered infertile when after a year of trying, conceiving still did not work. But not only the sperm struggle, the female anatomy can also be the cause of the inability to conceive. So both the male and the female can be infertile. The causes of infertility can lie in both sexes. About 40% of the issues involved with infertility are due to the man, another 40% due to the woman, and 20% is due to complications with both partners.

What does it mean when someone is infertile? The World Health Organization defines infertility as follows (WHO, 2015):

“For a woman, infertility (or a state of subfertility) can manifest itself as either: the inability to become pregnant, an inability to maintain a pregnancy or an inability to carry a pregnancy to a live birth. When men and women attempt to have a child or to expand their family, the causes and the difficulties encountered can be complex. Many simple, as well as more complex medical interventions can be attempted to help a couple or an individual to reach a state of pregnancy or to be able to maintain a pregnancy which results in a live birth.”

What are the causes of these inabilities to become pregnant and how can they the chances of conceiving be increased? In the next part cause for both female and male infertility will be briefly explained and this article will finish by explaining risk factors in for example lifestyle to consider when wanting to conceive.

Female infertility
Female infertility can be caused by a number of factors, including the following:

- **Damage to fallopian tubes.** Damage to the fallopian tubes can prevent contact between the egg and sperm. Infections and pelvic surgeries could have caused scar formation and fallopian tube damage.

- **Hormonal causes.** Some women have problems with ovulation. Synchronized hormonal changes leading to the release of an egg from the ovary and the thickening of the lining of the uterus in preparation for the fertilized egg do not manifest.

- **Cervical causes.** Some women have a cervical condition in which the sperm cannot pass through
the cervical canal.

- **Uterine causes.** Abnormal anatomy of the uterus, the presence of polyps for example.
- **Unexplained infertility.** The cause of infertility in approximately 20% of couples will not be determined using the currently available methods of investigation.

### Male infertility

Male infertility is mostly due to the following problems:

- **Low sperm count (concentration).** The man ejaculates a lower number of sperm, compared to other men. Sperm concentration should be 20 million sperm per milliliter of semen. If the count is under 10 million there is a low sperm concentration (subfertility).
- **Low sperm mobility (motility).** The sperm cannot "swim" as well as it should.
- **Abnormal sperm (morphology).** Perhaps the sperm has an unusual shape, making it more difficult to move and fertilize an egg.
- **No sperm.** When the man ejaculates there is no sperm in the semen.

### Risk factors of infertility

There are some factors that influence fertility. If one wants to prevent the risk of infertility, the following factors can be considered:

- **Age.** A woman's fertility starts to drop after she is about 32 years old, and continues doing so. A 50-year-old man is usually less fertile than a man in his 20s (male fertility progressively drops after the age of 40).
- **Smoking.** Smoking significantly increases the risk of infertility in both men and women.
- **Alcohol consumption.** A woman's pregnancy can be affected by any amount of alcohol consumption. Alcohol abuse may lower male fertility. Moderate alcohol consumption has not been shown to lower fertility in most men, but is thought to lower fertility in men who already have a low sperm count.
- **Being obese or overweight.** In industrialized countries overweight/obesity and a sedentary lifestyle are often found to be the principal causes of female infertility. An overweight man has a higher risk of having abnormal sperm.
- **Eating habits.** If you are a strict vegan you must make sure your intake of iron, folic acid, zinc and vitamin B-12 are adequate, otherwise your fertility may become affected. Also, women who become seriously underweight as a result of an eating disorder may have fertility problems.
- **Over-exercising or not exercising.** A woman who exercises for more than seven hours each week may have ovulation problems. But also leading an inactive life is sometimes linked to lower fertility in both men and women.
- **Sexually transmitted infections (STIs).** Chlamydia can damage the fallopian tubes, as well as damaging the man's scrotum. Some other STIs may also cause infertility.
- **Exposure to some chemicals.** Some pesticides, herbicides, metals and solvents have been linked to fertility problems for both men and women.
- **Mental stress.** Studies indicate that female ovulation and sperm production may be affected by mental stress. If at least one partner is stressed it is possible that the frequency of sexual intercourse is less, resulting in a lower chance of conception.

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**Sources**


Mom and Dad Combined

To know about fertilization, it is important to know something about what happens at the level of DNA. In the semen article the technical details of semen are described and there is some introduction to the fertilization process. Both the sperm cell and the egg cell are carriers of DNA. In this article DNA is described, to learn what Segerink is doing right now.

First I am going to introduce the genome, then some examples of what the genome programs for: proteins. After that I will explain genetics and the plans that the Lab-on-a-Chip group has right now with testing the sperm cells for with DNA.

The genome
The two cells combine their DNA contents into a new cell nucleus. The nucleus is the place in the cell in which all the genetic material is being kept. The name for all the genetic material is the genome.

The genome is the part of the cell that contains the instructions for how to function. You can think of it like a blueprint for a building or a source code for a computer program. It is not the cell, itself, but it instructs the cell how to function. The functioning of a cell works via proteins for most of the functions. Proteins do certain things, they are the building blocks or “machines” that do the tasks that are instructed in the genome. Proteins also control the gene expression by attaching to the genome.

In the genome, the cell is instructed. These instructions are sequences of four types of molecules: Guanine (G), Cytosine (C), Adenine (A) and Thymine (T) (Alberts et al., 2014) (p.177). Different combinations of these molecules form the “words” that instructs the cell to build the building blocks, these “words” are called genes. Genes translate into the building blocks, the proteins. A small part of a gene could be for instance -ATGCATCCTGATGGAGTCCTG-. These instructions are being “read” by certain proteins and copied. These copies are then being sent out of the cell nucleus, into the main proportion of the cell, and there being translated into proteins.

Proteins
Proteins do a lot of functions for a cell. In this part, three examples are given to get to know the concept of proteins. Collagen is for instance a very well known protein. This type of protein forms the building block for the world outside of the cell. They give the body shape and bind all the cells together into tissues and organs. Skin contains large amounts of collagen, but
also bones, teeth, tendons and cartilage. Almost every tissue in the body needs some amount of collagen (p.688).

Another very known protein is insulin. That protein is a hormone that regulates the blood sugar levels in the body. When somebody has diabetes, the working of that protein is less, resulting in several health issues (p.526).

Lastly, a more “machine” like group of proteins: enzymes. Enzymes are proteins that catalyze chemical processes. That means that they support or make it easier for chemical processes to happen. A very well known enzyme is amylase. Amylase helps to break down starch (zetmeel), into smaller sugars (p.122).

Genetics
Now we know how the genome works: the blueprint for proteins, we can go to how the genome is built up. Genes are located on chromosomes. The genome is built up from 23 pairs of chromosomes. That means that you have 46 chromosomes in total. 23 chromosomes are coming from the mom, they stay in the egg cell, and 23 chromosomes are coming from the dad. That means that each parent is contributor for half of the genome. When the egg and sperm cells are formed, they have only one chromosome of each pair. Cells with only one pair are called haploid. In humans, only egg and sperm cells are haploid. When they combine, they form a diploid cell. Below is an image of the karyotype of a man: the overview of the chromosomes.

In diploid cells, you have 23 pairs of chromosomes. As said earlier, the chromosomes are the carrier of the pair of each gene. Most of the time, one gene is dominant over the other gene. The other gene is called recessive.

**DNA in diagnostics for inheritable diseases**
Some diseases are transferred through DNA. That means that it can be seen in the DNA that offspring has such a disease. When the diagnosis takes place before birth, it is called prenatal screening. Before prenatal screening became possible, only after childbirth the parents could know that a child would be a bearer of disease. Right now we are becoming more and more able to detect diseases earlier using several methods. One of them is genetic prenatal screening. In genetic prenatal screening a small amount of the genetic data of the fetus is retrieved and tested for a given disease, for instance amniocentesis (“Prenatal diagnosis,” n.d.). In amniocentesis, a small amount of amniotic fluid is taken to get the genetic data. When a fetus has been diagnosed with a genetic disease, the parents can prepare for getting an affected child or choose to get an abortion.

Right now, there is a lot of controversy on a more recently developed possibility in the Netherlands (“Dossier Pre-implantatie Genetische Diagnostiek,” n.d.). The possibility of diagnosing genetic diseases before the embryo is inserted into the body in in vitro fertilization. This technology is called pre-implantation genetic diagnosis, or PGD. In PGD, at the third day after in vitro fertilization (but before implantation in the body), one or two cells of several fertilized embryos are taken and tested for a genetic disease. The cells that are being tested die during the testing, because it is an invasive test. Only the embryo without the inheritable disease is then being implanted in the body. That means that the child will not have the disease.

The controversy was about the possibility that parents could get designer babies, babies that have certain properties the parents want. However, right now this is not possible, because it is only possible to test for one specific disease, for instance inheritable breast cancer.
Segerink's research
There are still a lot of unknowns about the fertility of sperm cells. The karyotype (chromosome) level is still the golden standard (Matzuk & Lamb, 2008). However, testing for genetic defects is not enough if you are infertile. Loes Segerink is working on a chip that goes beyond PGD (de Wagenaar et al., 2015). This new chip tests individual sperm cells before they are used for in vitro fertilization. The chip consists of two main channels. In which between small micrometer wide channels are placed. When sperm is put in one of the main channels, a pressure difference is applied. In the micrometer wide channels, the sperm cells then become individually trapped. A non-invasive diagnosis can be done to that trapped cell. If they do an invasive diagnosis, the cell becomes damaged, and is not viable anymore for in vitro fertilization. Right now they are researching on how to do the diagnosis. In the end, they hope that it can be possible to first select a viable cell for in vitro fertilization.

Conclusion
DNA is the code in which is described how the cell works. On strands of DNA genes are located, which are “words” for proteins, which are the molecules that perform functions. Some genes are expressed, while other are not expressed, because genes always come in pairs on chromosomes. An expressed gene is called dominant; an unexpressed gene is called recessive. It is becoming possible to test earlier in the birth process to test children for inheritable diseases. This is very controversial. Loes Segerink is researching right now on sperm cells to test them on DNA defects before they fertilize egg cells.

Eye color example: how dominant and recessive genes work.

A nice example of how the dominant/recessive principle works is the eye color. The gene for a blue eye color is recessive, while the brown eye gene is dominant. When a woman has brown eyes, and has two brown eye genes she will have a Brown-Brown gene combination. If she wants to have children with a blue eyed man: Blue-Blue, one gene of both the parents will be given to the child. Lets assume they get a daughter. The daughter will have Brown-Blue genes, which means that she will have brown eyes, because the brown gene is dominant. When the daughter gets in its turn children with another blue eyed man (Blue-Blue), there will be a 50 percent chance that their child will have blue eyes. The child will get a blue eye gene from the dad for sure, but from the mother it will get either the brown eye gene (Brown-Blue), or the blue eye gene (Blue-Blue).

Sources
Before we can talk about semen testing, or male fertility, we first need to get to the core. We need to get to the beginning of the whole story. This story begins with semen. So what is semen exactly? Firstly, it will be explained what semen consists of. After that it will be explained what sperm cells are. Finally the normalities and abnormalities of semen and its cells will be elaborated in a conclusion related to the fertility test of Loes Segerink.

Semen

The term semen refers to the male reproductive cells and is derived from the Greek word “sperma” which means “seed”. It is developed in the testicles and is released from the penis. The process that results in the discharge of semen is called ejaculation. During the process of ejaculation, sperm containing the semen passes through the ejaculatory glands and mixes with fluids from the seminal vesicles, the prostate, and the bulbourethral glands to form the ejaculate. The seminal vesicles produces a yellowish viscous fluid rich in fructose and other substances that makes up about 70% of human semen. The prostatic secretion, influenced by dihydrotestosterone, is a whitish, thin fluid containing proteolytic enzymes, citric acid, acid phosphatase and lipids (Mann, 1954). The bulbourethral glands secrete a clear secretion into the lumen of the urethra to lubricate it.
Sperm cells
A gamete is a cell that fuses with a cell from the other sex during fertilization in organisms that sexually reproduce. A sperm cell is a ‘male’ gamete and is smaller than the female one; the egg cell. A uniflagellar sperm cell (a sperm cell with a tail) that is motile is referred to as a spermatozoon. A motile sperm cell is able to move because of its lashing tail. In contrary, a sperm cell that can’t move, a non-motile sperm cell, is referred to as a spermatium (Ishijima et. al, 1986). The sperm cells are carried in semen. In humans, seminal fluid also contains several components besides spermatozoa such as enzymes and fructose that promote the survival of spermatozoa and provide a medium through which they can move or discharge may contain more than 250 million spermatozoa.

"Abnormal results could indicate infertility, but also infection, hormonal imbalance, diabetes, gene defects or exposure to radiation."

"Swim". A mature sperm cell is microscopic in size; about 50 μm (micrometer) long. Human sperm cells consist of a flat, disc shaped head and a long tail. Because of this tail, it can move itself forward at about 3mm per minute by making vigorous lashing movements with it. Semen do not reach full motility until they reach the vagina where its alkaline pH is neutralized by acidic vaginal fluids. This gradual process takes 20 to 30 minutes. From this point the journey to the egg cell and further fertilization begins (Smith, 2009). This process is described in a previous article.

Spermatozoa are produced in the seminiferous tubules, which are located in the testes. It develops through different stages. Firstly it is a spermatogonium, than a spermatocyte, after that a spermatid and finally a spermazoon. When mature, the spermatozoa are carried in semen. When a man and a women have sexual intercourse, the semen is discharged during the male orgasm into the vagina of the female. A single spermatozoa are the part of the semen that is generative. This implies that they can cause fertilization of the female ovum. Once it leaves the male body the sperm is vulnerable and it may die. This would decrease the total sperm quality. Therefore, spermatozoa will only survive in warm environments. Sperm cells come in two types; "female" and "male". Sperm cells that give rise to female (XX) offspring after fertilization differ in that they carry an X-chromosome, while sperm cells that give rise to male (XY) offspring carry a Y-chromosome. Because an egg cell is female (XX) and therefore it contains always a X chromosome, it depends on the sex of the spermatozoa what the sex of the child will be when reproducing. In other words, Spermatozoa can pass either an Y or a X chromosome, whereas an egg cell can only pass a X chromosome.

Sperm cells cannot divide and have a limited life span, but after fusion with egg cells during fertilization, a new organism begins developing, starting as a zygote. A zygote is a single cell, with a complete set of chromosomes, that normally develops into an embryo. The human sperm cell is haploid, which means that it has a single set of chromosomes. Its 23 chromosomes can join the 23 chromosomes of the female egg to form a diploid cell. Diploid cells have two homologous copies of each chromosome. This means that a diploid cell contains two sets of chromosomes that are identical to each other.
Normalities and abnormalities
Because this article is connected to the lab-on-a-chip fertility test of Segerink, we conclude with some normalities and abnormalities of semen. Semen which we consider normal and should have no problem with fertilizing a woman has an acidity (pH grade) between 7.2 and 7.8. It has a greater volume than 2 millimeters and looks whitish to gray opalescent. More than 50 percent of spermatozoa are shaped normally and more than 50 percent move normally. It’s smooth and watery and counts 20 to 100 million semen cells.

When a man is tested on fertility, there are three standard criteria used in medicine. Sperm could have trouble to reach and penetrate eggs, which makes conception very difficult. It is therefore not strange that motility is one of the measurements of fertility. This is the first criteria that is often used in medicine to investigate semen. Another sign of infertility is often found in the concentration of semen. The less sperm cells semen contains, the harder it gets to fertilize a women. The last criteria of sperm which is often used is morphology. A deviation is the shape of the sperm cell could also indicate infertility. When semen gets tested, for instance by the sperm chip of Segerink, and the results turn out to be abnormal, the doctor mostly suggests that you take some additional tests. For instance genetic tests, hormone testing or taking a tissue sample from your testicles. Abnormal results could indicate infertility, but could also indicate infection, hormonal imbalance, diseases such as diabetes, gene defects or exposure to radiation. The sperm chip of Segerink is only part of the beginning of tests. And it all begins with semen.

Sources


Shrinking laboratories and costs

Over the past years, global medical expense have increased and in many countries. This has placed increasing pressure on society and the Netherlands is no exception. It has frequently sparked the debate about health care expenses and budget cuts, but also the search for more affordable alternatives to traditional parts of health care. One cost-intensive part of modern medicine is the performing of lab tests. Lab tests often require specialised personnel and laboratories that both come at considerable price and subsequently put pressure on the funding and the availability. A very promising solution to this problem is to create miniature labs on chips that perform measurements autonomously and require a minimal amount of skill and knowledge to operate.

Lab-on-a-chip
It is not hard to guess what a lab-on-a-chip is; you will probably assume that it is a very small laboratory on a chip. And you are right. Though you might not have a clear idea of what sort of laboratory operations it performs, and might think a bit too much along the lines of a computer chip, you are right to assume that it performs it's measurements automatically, like a computer chip does it’s things without you needing to understand what it does.

Roughly sketched, there are three parts in every lab-on-a-chip, the fact that these steps are performed by the chip and its connected computers itself, makes it very uncomplicated to use and often only requires someone to supply the sample and place the chip in some sort of measuring device. The technology does the rest.

The first part is to ‘handle’ the sample; this means that it is the chip’s task, for example, to contain it, to transport it, to filter it, to mix it with other fluids, or to make tiny droplets of the sample. This handling is necessary in order to present the sample to the ‘sensor’ in the right way. The second part is the sensor that analyses the sample and produces data about it. Without interpretation that data is quite meaningless, which requires the third step to be ‘interpretation’ of the data, which is where algorithms deduce the relevant clinical data and eventually tell the, for example, healthcare practitioner what he wants to know about the sample.

Because of this three-step system, and the fact that one type of sensing technology can be applied to a very wide variety of samples,, the number of potential applications for medical lab-on-a-chips is continuously expanding. Take for example Raman spectroscopy, a very promising and popular...
technology ("Raman Spectroscopy," n.d.). Just to give an impression, it can be used to detect lung cancer in saliva (Li, Yang, & Lin, 2012), drug use in urine (Dong, Weng, Yang, & Liu, 2015), hepatitis in blood (Kamińska et al., 2015), sweat for forensic purposes (Sikirzytski, Sikirzytskaya, & Lednev, 2012), arthritis in synovial fluid from the joints (Esmonde-White et al., 2010); and as will be discussed later, can of course also be used on semen for assessment of the intactness of the DNA.

**Microfluidics**

Lab-on-a-chips very often work on the basis of handling and analysing fluids or gasses instead of solid samples. Because of the micro scale of the chips and the subsequent micro scale of the fluid samples these chips and the internal workings are referred to as ‘micro fluidics’. Because so many lab-on-a-chips use microfluidics, it is interesting to take a quick look into the origins of it, and the underlying advantages.

Microfluidics became possible short after the emergence of micro technology halfway the 1950’s because the emerging micro technology made the necessary tools and techniques available. Micro technology was predominantly busy creating computer chips and circuits and made microfluidics possible because the micro technology scientists used a method that later allowed the microfluidic research to create it’s necessary channels. The micro technologist’s method consisted of carving very small grooves into thin slices of semiconductor material, called a wafer, with which they created electrical chips, a method called etching ("Wafer", n.d.). As the etching technologies became better and better, it became possible to etch not just electrical circuits into the wafer, but also create more complex three-dimensional structures that made it possible to make very small fluid channels, and quite some science later, micro pumps for creating micro flows, flow sensors for measuring flow rates and strategies for handling fluids such as mixing and separating flows and creating droplets ("Microfluidics," n.d.; Teh, Lin, Hung, & Lee, 2008).

The advantage of microfluidics as a foundation for a lab-on-a-chip system is that, because of the very small diameter of the channels, the size of the fluid sample can be very small. Apart from the stable nature of a microfluidic environment the small size of the channels cause the flows within the channels under most ‘normal’ circumstances to be laminar instead of turbulent. This means that the fluid flows in straight lines instead of uncontrollably constantly mixing itself. Subsequently fluid behaviour becomes very predictable and controllable, which is a big advantage for a controlled experiment or measurement.

**The Pioneer of Labs-on-chips**

In order to give an example of a lab-on-a-chip application that might clarify what it can be, it is interesting to look at one of the very first lab-on-a-chips ever. This system both provides an example of how a complete lab-on-a-chip system works, on what mechanisms it is based, and clearly shows the three different parts of lab-on-a-chips.

![A schematic impression of Goldsteins gas-chromatograph.](image)
The first lab-on-a-chip that was published, was a miniaturised gas-chromatograph (GC) (Goldstein et al., 1979). Gas chromatography is a chemical analysis method that can identify the different constituents of a blend of gases. The following section will explain how Goldstein managed to fit an machine that usually box-sized onto a flat chip of several inches (admittedly without all the supporting and necessary hardware).

The chip was quite simple and consisted of nothing more than a spiral-shaped channel in a glass slide. Taking a regular wafer, which were being used in microelectronics, and etching out a spiraling groove into the wafer creating the channel. Then they took a slice of Pyrex glass and simply fused it on top of the wafer, turning the groove into a channel. They connected valves to the start and the end of the spiral that allowed them to provide the chip with a sample and a carrier gas, and collect them again afterwards for analysis.

The working principle of the chromatograph is quite simple as well. A very small sample volume of gas (nano liters) is let in through the valve just past the starting point of the column. In the starting point of the column a known type of ‘carrier’ gas flows into the column with a known flow rate. This carrier gas carries the sample through the column to the end of the column where it flows through an analysis set-up.

The walls of the column are coated with a very thin layer of a liquid substance that is called the ‘stationary phase’. The particles in the gas all have a different volatility, which is a different tendency to be absorbed and rejected by the stationary phase (“Gas Chromatography,” n.d.). The more volatile a gas is, the more easily its particles are absorbed and the longer they stay absorbed.

Because of the carrier gas, all the gas particles are carried through the column equally fast. However, because all gasses have slightly different volatilities, there are differences in the amount of time their particles are stranded in the stationary layer. Based on the consequent differences in average velocity, the different gases will come out of the column separate of the other gases. The lower their volatilities, the sooner they come out, the higher their volatilities the later they come out. This is how this system handles and manipulates the sample.

The separated gases are at the outlet of the column identified and quantified by a sensor that measures the thermal conductivity of the exiting gases, a property that is unique for every different gas and can be determined as the gas flows past. This is the sensing part.

The interpretation of the data encompasses retrieving how long the different gases flowed past the sensor in order to determine how much of a gas was present in the sample compared to the other gasses.

Cost Reduction

The range of possibilities is not the only reason for the sudden interest in lab-on-a-chip technologies. An important factor stimulating the development of clinical lab-on-a-chips, as was already mentioned in the introduction, is the potential it has to save money by reducing the costs of analysis. There are a number of scenarios and ways in which lab-on-a-chip applications in healthcare are argued to save costs in the process of healthcare.

First of all, many current medical lab tests depend on a chemical reaction between a reagent and a sample bodily fluid, such as blood. These reagents are quite expensive and the larger the fluid sample, the more reagent is needed and thus the more expensive it is. Lab-on-a-chips generally use samples that are easily a 1000 or 10,000 times smaller than traditional analysis systems, very significantly reducing the amount of reagent used (Figeys & Pinto, 2000).

Furthermore, there are currently quite some forms of medical analysis performed that require the doctor or analyst to actively perform measurements on samples. A good example of this is the current method of diagnosing gout where the rheumatologist himself needs to search for shimmering crystals in joint fluid under a microscope (“Gout,” n.d.; Jansen, 2009).
This can take more than 15 minutes, and does not even detect all kinds of arthritis. More or less the same situation applies to fertility research in which clinical analysts count and judge sperm cells ‘by hand’.

Because lab-on-a-chips are often quantitative and objective, the chances of misdiagnosis by human failure significantly decreases. If such a technology would be very stable and reliable, it could prevent mistreatment, in which a patient receives the wrong kind of therapy, which is often a very costly affair and often deteriorates the patient’s situation.

A general rule is that the more trained personnel are, the more expensive they are to maintain. Because lab-on-a-chips are generally aimed specifically to not require great skill and training, analysis can be performed by people that are less trained in a clinical discipline, which should reduce the price of analysis.

Expanding lab-on-a-chip
Goldstein and his team showed that their design, but most of all their idea of a lab on a chip, worked. Since then it has inspired other research departments to start developing lab-on-a-chips for a variety of applications and it has remained a promising field of research. The applications almost seem unlimited and it has the potential to reduce costs, not just in healthcare but in many lab-testing environments. But even though the promises lab-on-a-chip technologies seem to make, there still are quite some obstacles along the way. It are not just the technical challenges that thus far keep the number of clinically applied technologies very limited, also the fact that they do not always easily fit into the existing diagnostic infrastructure.

Scientists generally prefer to speak of those obstacles as challenges and further on in this magazine, in the article ‘From societal problem to scientific idea’, we will dive deeper into those challenges surrounding creating clinical lab-on-a-chip technologies, by talking to dr. Segerink, an expert and a pioneer in the field of lab-on-a-chip semen analysis at the University of Twente.

Sources
An interview with Loes Segerink

Over the past few years the political and societal demand for knowledge valorisation in The Netherlands has increased. Valorisation has been considered to be so important that, about ten years ago, it has been added as a university’s primary task alongside teaching and research. How valorisation should be defined, and how it should be assessed remains rather vague and widely debated, but the general purpose is for academia to produce valuable knowledge, both economic and societal, that should yield its result relatively quickly.

Valorisation requires knowledge and how science creates that necessary knowledge may easily be overlooked when demanding more valorisation. So what role does valorisation play in actual scientific practice? Where do you find your questions? How do you answer them? And how do you make sure they are valuable? In order to give a general impression of the scientific practice of valorisation, we met with dr. Loes Segerink. Dr. Segerink works as an assistant professor for the BIOS lab-on-a-chip group at the University of Twente, is an expert on microfluidic lab-on-a-chip technologies which she successfully applies to challenges surrounding fertility; work that has repeatedly reached the news and secured quite some research funds for her.

Starting in science
Dr. Segerink started working on the Lab-On-A-Chip semen analysis in 2007 simply because it was part of the existing promotion project she was hired to work on. “I was hired as an AIO on the existing project, that is something you can simply apply for. You can either be fortunate or unfortunate and be hired or be turned away. In my case I was hired, that determines what you will be working on for four years.”

The project dr. Segerink worked on, aimed to develop a more quantified approach to fertility assessment. Though the goals of the PhD project were clear from the start, “I received a lot of freedom from my supervisor, so I first tried to figure out what actually was the problem. Why did they come up with the plan to develop such a fertility chip?”

She figured this out by interviewing people that were
part of the apparent problem, such as the people in the hospitals, the people that are part of the daily routine of the problem. “They just said that the problem currently is that we can’t give patients the right treatment because we don’t really know what is the real problem is. Trying to create insight in what those problems are is actually the real goal. The problem partially exists because the diagnostic options are not good enough, but also partly because one does not know where to look, which makes it impossible to provide adequate and adapted therapy to those patients.” “We decided to improve the analysis of sperm cells in order to produce outcome-values that can actually be used in order to shape therapeutic strategies.”

Segerink aimed to create an on-chip quantification method of the traditional parameters that are normally checked as part of male fertility diagnosis in the hospital: The concentration of sperm cells in the semen and the motility of the sperm cells.

A few years into Segerink’s research project she successfully submitted a paper that was published in the scientific journal Lab on a Chip in 2010. The article described an innovative lab-on-a-chip method, she had developed, of quantifying the first traditional parameter: The concentration of sperm cells in semen (Segerink, 2010).

The sperm chip, a result of science.
The chip dr. Segerink developed, and eventually successfully patented was capable of determining the concentration of sperm cells in a human semen sample (Segerink, Sprenkels, Den Albert Berg, & Bomer, 2013). The chip consists of a narrow fluid channel that connects an input and an output reservoir. Halfway the capillary it has two electrodes measuring the electric impedance inside the fluid channel.

Electric impedance is the amount of resistance an electric current experiences when it tries to flow through something. However complicated or too simple this may sound to you, it should simply be understood as a property of the contents of the capillary within the measured area. Just as you can use colour as a property to distinguish between many of the different fruits that you can buy in the supermarket, the sperm chip uses the property of electric impedance to make a distinction between the different types of cells and proteins within the semen that flow through the electrode area one after the other. Dr. Segerink shows in her paper that by measuring the electric impedance of the semen that flowed past the electrodes, individual sperm cells could indeed be discerned from the other constituents in the semen. This was of great importance because this is necessary for counting the sperm cells. But just counting the sperm cells is not enough for knowing the concentration; you also need to know how much semen has flowed past.

The fluid channel in the chip is in fact so narrow that it exerts ‘capillary forces’, that causes the semen to flow from the input to the output automatically. For a lab-on-a-chip disposable chip this is a brilliant principle because it requires no complicated mechanical or electrical components in order to make the semen flow, which makes it both very dependable and cheap. However favorable these advantages are, it comes at a price: It does, because the whole mechanism works automatically and simply because of its geometry, not allow the flow to be actively controlled. That you have no control does not only mean that you cannot control whether it flows or not, but also that you cannot control how fast the semen will flow through it. Especially because of this second limitation you do not automatically know how much semen flows through the capillary. This was a technological hurdle because, as was mentioned earlier, this information is necessary in order to calculate the concentration of sperm cells in the semen sample.

She solved this puzzle quite elegantly by mixing a known amount of very small polystyrene beads into a known volume of semen, creating a sample with a known concentration of beads. Because the polystyrene beads have a much higher electric impedance than the sperm cells they result in a different impedance signal that allowed her to distinguish the sperm cells from the beads and count them separately. Because the concentration of the
beads in the semen sample was known, counting the beads as they flowed past, made that she knew how much fluid flowed past. This was precisely what she needed to know, allowing her to actually measure the concentration of sperm cells in a sample of semen (Segerink, 2010).

Though the research was interpreted by some media as having created a home testing application that would allow couples to test sperm in the safety of their homes, saving them a trip to the hospital for more expensive and slightly embarrassing semen analysis, the university’s media department concluded their press release by quoting Dr. Segerink that this was only one step towards home testing and that more parameters than concentration are required to establish a decent method (“Reliable Home Fertility Test in Sight,” 2010).

Looking beyond tradition

But the story does not end here. After Dr. Segerink finished her PhD and was successfully promoted, she was hired as a postdoc in order to continue her investigations into the analysis of fertility. However she decided to continue not precisely along the lines of her PhD research:

“What I am mainly looking into now, which started after my PhD, is whether the fertility diagnosis can be improved by looking beyond concentration, motility and morphology; the three standard parameters. I am now investigating if there are other parameters available that might be of greater predictive value.”

“Research has shown that in some cases of male infertility the men do still have sperm cells and that those cells swim alright as well, which technically makes them fertile, but yet they appear to be unable to conceive children. It often turns out that though their cells seem fine, much of their DNA is damaged.”

“We want to know whether there is something we might be able to say about that DNA damage. In order to do so, I work together with a group in Germany, near Münster. The research group is capable of performing Raman measurements (1) on individual sperm cells, which does indeed tell whether the DNA is damaged, or not. Unfortunately they still need to fixate the sperm cells because the measurement takes a few seconds, which causes the cells to die. My part is trying to solve that problem and allow those measurements to be performed while keeping the cells alive, because eventually this method could be used for selecting the healthiest candidate sperm cells in case of a intracytoplasmic sperm injection (ICSI)” (ICSI is a method in which a single healthy living sperm cell is injected into a healthy egg in order to be placed back in the woman’s uterus). “Some people have ethical concern about this because they think that we can use this method, for example, to specifically make blue-eyed babies, but that is way too complex and not even possible. We can only test if the sperm cell is packed in the right way.”

Collaboration and Competition

It is neither secret nor a mystery that the world of science revolves around the production of publications. While scientists that are working together on the same subjects but for different research

(1) Raman spectroscopy is an analysis method that uses laser light in order to determine what molecules the illuminated sample is made of. This method works because of interactions of the light with the specific vibrations of specific molecules before the light is scattered back from the sample towards a wavelength recording setup. Because the interaction with the molecules causes small wavelength shifts in the scattered light, the returning light is of a slightly different wavelength than the emitted light. Because the vibrational properties of a particular molecule correlate with the magnitude of the shift, measuring the wavelength shift creates knowledge of what kind of molecules scattered back the light and thus what the sample consists of (“Raman Spectroscopy,” n.d.).
groups are in some way colleagues with whom you share about skills, expertise and knowledge in order to collectively be as successful as a field as possible, they are at the same time opponents that compete for being the first to discover or invent something. Positive aspects have been advocated about competition in science, but competition also makes scientific collaboration a challenging aspect of the scientific practice. How do you both work together in order to generate the best possible outcome while at the same time making sure that the rightful ownership of ideas and discoveries will be respected? Dr. Segerink, who is currently working with other research groups, argues that collaboration can greatly benefit research, but that there is one fundamental demand for it in order to be successful:

“As a scientist, you can’t be good at everything and you can’t be an expert in everything, although some people think so, they never are. I think it is therefore good to use each other’s quality. That is what collaboration is. However, there are scientists, and maybe that is fair because the scientific world is very competitive, who are scared to share their ideas with the world because they fear that others will steal them.” “I had a strange experience with this myself.”

"When my collaboration with Münster had already started, someone from another university that had visited Münster where he heard about our collective project, approached me. He told me he wanted to join. I told him: “I am already doing this together with Münster, what would you be able to contribute?” I told him that it would fine by me if he joined, but that Münster also had to be okay with it. Münster agreed, but in the end the person was not interested anymore. That was very weird and I still have no idea what the exact reason for this change of mind was. Ultimately collaboration is founded on trust, but that seems to be very different for some groups.”

It’s all about the money
But, scientific competition does not end at the battle of publishing. Also when it comes to acquiring the necessary funds for actually doing the research the competition among researchers is ever increasing. Most funds in Dutch academia come from the government, however in the period between 2010 and 2016 those funds will be cut by more than 700 million euro, over 10 percent of the entire contribution, which has made it more difficult to successfully apply for grants (Cousin, 2012). Even though receiving funds has become more difficult it is not at all impossible to receive them. Dr. Segerink herself received a Veni grant of €250.000 from the NWO (Dutch organisation for scientific research). But what do you need to do, and what does your project need to comply with, in order to actually have a shot at receiving grants?

“I applied for the Veni grant myself, it is an individual grant. The competition was very strong: only about 20 percent of applications were accepted. I wrote a good application and it was accepted, but there were also other good applications that were not accepted.” “The UT provides courses to help researchers apply for grants and is generally very good with getting funds. But the UT is also very modest, when I attended the course and we were asked “why are you here?”. Some of the others said: “Because I have to” Very often most of them are too modest to say that they are very good at what they do. Personally I also dislike to do so, but sometimes you must because you have to convince the funding committee that you are the right person for that research.”

Valuable science
So, though we illustrated the story of just one scientist, is there something that we can conclude from this that tells us about how science tries to provide solutions to societal problems. To some extent we definitely can. First of all, it is clear that a scientific idea is much more than just an idea, it greatly exceeds the complexity of just some creative thoughts and it requires a lot of research in order to turn the ideas into actual technologies that are both general and specific enough so they can be integrated in society.

Furthermore doing research is not as straightforward as simply utilising a researcher’s skills; it always requires grants and funds in order to actually finance the research project and the academic position itself, such as a PhD, a post-doc or a tenure track. Basically this means that, unless research institutes have unlabelled money available to invest in projects of
In 2012 Loes won the Simon Stevin Gezel Prijs. That award is for very successful just promoted researchers of a STW funded research. The candidate has to be put forward by the project leader, and has to show how the candidate is working hard to valorize the research results.

Sources
Looking at the valorisation from the point of view of a business developer

One of the previous articles described the process from societal problem to scientific idea gave, in light of the lab-on-a-chip project of dr. Segerink, insight into the activities of a researcher in the innovation process. It became clear that doing research is not as straightforward as putting a researcher in a lab, but also that dr. Segerink worked together with parties outside the university in order to valorise her ideas. In order to form a more complete picture of the process of valorisation we had an interesting conversation with Bram de Moor, dr. Segerink’s business partner. This article takes a closer look at the business side of valorisation, concerning the lab-on-a-chip project and in general.

Business developing
To understand the business developer’s role and contributions to the process, it is important to understand his background. Bram de Moor has studied law and marketing, has worked as a senior brand manager at the Dutch coffee company Douwe Egberts for 11 years, is married to a radiologist, and has family connections in the veterinary care. When his wife got a job in the hospital in Enschede, they moved from Utrecht to Enschede. He decided to quit his job and do something completely different.

Bram now works for a company called Blue4Green, a company that develops a variety lab-on-a-chip technologies for the veterinary market, as a marketing and sales consultant. Blue4Green had partnered in research with the University of Twente before and when dr. Segering asked around for a business contact she soon got in contact with Bram de Moor, who decided to partner with dr. Segerink on valorising her sperm chip technologies, on personal title, outside his affiliation with Blue4Green.

Seeing beyond the fertility chip
Valorisation is often described as something economic, as making profit of scientific knowledge, but valorisation is more than commercialisation. To do justice to valorisation we have to consider that valorisation is a matter of co-production and that it has broader societal contributions than just profiting of knowledge (Benneworth & Jongbloed, 2009).

Bram de Moor agrees: Someone has to take the knowledge out of the lab and see if there is a market
for any application of the technology. That is what a business developer does: finding alternative use cases instead of waiting for the technology developed at the university to be perfect. If we would follow the pace of the researcher there would never be a product. Key to business developing is to not follow the direction of the scientist but to look for the width of the technology. It is like eggs in a basket, Bram de Moor says, you spread your chances by aiming at different applications at the same time, if one basket fails or if one application fails you don’t break all your eggs. Those alternative uses don’t need to be the final goal of a technology, Bram de Moor says, they may very well serve as a necessary intermediary funding source for further develop the technology and other applications. This is precisely what Bram de Moor and business developer can provide new problems for science to solve. Bram’s contacts in the veterinary industry told him there is need for a faster and more reliable method that can separate X from Y chromosomes in order to prevent the undesired birth of bulls, and now someone in dr. Segerink’s team is working on developing a chip for just that.

The entrepreneurial University
Valorisation has been added as a university’s primary task alongside teaching and research. But Bram is skeptical of this ideology of the entrepreneurial University. The three technical universities in the netherlands (TU Delft, Eindhoven University of Technology and University of Twente) have a joint goal of strengthening and pooling technical knowledge. This corporation goes by the name of 3TU and has the aim of conducting outstanding and socially relevant research of an international standard, and of promoting cooperation between research institutes and businesses. The University of Twente aims to support the business side of valorisation by the existence of Kennispark Twente. Kennispark Twente is a location close to the University of Twente where businesses can be settled. The primary goal of Kennispark Twente is supporting start ups, industrial companies and creating a business climate.

Although this may sound promising, Bram de Moor does not see a lot of this being done in Twente. His experience with researchers is that they their only goal is being promoted. Most researchers have their assignment they want to complete, and valorisation is not something they intrinsically aim for. Bram notes that he might not see the whole picture, but from what he sees all the UT start-ups that are used by the university as success stories seem not to rely on knowledge from actual research but are rather just

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**Valorisation emcompasses all activities that contribute to ensuring that the outcomes of scientific knowledge add value beyond the scientific domain.**

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dr. Segerink now attempt by using the cell-counting ability of dr. Segerink’s first chip in order to help the urologist quantitatively assess the successfulness of male sterilisation. The chip that was yet too primitive for fertility assessment turned out to be perfectly suitable for the urologist’s laboratory.

Valorisation as co-production also means that a
good ideas. They may be started by UT alumni, but are they created with a scientific fundament?

In the domain of health and life sciences, according to Bram, this might be due to the fact that it is very difficult to start a profitable business, which makes great successes scarce. It can be done, but it takes at least 7 to 10 years. “It is a long and difficult road with a big chance of failure”. In science this is referred to as the medical valley of death: that place between the laboratory and the market where many good biomedical ideas wither away and die. This is partly due to a gap in funding: Large investments improve the chances of success but are hard to come by because also investors spread their chances. Grants from the biggest funders of biomedical research generally focus on basic research, but most basic science discoveries require further testing before it is actually valorised, which makes valorisation particularly difficult (Butler, 2008).

All about taking risks
Valorisation encompasses all activities that contribute to ensuring that the outcomes of scientific knowledge add value beyond the scientific domain. Bram de Moor allowed us to take a closer look at this process by sharing his experiences with us. There is no guidebook to describe what one could do to valorise knowledge from the business side of things. Bram de Moor showed us that being a business developer is all about the ability to take risks. A lot of work has to be put in and it takes a long time and a lot of effort to get to the point where money can be earned from it. The fact that his wife provides his family a stable financial situation enables him to take a risk: if the project does not get airborne Bram’s family does not have to suffer. That is the reason why this job is not right for everyone, not everyone can wait for years until a product is profitable and a salary can be earned from it. Besides the financial risk, his network is key to his success. If he did not have family and friends in the medical and veterinary sector, these ideas for dr. Segerink’s project would never be triggered. Inspired by the conversation with Bram we got the strong suggestion that personal preconditions are key to being a successful business developer. So what does this mean for the entrepreneurial University? The University of Twente’s initiative of the Kennispark now has a business development team. Because they are employed by the University, the financial risks are decreased. Is this the begin of a flawless process of valorisation? We certainly hope so.

Sources
A search for the objective truth in the science of fertilization

In history, the role of sperm in fertilization was always considered as very active, while the the egg was considered to be very passive, as if it was a field of a farmer that waits to be sown. If something went wrong with the fertilization, it were often the woman who got the blame. For instance, Henry VIII did get about 20 daughters and only one son by multiple women. He executed his own wife because he couldn’t get him any sons. It turned out to be that he himself had a disease which made him almost incapable to produce any male offspring. Currently, we still see the same image of an active sperm cell versus the passive egg cell sketched in our biology books. The egg waits desperately in her ivory tower to be fertilized by a strong masculine sperm cell. This view seems also internalized in medical technology. The criteria they use to test the quality of sperm are motility, concentration and morphology. The faster the sperm cell the better, the more the merrier and shape seems to equal quality. But how objective are these criteria exactly? For instance, scientific accounts of reproductive biology still seem to rely on stereotypes of our cultural definitions of male (active) and female (passive). Also, a lot of medical technologies follow the same values as the tradition in medicine. Science seems very much intertwined with our social and cultural background. This raises the question; in how far can we speak of objectivity in science?

In this article, it will be discussed in how far science could be considered objective. The first theory that will be described is from Foucault, who introduced the concept of Discourse. With this notion, he described how words get their meaning and how they not only create our worldview, but also our truth. More contemporary, Lorraine Daston and Peter Galison published a book about objectivity, which relates to the subject of discourse and truth. Therefore, their theory will be secondly argued. Finally, it will be discussed if the made conclusions have any consequences on the science of the fertility chip developed by Loes Segerink.

**Discourse and truth**

Someone who questioned objectivity was Michel Foucault. According to him, the meaning of words is not determined by the people who pronounce them. There is no pure subject that precedes the usage of words. Our actions and thoughts are determined by history. It is important not to understand this as radical determinism. Foucault means that our actions and thoughts are always part of a certain conceptual space. He calls this a discourse. We say the things we say and we do the things we do because they are one of the options in a discourse. Within this conceptual space, it
is possible to think and speak. To give an example, to say that someone has a broken heart does only make sense in a discourse where a heartbreak is a normal expression. Otherwise we would assume that someone’s heart is actually broken and stopped with beating. It is impossible to live outside a discourse, because all the words you would use would be meaningless. The meaning of words can only arise in a discourse. Actually, you will not even come up with words, because they do not have any content and therefore they do not exist in the usage of language.

Foucault writes in The history of Sexuality (1976) that truth is circular related with systems of power who produce and keep this truth. What is true and what is untrue depends on the discourse a claim is in. Because truth claims are a big part of science, even what is true in science is part of a discourse. To give an example, we used to think that our universe consists of perfect circles. When science discovered more and more inconsistencies, they didn’t change their theory of perfect forms. They tried to come up with additional theories to explain the movements of the stars without eliminating the old theory. Scientists lived in a discourse where it was ‘certain’ that the universe was perfect, so everything that seemed imperfect was forced to match in the theory. They lived in a discourse with its own ‘truth’. It took ages before scientists accepted that the universe didn’t consist of perfect circular movements and they abandoned the theory. According to Foucault, the conditions of discourse can change over time (Foucault, 1966). Therefore something can be ‘true’ in one period’s episteme and ‘false’ in another. What is truth in science depends on the discourse of that time and is therefore not objective.

A critique on objectivity
In Objectivity (2007), Lorraine Daston and Peter Galison argue that the notion of objectivity wasn’t always a part of science. This notion arose in the mid-nineteenth century along with logical positivism. According to this philosophy, a scientific theory had to eliminate all subjective interferences. A scientist needed to be passive and as ‘absent’ as possible. Before the notion of objectivity, science was done in a whole other way. In the eighteenth-century a scientist had to find the universal aspects of every particular case. Daston and Galison call this epistemic virtue ‘truth-to-nature’. To give an example, a naturalist had to find the ideal form, the type of each species, instead of grasp every unique specimen. Also this epistemic virtue was related to the philosophies and theories of knowledge of that time. We can think of the post-Kantian theories here. Subjectivity was regarded as something active and had an organizing purpose. This was the attitude a scientist had to have.

In the twentieth century another epistemic virtue emerged, the so-called ‘trained judgement’. Scientists relied on intuition, judgement and the skill to interpret. Instead of denying the self as in the nineteenth century, the self of the scientist became important again. However, this was a very different self than the self in the eighteenth century. The self in trained judgement is “as an archaeological site of conscious, subconscious, and unconscious levels” (Daston & Galison, 2007, 44) It doesn’t search for the truth hidden under the veil of appearances (truth-to-nature) nor does it sacrifice the judgement of the scientist (objectivity) (Monti, 2009, 278). Trained judgement asks from the scientists to develop the skill of reasoned observation. It’s their task to translate an
unrepeatable scientific object (such as a human) to other untrained eyes. This idea of different epistemic virtues over time seems compatible with Foucault’s notion of different discourses over time.

The second aspect of Objectivity emphasizes that there is no real objectivity in science. Their first critique on objectivity considers the scientific self, which always has a history. This is in line with Foucault’s epistemology. Therefore it is not strange, that they often refer to him. When the scientific self has a history, it means that the self is not objective. There is always an “intrinsic connection between epistemology and self” (233). Knowledge and knower are always intertwined. The three different epistemic virtues show us this. Every virtue is connected to the mindset and people of that time. To reach full objectivity, the scientist has to nullify his self. He has to sacrifice his own will to become fully objective. However, this will never be realisable according to Daston and Galison, but that doesn’t mean that there can be no science. “There can be, there has been, there is science without […] objectivity” (371).

The second critique states that scientific research cannot collaborate with the metaphysics that subjectivity encourages. As an example, Daston and Galison use a case of an atlas, as they do many times in their book. They ask themselves the question: “What would a perfectly objective atlas look like?”. This would be “a mere collection of unsorted individual specimens, portrayed in all their intricate peculiarity”(185). Such an atlas would be useless, according to them. Without generalizations and comparisons, there cannot be science.

Daston and Galison’s last critique is of a historiographical nature. They apply the results of their investigation to their own methodology. The critique of Daston and Galison on so many historians is in itself an example scientists who try to find “patterns that show that even if a historical formation is contingent, it is not thereby a hodge-podge or chimera” (205). Also their writing isn’t objective. They use a chronological approach and divide several time-periods, just like all historians of their time do. They make themselves guilty of their own critique on objectivity, because instead of taking time as an unsorted series of events, they generate different time periods which they compare with each other. Such a method isn’t in line with objectivity.

**Back to fertility**

We have seen that real objectivity seems actually impossible. We cannot nullify the self when it comes to knowledge. Also, we always live in a certain discourse that influences what is true or false or prescribes our methods. We often think that science describes our world. But it is important to realize that the theories and the terms we use are part of a discourse and that they actually shape our vision of the world. They create a certain truth in that epistemic
period. We could say that in a certain way scientists actually create our world instead of describing it. They create what is true in that time and at the same time they are the victim of their own discourse. Therefore, we cannot speak of real objectivity. Luckily, following Daston and Galison, science is still possible. We can do science with other epistemic virtues than objectivity.

Applying this to the fertility test of Segerink, we can argue that the testing of fertility is also not objective. With the lab-on-a-chip fertility test, we are putting male fertility to the test. As sperm gets traditionally checked on motility, concentration and morphology, this is also exactly what the chip of Segerink aimed to do. We can conclude that this technology embodied the same values of good sperm as current medicine does. The fertility chip fits right in the tradition. Or should we say that the test fits right into the discourse of medicine? The best sperm is still considered active and matches our gender stereotypes. Also, the method medicine uses is just like the method Daston and Galison use a result of tradition. The fertility chip of Segerink matched with this contemporary views on the male gamete and seems therefore to rely on a discourse. This means that with this fertilization test, we cannot speak of objectivity in the way it approaches sperm.

Recently, Segerink has expanded the lab-on-a-chip fertility test and is currently working on a method that goes beyond the three standard parameters. She is now investigating other parameters, to look if they have a greater predictive value. It often turns out that infertile men do have sperm cells and that these cell are often motile, but still they can’t conceive children. According to Segering, it turns out that although the sperm seems fine, a lot of their DNA is damaged. That is why she wants to test the DNA quality of a sperm cell. With this development, the aspect of the activity of sperm gets less important. Good DNA gets more important. The definition of good sperm doesn’t rely anymore on something ascribed to gender roles as motility or concentration, but on something what seems more ‘objective’; on DNA. We might say that the roles ascribed to the egg and sperm cell become less dependent on gender stereotypes because of this innovation. Is this test changing the discourse of our reproductive cells and also the discourse of medicine? I guess we will never find the objective truth, because it remains quite uncertain that there is one, but that’s just fine.

Sources
"Identity is our mystery. We have no idea who we are – what humans are, and what humans are good for. [...] Self-tracking and the Quantified Self movement are contemporary probes into this mystery, part of our feeble attempt to figure out who we are – as individuals and a collective. Quantifying your self is an act of self-assertion. All this attention is not a narcissist adoration of the self, but a self-definition in an age of great uncertainty about who we are.” - QS co-founder Kevin Kelly, 2011

The vision of the lab-on-a-chip group was once for the fertility chip to be a home-test. Though the researchers did not follow up to this idea, it is still interesting to note that it once was a vision. That notion is interesting because the trend of tracking your own health-data is booming. Internet devices enable us to track health-related data like body weight, sleep quantity and quality, blood results, blood pressure, nutrition habits and mood. There is a community that promotes this self-tracking of data which goes by the name of the Quantified Self-movement. This article will introduce the practice of self-tracking, give a brief introduction the the debate whether self-tracking is alienating us from ourselves or if it is enhancing us as humans and envision the future of fertility testing in the Quantified Self-movement.

**Know thyself**
Our bodies are constantly radiating important data and most of the time we ignore the data. Until something goes wrong, then we visit the doctor. We are now owners of technology that enable us to collect some of the data. This is allowing us to analyze the data in real-time and make behavioural changes to influence it. We have apps that can tell us when we are most focussed or when we get enough sleep. A device that can tell us when we are most fertile would fit this line.

The term Quantified Self (QS) was introduced in 2007 by Gary Wolf and Kevin Kelly when they founded the Blog QuantifiedSelf.com. Following their credo: self knowledge through numbers, they are organising meet-ups and conferences throughout the world. It is currently an active community and some might argue that the age of the QS is upon us.

**Human enhancement**
With wearable devices that can measure the data our bodies are radiating we are allowing ourselves to become super-humans in control over these data. This raises some questions: is this ability alienating us or expanding our humanness? This relates to a contemporary debate about human enhancement. Human enhancement is any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means (Bostrom and Sandberg, 2007). Is this desirable? There are two sides in this human enhancement debate that attempt to answer that question. On the one side are the bioconservatives who want to sustain human nature and on the other side there are transhumanists who recognize and anticipate the radical alterations in the nature and possibilities of our lives resulting from various sciences and technologies (More, 1990).
Transhumanism
Transhumanism is derived from humanism. Human is a philosophical and ethical stance that emphasizes the value and agency of human beings and prefers critical thinking and evidence. Transhumanism is a kind of humanism+, sharing this stance but to add on it transhumanist claim that we should not accept biological limits as natural. Transhumanism is about realizing values like rationality, individuality, unlimited self-development through the newest technologies. Why should we rely on random chance if we can have technological control over it? Why should we forget things if we do not have to? Why should we even die? Examples of technologies encouraged by transhumanist are artificial limbs, artificial organs, brain-computer interfaces and cryogenic suspension. Transhumanists think we should free ourselves from anthropocentrism, the idea that human nature is the most significant on the planet.

Bioconservatives
On the other side of the debate are the bioconservatives who believe we should leave the nature in tact. Aristotle already made a distinction between the made and the grown: technē and physis. Nature is the grown and technology is the made. These categories will de-differentiate as soon as we fundamentally interfere in nature, which will affect our view of autonomy and moral self-understanding. Bioconservatives stress the importance of rationality and the ability of humans to understand and reflect upon the world. Transhumanism would endanger that and therefore we have to prevent the world from making the mistake.

Self-tracking
Transhumanist would claim that ‘we should keep nature in tact’ would be a weak argument because there is not ‘natural’. We are already transhuman. If we drink coffee to focus, we are also enhancing our cognitive capacities. Where can we draw the line between natural and enhanced? And even if there was a ‘natural’, that would not mean that the natural is necessarily the good. We can accept the natural as a gift that we not accept. Self-tracking devices are enabling us to make the invisible visible. With the information our bodies are radiating we can make achieve better health and better well-being. The argument that it is not ‘natural’ is not sufficient, because going to a doctor with medical equipment would then also not be ‘natural’.

Fertility tracking
The quantified self movement will probably not cease to exist anytime soon. But what is the future of fertility in QS? There are already different ways for women to track when they are most fertile. In that sense, a home fertility test for men would not be so science fiction-like. Self-tracking of fertility would mean that men could have an overview of their fertility data and have control over it by for example making lifestyle changes. And all of that would be possible without having to consult a doctor. Implementing a fertility test in the routines of self-tracking would also generate information about the causes and conditions of infertility. Important information we currently have little knowledge about. This information could be used to find new and better treatments for infertility. Leaving all previously discussed practical implications aside, in the light of the QS there is a fertile ground for the fertility home-test.

Sources
We have written extensively on the subject of fertility and Dr. Segerink’s chips and technologies that aim to assist in the process of procreation. Dr. Segerink’s chip is not the only technology that aims to help fertility and procreation and many of those technologies are being developed with public funds, which is also a main source for the funding of the subsequent treatment in order to assist the procreation that was earlier prevented by limited fertility. Though the matter of funding is actually very complex, it inspired the question of whether we have a right to procreate. I will not answer the question about the allocation of public funds for fertility technologies and treatment because it is a bit too complex for this article.

Governments have interfered with its peoples procreative activities for ages, and not always for the most ethical imaginable reasons. Much of these activities were effective instruments of repression, and it comes as no surprise that reproductive rights were added as a subset of the United Nation’s Universal Declaration of Human Rights as part of the 1968 proclamation of Teheran, which defines it as follows:

"Reproductive rights rest on the recognition of the basic right of all couples and individuals to decide freely and responsibly the number, spacing and timing of their children and to have the information and means to do so, and the right to attain the highest standard of sexual and reproductive health. They also include the right of all to make decisions concerning reproduction free of discrimination, coercion and violence."

Though this right is rather incomplete and leaves quite some room for discussion about interpretation of it, most national courts in in the world recognise some form of, at least the most primitive and fundamental, sexual rights; for example the right not to be raped.

If there would be a universal right to procreate it might, depending on the weight of the right with respect to other rights, influence many aspects of society that might seem to be individual issues. For example, if there would be an inviolable right of reproduction it would indeed be just to allocate funds to individual fertility, but would at the same time make population control immoral, just as chemical castration of repeated sex-offenders.

The article will first shortly focus on what a right actually is and what having a right actually means (There can’t be infinite consequences for keeping up
the maintenance of a right). After that some exemplary cases involving procreation will be discussed with respect to the claim of a procreative right, in order to give a brief conclusion on the significance of the right.

What is a right?

Most people have a certain understanding of what a right is and all around us you can hear people claim to have certain forms of entitlement. Some of those rights are acknowledged by most people within a culture or even their nation’s laws, think for example about the right of freedom of speech, the right to defend yourself, to vote, to education or to child benefits. However other claims seem to be rather more personal and debatable such as the right to do as one pleases, the right to beat one’s child, the right to voluntary intoxication or the right to kill people on your private property.

The word right is often used as a synonym for an absolute and universal entitlement. Though it works great as a superficial argument the reality is that rights are rather more complex. Though we acknowledge a full freedom of speech, we don’t allow it to be used to express threats to others, there is no voting right for people younger than 18 and you will not receive child benefits if you don’t have children. Some rights serve as a guarantee that we are allowed to do something, other rights prevent other people from doing things to us, but there can be rights that force other people to do things for us.

In an attempt to better understand the apparently different kinds of rights, a jurist by the name of Wesley Hohfeld (1897-1918) created four distinctly different categories of rights which are called the Hohfeldian incidents: (1) Privileges, allowing you to do something, (2) claims, requiring someone else to do something, (3) powers, allowing you to change other’s peoples rights, and (4) immunities, allowing your rights not to be altered by power (“Wesley Hohfeld,” n.d.).

The procreation issue does not relate to one single type of right, actually all Hohfeldian incidents apply to different aspects of the question. The freedom of procreation seems to fit well with a privilege allowing you to make your own choice. However if procreation is perceived as a right to fertility it easily becomes a claim to society and health insurances and if we look at the state trying to perform forced birth control it becomes a conflict between the powers of the state and the immunities of the receiving party.

But, however arbitrary rights may sometimes seem to arise and be proclaimed, there is a certain real value about rights, because all countries have governments and all governments have laws, which always results in entitlements for at least some of the population. That does, however, not ensure the enforcement of universal and globally expressed basic human rights. Those rights have been formulated quite extensively by the United Nations, but are in no way legally binding; they do serve as a foundation for national and international law and a tool for applying pressure on negligent countries. So though there might be something as a universal moral philosophical entitlement, which the Universal Declaration of Human Rights defines, there is no such thing as legal global human rights; which demarcates a clear distinction in its effectiveness.

Past uses of the argument

Forced Sterilisation

In the period between 1870 and 1945, forced sterilisation was for some countries an important instrument of population and public health control. These methods that can safely be called eugenic, were not only employed by Nazi Germany, but also among others, countries such as the US, Japan, Sweden and Switzerland (“Compulsory sterilization,” n.d.). Though eugenics is often thought of as something from the past the World Health Organisation published a report in 2014 about eliminating the performance of coercive sterilisations, indicating that it is still an active issue (Ohchr et al., 2014). According to the report, gathered from other sources, there are still countries, for example Namibia, Peru, Chile and Hungary, where involuntary sterilisation is performed on people of certain population groups, such as for example: HIV-patients, disabled people, ethnic minorities, transgender and intersex people (Miranda, 2004; Mallet, 2008; Nair, 2011; Canada, 2011).
The condemnation of the WHO of these practices is based not just on moral discomfort or a shared sense of a claimed obvious wrongdoing, instead the WHO argues against it on the very specific grounds of a set of rights from the UDHR. According to the WHO coerced sterilisation is a violation of: “...the right to health, the right to information, the right to privacy, the right to decide on the number and spacing of children, the right to found a family and the right to be free from discrimination”, emphasising once more that, amongst other rights, the right of procreation is considered to be a real right.

Chemical castration
Chemical castration sounds to be something very similar to forced sterilisation, and though it certainly has got quite a bit to do with that discussion, it is slightly different. First of all, chemical castration involves only the administration of antiandrogen drugs that significantly reduce sexual desires and drives and do not require any form of invasive surgery (“Compulsory sterilization,” n.d.).

Chemical castration has been around from just before the 1950’s, computer scientist Alan Turing was a famous recipient of chemical castration as an alternative for imprisonment for performing homosexual acts that were deemed indecent and were forbidden by law.

In the US, a country that has the power to enforce chemical castration on its people, an association called the American Civil Liberties Union is one of the parties that opposes the legally enabled coercive chemical castration (Spalding, 1997). In order to argue against it, they mainly appeal to the Eighth Amendment by claiming that chemical castration fall under the ‘cruel and unusual punishment’ that the amendment should prevent, the right to procreate plays only a supporting role as part of their appeal.

Mutilation
Apart from the state enabled forms of involuntary deprivation of the ability to procreate, there is a surprising amount of civil cases where the victim’s procreative ability was severely affected by the aggressive mutilation of their reproductive organs, something that can happen to both men and women. Because many of these cases have taken place in countries where a reproductive right is acknowledged by the state, the question is whether the decision of the court involved consideration of the violation of the right to procreate in order to determine a sentence. Law is a bit too complex for a full review of the cases, but showing the outcome of some notorious cases is definitely possible.

A particularly well documented sequence of events took place between 1973 and 1980, a period in which one hundred Thai women cut of their husband’s penises as revenge for having a sexual partner besides themselves (Bao, 2004).

Though having extra sexual partners is a historical aspect of Thai culture, the law enforces a monogamous policy and none of the one hundred women were prosecuted because the commonly shared opinion was that the men deserved it (“Lem, kjære lem,” 2003). Apparently the male rights to procreate were undervalued with respect to the female’s right to revenge as justification for the men’s unfaithfulness.

However, also in cases in the US where the women were actually brought to trial the right to procreation does not really seem to play a role. For example the American court case of John VS Lorena Bobbitt. Lorena cut off John’s penis after a marriage littered with John abusing Lorena. She plead not guilty to the charges of ‘malicious wounding’, appealing that depression and post traumatic stress disorder had caused her to snap. The jury believed her and she was found not guilty after all (ROSS, 1994).It is interesting that, though the US endorse the right to procreation, it did not play any role in the trial which focused only on ‘malicious wounding’ Another example of a similar case, is the case of Catherine Kieu, who also cut off her husband’s penis, as an act of revenge. The assailant was indicted of ‘torture and aggravated mayhem’. The victim claimed to feel ‘murdered’ by having his manhood taken because his penis could not be reattached. Of course this can easily be placed under the general term of torture but the reproductive right is not featured in trial (“Catherine Kieu,” n.d.).
So, is there a right or not?
It is clear by now that for a right to be a right it needs to be granted by some form of authority. The United Nations seem to perceive themselves to be an authority that has the power to determine and define a set of ‘Universal’ declaration of human rights, granting rights to the entirety of the human race. This includes our apparent right to procreate in the form of freedom in the ‘number and spacing’ of children, making virtually any form of population control a violation of that right.

But the United Nations are not actually effective in their granting of rights because they, as opposed to actual state governments granting rights to their legal citizens, have no legal authority over humanity in general; as their declaration implies that they do. Because they have no legal authority over humanity in general, it is only a little bit more sensible and legitimate as granting voting rights for all goldfish ever in the world just because I have two of them in a fishbowl; which would only work if all goldfish ever in the world are subjected to authorities and all those authorities would happen to agree with me and decide to also grant them the right.

Because world politics does never seem to play out that way, the power of the Universal Declaration of Human Rights seems to be quite a bit less powerful than the word ‘Universal’ implies, no matter of how valuable or justified those right might seem to be.

Furthermore, it has been made clear that there is an incredibly wide range of cases to which this right to procreate seems to apply. Though this is the case for many universal human rights, it makes it very difficult to actually use them in court because they are often to broad to be adequately legally applied, it is much easier to satisfy our sense of justice by appealing to the rights and laws that are simultaneously violated but for which a wide range of judicial history and resources are available.

It is understandable at this point to argue that a right to which no legal enforcement seems to apply is not actually a right, because what good is a right if it does not give you any of the four Hofsteldian instances? This is a fair point and it seems sensible to agree to this. However, that does not necessarily mean that the claim is not powerful in itself. Documents like the Universal Declaration of Human Rights might have no direct legal power, but they certainly are of significant influence and inspiration to its subscribing authorities, the public opinion and the ideals of many other opinion forming and lobbying agencies around the world, at least giving the document and its ideals a form of very real power.

Sources
ANTINATALISM

Philosophy against life

As philosophers we are taught and ought to look critically at the presuppositions that might be part of our views on issues concerning society and the world. Throughout this whole serie of articles on fertility there is one major assumption that makes scientists and engineers pursue innovation; the assumption that life is something you should want. When we live we want to live longer and we continuously develop knowledge about preventive health and curative therapy in order to avert death as long as possible, sometimes even at the cost of sustained suffering. When someone seems to be infertile and incapable of procreation it is considered a lost chance at helping something intrinsically valuable into existence. This may be considered a certain form of chauvinism and it often does not seem to require any justification to accept life as intrinsically valuable.

So we eat healthy to stay healthy, avert unnecessary risks to stay safe, to seek medical attention when things seem to be wrong and to desire to reproduce ourselves at a some point in life. But however easy it is to accept this positive life-presupposition for me and for most, it is not for all of humankind and the opposite presupposition serves as a point of departure for an interesting philosophical anti-movement: The antinatalists.

Screw birth! But why?
As the name implies, antinatalists are predominantly against birth. Birth is inextricably linked to life because if all goes well (by the life-chauvinist standards), birth eventually leads to life. Just as positivism about life inspires the thought that procreation is a good thing, negativism about life inspires the thought that procreation is a bad thing. This may feel a little uncomfortable, but this article will explain why anti-natalist actually have tenable arguments. This article will not argue that we should stop giving birth but it will introduce you to the arguments natalists and (contemporary) antinatalists have.

Natalism
Before we look at antinatalism let us take a look at what this antinatalism is against. Natalism is the belief that promotes human reproduction. This sounds like stating the obvious because it is basically the view most people have of procreation. Without cognitive involvement people engage in giving birth and
continuing the existence of human life. But when we view natalism as a philosophical stance, there are cognitively grounded arguments for why we should procreate. The level of natalism varies between individuals. One extreme end of the spectrum of views presents natalism as a life stance and holds natalism as of ultimate importance, we are alive to take care of our offspring. Philosophical motivations for natalism include considering the value in bringing potential future persons into existence to continue the existence of human being in the future. Stating the obvious, you could almost say.

pleasure can never outweigh the pain. The conclusion that Schopenhauer drew from this is that the most reasonable position to take was not to procreate. Why should we throw children into a miserable existence? Antinatalists argue that natalists reason according to the logical fallacy of appealing to nature: believing that everything that occurs in nature maps on to some higher good, and therefore should be the right thing. Antinatalists would claim that the natural is not necessarily the good. We could accept procreation as something that is biologically determined in us, but we could reject following this biological path. In other

Antinatalism
Antinatalists give a negative value to life and birth. One of the most famous antinatalists is Arthur Schopenhauer. Schopenhauer (1908) was a German philosopher with a rather pessimistic worldview. His antinatalism entailed that the value of life is ultimately negative because the positive experiences will always be outweighed by suffering. We may sometimes experience moments of pleasure of happiness, but those feelings are always clouded by moments of suffering and pain. Schopenhauer saw suffering as a more powerful feeling than happiness and therefore words, antinatalism is willing to divorce certain biological functions from the philosophical. The difficulty with antinatalism is that is hard to quantify suffering and happiness which makes it difficult to prove that one actually outweighs the other. You could of course ask others about their personal perception of suffering and happiness but the answers remains subjective and the balance between suffering and happiness not distributed equally among different people. However, if we accept the premise that life entails more suffering than joy, the antinatalism argument is a tenable one.
Contemporary antinatalism

Antinatalism may sound a bit outdated but there are still contemporary antinatalist philosophers. The best known and most influential current antinatalist is African philosopher David Benatar, head of the University of Cape Town Philosophy Department. He wrote the book Better Never to Have Been: The Harm of Coming into Existence (2006), in which he argues that coming into existence is a serious harm, regardless of the feelings of the existing being once brought into existence. So as a consequence, it is morally wrong to create more sentient beings. Benatar argues from the antinatalist premise that pain is, in itself, a bad thing.

American author, journalist and activist Johnathan Rauch wrote an article published in The Economist entitled Sui Genocide (1998), in which he promotes a unique form of antinatalism he calls teleological antinatalism. This entails that it would be more dignified to "call time" on humanity at a moment of our own choosing, rather than letting the inevitable death of the universe kill us brutally.

Another controversial example of a more organised and contemporary form of antinatalism is the Voluntary Human Extinction Movement (VHEMT) founded by Les Knight. This environmental movement calls for all people to abstain from reproduction causing a voluntary extinction of humankind. VHEMT’s aim is human extinction, because it should prevent further environmental degradation. It logically claims that a decrease in the human population would prevent a significant amount of human-caused suffering. The extinctions of non-human species and the scarcity of resources, required by humans, are for them evidence of the harm caused by human overpopulation.

Pragmatic approach

When we are confronted with these arguments it is hard to philosophically reject them. Instead of taking sides for either natalism or antinatalism we could adopt a more pragmatic approach to procreation: sympathetic neutrality. That means that you accept the arguments but recognize that it is never going to hold in the grand human scheme of things because people are running on an autopilot. Sympathetic neutrality would in this case mean: yes, antinatalists have tenable arguments to not procreate, but our biological urges compel us, so we will do it anyway. After all, evolution does not care about happiness, it cares about making copies of genes. It is somewhat ironic to think about the future of antinatalism but, even though antinatalism seems controversial and an unpopular approach to life, it is is still a present subject in the mainstream media. Only the future can tell just how persistent antinatalism will become in the public mass-consciousness.

Sources

How Segerink's chip is a nice example of the unpredictability of science

When Loes Segerink was hired for the research on a sperm chip. She was researching on a device that was presented to be used at home. Her research assignment was to find a sperm test using lab-on-a-chip technology. Several media appearances showed that she was designing a home sperm test (Rispens & den Hond, 2012). However, during her research, she could not get the technology in such a way that users could take it home safely. The test was still only available to lab technicians.

A friend of Loes is owner of the company Blue4Green, which is a company that delivers on the spot lab-on-a-chip diagnostic tools for veterinarians and farmers. When he heard about Loes’ chip he thought of another possibility: to use it as a mastitis chip (B. de Moor, personal communication, February 19, 2015). Nowadays that is one of the ways that Segerinks chip is being used.

So the research of dr. Segerink is based on a scenario that until now did not turn out to be. Does that matter? Is that an issue?

Yes, it does matter, because it is an inherent property of science that things do not turn out the way as expected. There could be a whole lot of reasons why. You can categorize them in two types of reasons: scientific and societal. A scientific reason could be that the laws of physics are misunderstood, or that the design of the technology is not working. This type is more classical, if you think about a struggling scientist, you think about this. A societal reason could be that the financing of the research is stopped or that (the intended usage of) the knowledge is not being recognized or applied, this is much more tacit, and has since Kuhn’s philosophy in the sixties been recognized in the realm of science: the sociological approach in science and technology studies (STS).

Federica Lucivero et al., have an example of how usage scenarios can be misunderstood completely (Lucivero, Swierstra, & Boenink, 2011). In the research of Segerink there is an assumption that a home technology is per se better than a lab technology, because it would be more patient friendly: the patient does not have to do the “embarrassing walk of sperm” to the hospital anymore. He can just put a blob on the device, it will measure the fertility of the sperm, and then the gynecologist will tell him the test results.
However, Lucivero states, that philosophical analysis is necessary to “disentangle” the concepts and values behind the exciting claims, to get an honest debate on the actual desirability of the technology. What is important, that technology not only is, but that it also helps to shape society, it can have a lot of moral effects. The sperm test is not necessarily more patient friendly for example: maybe the patient has to test himself constantly for one month and wait for the verdict of the gynecologist. That means that the patient has to do much more at home than it was before, when he had to come to the hospital. If it really is a hassle, the compliance of the patient could also be less. Furthermore, it could be that the patient does not mind going to the hospital for a test.

This emphasizes that it is really unpredictable what the effects of science are. As a society we should know and recognize this, so that policy can be made to justify the unpredictability of science. We should focus more on the uncertainty that science possesses, and that this is okay. Helga Notowotny supports this claim, and states that science is both a bottom-up and top-down approach, that it is a combination of planned and unplanned outcomes. Users have a very important role, which is really hard to predict and idealize (Nowotny, 2005). The same accounts for funding.

Segerink’s research has been partly funded by the Dutch foundation for the technical sciences (STW). I have performed an interview with a program officer of STW, Ron Winkler, on how they think about this unpredictability and how they deal with it (R. Winkler, personal communication, March 16, 2015).

STW is a foundation that funds application-focused research in the technical sciences. The research projects they fund always have to be innovative; it is not about applying already known concepts. To ensure that the application is always kept in mind, user groups are set up for each funded research. User groups are people that the scientists intend to be the users they are researching for. STW can also suggest some users. These user groups could just be giving feedback to the researcher from the “field”, but it could also mean that they partially fund the research. To secure these user groups, letters of intent are set up. Whether a research is being funded or not a comparison is made on several grounds. They are being assessed on the scientific and on the application-focused value. Quantification is put on these values using assessment sheets, which is then being ranked in a subsequent order. Only the highest ranked research applications are being funded.

STW knows that the outcome of research is very unpredictable: 90 per cent of the research does not deliver a usable technology. It does always deliver usable knowledge nevertheless. For instance the research of Segerink does not only deliver a sperm chip, but also a lot of extra input in the lab-on-a-chip research group where she is part of. Furthermore, Ron states, research that results into a commercially very profitable product takes a very long time to achieve. Most of the time it takes fifteen years or more to have an available product. These cases are very rare.

This shows that the funders at STW have a very nuanced vision on technology. They know how unpredictable science is and they do not distrust science based on that. However for society in general, this is not yet common sense (Borup, Brown, Konrad, & Van Lente, 2006). Firms and policymakers are continuously bombarded with promises and a lot of them do not come true. The expectations have a lot of political impact, because they shape the policy for the
research. It is important to know that science shapes society and that society shapes science (p.287). The policy we have is based on how we see science and society right now. The tendency of how we see the future is a more fancy version of the current society. A future with the hopes and fears we have right now. Not the hopes and fears of the future, because we do not know them yet.

What important is, about this story, is that the expectations we have don’t necessarily come true. We should keep that in mind when we decide whether or not to invest in a research project. We should know that no outcome also is an outcome, that another outcome can be as good, or maybe even better than the expected outcome. Scientific/technological development is a social practice with expectations that not always withhold. The future will be different and knowing that, the expectations we have are mere guidants, than promises made.

Concluding, it seems to be that society does not value the unexpected outcomes of science. Everything should be justified beforehand, the economic value is only acknowledged for an expected outcome. What we should recognize however is that unexpected outcomes can also have a lot of value. If we recognize that, I think science as a practice is more justified and will be less distrusted. The role of institutions like the Rathenau institute is to show this to politics and society, that the outcome of science can be unpredictable, and that science still is justified that way. Luckily they have a project running right now that is showing this to our society: the project “de waarde van wetenschap” that translates to “the value of science” (“Thema’s: Waarde van wetenschap,” n.d.). Thus we (the Dutch society/government) are working on that!

Sources
"The Fertility Chip, now at NANO Supermarket!"

"ENSCHENDE, 2025: Today a new supermarket opened its doors. It is called the NANO Supermarket and it brings nano products to the people. Their claim: “Making the impact of nano technology tangible.” The shelves of the NANO Supermarket are stocked with the most wonderful nano products, products that use technology at nano scale.”

NANO Supermarket is a fictional supermarket that is filled with (mostly) yet not existing products. It is actually made physically by reconstructing an old Dutch SRV-mobile supermarket. In the car fictional products are being exhibited. Products like wall paint that can change color with a smartphone app, or condoms that are capable of letting only male (Y) or female (X) sperm through. NANO Supermarket is funded by the government, by funding the organization behind it: Next Nature. Next Nature is emphasizing that technology is becoming more and more complex in such a sense, that it is becoming a new type of nature. By explicating this notion, Next Nature wants to make the role of technology more tangible. Next Nature is funded by Creative Industries Fund NL, which is funded by the Dutch ministry of Educational, Cultural and Scientific affairs (K. van Mensvoort, n.d.).

“We sell small products, big impacts”

NANO Supermarket wants to call attention to the big impact that nano products can have on our society. We are in a nano revolution. Nano technology is technology that takes place at molecular and atomic scale: 1-100 nanometers. Right now, science is working on a shipload of technologies at that scale. They are already used in consumer products nowadays. Think for instance of extra UV-protection in cosmetics or ways to improve the bounce of tennis balls (K. van Mensvoort, Wouters, & Vos, 2013).

The discussion of NANO Supermarket

We should have a public debate about nanotechnologies. It is already taking place in science
Google Nose - Smell is not incorporated into technology yet. The Google Nose will make it able to "see" smell much earlier.

Rayfish footwear - DNA technology will make it possible to design your own stingray, using online design tools: you can choose between a lot of colors and patterns. That stingray will grow with your one of a kind designed leather skin. This skin can be tanned and made into a pair of sneakers. It will create unique footwear. But is it okay to create your own stingray for just the purpose of a leather sneaker? And what if such a stingray gets (accidently) interbred in nature?

Wallsmart - Are you bored with your current color in your house? Or would you like to live very dynamically? This paint will make it able for you to change the wall color in your house into every color you want. Just use the smartphone app and you are done. Never painting again!

Coating Cola - The next thing in the diet cola family! After a decade of making "light" cola more natural with Cola Life, this is the real diet cola! Even better, you don't even have to diet, because this cola is different. It will add a layer to your intestine that blocks fats from other consumptions. So you will never be what you eat!
cafés, magazines and theaters for instance, but current debate is mostly addressing the fascinating science or the safety of nanotechnology. It is not at all about the big impacts it has on society, the changing nature of nanotechnology on mankind. By making the possible products touchable, the public debate can go to a more sociological level, how will people react to the products and think about the intrinsic desirability. It can also give information to designers to take the public opinion more into account.

NANO Supermarket has chosen to use the notion of the supermarket to show the impact on society, because supermarkets are embedded into our daily life. The supermarket is the place where new habits, lifestyles and technologies are becoming regular life. By showing the possible products in a recognizable environment, they are cognitively embeddable into daily routine and so the societal effects can be taken into account.

These products can have a big impact on our daily life, because they can change the whole way we think about the world. The NANO Supermarket says that nanotechnologies can be compared to historical technological developments like digitalization, the industrial revolution, electricity, the printing press, the written word or the beginning of agriculture. The products can make dreams of people to come true, but it can also lead to products that we should not want to have.

Where are the products coming from?
The products were submitted by designers and technologists from six different countries. A panel of professionals in the field of nanotechnology selected the products on originality, quality of design, technological feasibility, social implications and how controversial the product could be. The products were assessed for their feasibility, which is shown in the feasibility meter. The NANO Supermarket says that there are lot of tall stories going around. By showing how feasible a product is, they want to show how close a product is to reality, so that the discussion is realistic and fruitful.

It is important to remember that NANO Supermarket is not predicting the future; it is still just gazing and guessing into the future. Nanotechnology is becoming more and more part of our society and therefore we should debate about it. NANO Supermarket tries to serve products that are something to hold into the present, to think about a future that we really want.

How Segerinks chip fits in NANO Supermarket
Segerinks chip is a nice example of the possibilities of nanotechnology. It is still in the development phase, but it is coming more and more to a usable product. Especially the entrapment chip could have big impacts, because it could be making it possible to allow parents to select their future newborn's gender for instance (de Wagenaar et al., 2015). It is important to think about possible societal effects of these technologies. History has shown that pre-implantation genetic diagnostics are very controversial (see the genome article - Mom and Dad combined). The possibilities of lab-on-a-chip sperm selection goes further than that, so it is important to think about what the effects could be, for policy makers and scientists. Policy makers are the people that create new laws for technology. On the other hand, scientists create new technology that in the end is going to be used in society, so if they think about possible effects, they can anticipate more.

The policy of debates
I have claimed several times the importance of public debate, however, knowing the importance, a public debate needs encouragement. Alan Irwin has described the way the government is encouraging debate and why that is important. The public must get opportunities to dialogue with scholars and politicians, to get to know the impact of new technologies on society and to express their views on where to go to (Irwin, 2006) (p.300). Before debate about technology was mainstream, public debate was not enhanced, because the intertwining of technology and society was not acknowledged. There was a ‘technocracy’ and ‘democracy’ dichotomy. Science and technology studies tries to bridge this polarization (p.301). When the government enhances the public debate, the regular stakeholders can be more balanced, to get to a
more fruitful and fair debate (p.311).

However, it is quite uncertain if the encouragement of debates really transforms culture and policy (p.316), because such talk distracts from the places where knowledge is gained and policy is made, the universities, R&D departments of companies and respectively parliaments. On the contrary, Irwin states that such criticism still does not account for the phenomenon of public engagement. He pleads for a more open debate of science-public relations, to consider them as social experiments in themselves, and so as an output of society: institutional frameworks and social constructs (p.317). Lastly, Irwin concludes that debate can be seen as non-meaningful rhetoric, but that does not justice to how debates in itself represent a focus on social scientific research (p.318).

**The value of NANO Supermarket**

By enhancing the public debate about nanotechnology and making it tangible, the social effects of nanotechnology in reality can be approached. This way the public gets informed about the possible effects and scientists can see their role in society. In the end the impact of nanotechnology is still very much unknown, but NANO Supermarket gives examples to think about and helps fruitful debate. (*The examples along this article are from NANO Supermarket, except the example of the fertility chip. The texts are interpretations of the descriptions from their website.*)

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**CloudCrayon** - Do you like fireworks? Don't you like rain and clouds on New Year's Eve? Then CloudCrayon is your product of choice! Every year firework shows are becoming more and more boring. Nobody is watching anymore and just drinking champange. Also suitable for festivals, national holidays, and advertising.

**Fertility Chip** - The next thing in fertility. We all "know" that you want to choose a daughter. Or that you would like philosophy talented kids. Now you can choose which part of papa is going to be transferred. Just let him drop on the chip and bingo there your little superhuman is. We will all be perfect. Or are we? Maybe the chip is only for the really rich? Is perfection really what you want?

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**Sources**


THE ETHICS OF FEMALE SPERM

Utilitarian and Deontological answers to the ethical questions of artificial sperm

Most of the previous articles consider fertility, and in particular sperm, biological. However, since the previous decade, there is a lot of research on artificial sperm. The most controversial about this might be the so called ‘female-sperm’. If this technology could be developed, it would be possible to get an all-female conception. Artificial sperm would not only allow couples in which the man is infertile, but also lesbian couples to give birth to their own biological child. One of the biggest problems of this research are the scientific ethical issues the subject involves. Some people may get hope from these experiments, others might be completely against them.

In this article, it will be discussed to what extent utilitarianism and deontology can help solving the ethical problems of female-sperm. First, an introduction in the technology of female-sperm will be given. After that, the ethical problems of this technology will be examined. Subsequently, the ethical problems will be evaluated using utilitarianism and deontology. It will be discussed whether the technology is ethically justifiable by these two theories. This article ends with a conclusion which contains some suggestions on how the ethically problematic aspects can be avoided or even solved.

A brief introduction in female-sperm

The term female-sperm can refer to two things. On the one hand, it can refer to a sperm cell that contains an X chromosome, produced in the usual way by a male. This refers to the occurrence of such a sperm fertilizing an egg and giving birth to a female. However, in this article female-sperm refers to the second meaning of the term: sperm containing genetic material from a female.

The possibility of creating female-sperm was first raised in a patent filed in 1991 (Ralph Brinster, 1991). The technique they used was to inject woman’s cells into a man’s testicles. Until 2007 there was a lot of research going on about this topic, whereupon it suddenly seemed to stop. After some years, in 2013, research in Japan made new progress in the field of female-sperm. Katsuhiko Hayashi of Kyoto University in Japan has published research in which skin cells from mice were used to create primordial germ cells. These cells, the common precursor of both male and female sex cells, were then developed into both sperm and eggs. This technology is created via in vitro fertilization, which is completely outside the body. Although the techniques involved are still in their infancy it might make it possible for sperm and eggs cells to be created from either males or females (James
How does this technology actually work? The process begins by extracting pluripotent stem cells from early-stage embryos and somatic cells (which is any body cell other than an egg or sperm). In this case the somatic cells are skin cells. An embryo's cells, unlike an adult's somatic cells, are already functionally geared to producing gametes and are therefore important to use. After that, the cells are converted into primordial germ cells (PGCs) using ‘signaling molecules’. These germ cells were transplanted into the ovaries and testes of living mice to develop. Once these cells were mature they were extracted and used to fertilize one another in vitro (James Vincent, 2013). Currently, the Japanese team led by Saitou and Hayashi is using monkey embryos as a step to get to humans in the future. Hayashi predicts that they could succeed with primates within ‘5-10 years’ and shortly after that with the creation of human PGC’s. (James Vincent, 2013).

Ethical problems
Creating female sperm involves a lot of scientific methods that are ethically controversial, especially cloning, using embryonic stem cells and creating artificial chromosomes. If these ethical issues can be justified, it would be a lot easier to justify the creation of female-sperm itself.

First let us consider the ethical problems regarding cloning. Even scientists agree that cloning for reproductive purposes should not be allowed. However, many scientists are not against therapeutic cloning. Therapeutic cloning is another phrase for a procedure known as somatic cell nuclear transfer (SCNT). A scientist takes the nucleus from a somatic cell and trades this with the nucleus of an egg. The egg now contains the patient's genetic material, or instructions. The egg is stimulated to divide and shortly thereafter forms a cluster of cells known as a blastocyst. This blastocyst has an inner cell mass that is rich in stem cells. The cells in the inner cell mass get isolated and then used to create embryonic stem cell lines. These are used to cure diseases like diabetes, parkinson and some say even cancer, but also for developing female-sperm (Ian Murnaghan, 2015).

The method of therapeutic cloning is very much related to the issue of using embrionic stem cells. These are the cells which are derived from the inner cell mass of a an early-stage preimplantation embryo, a blastocyst. Human embryos reach the blastocyst stage 4 to 5 days after fertilization. Isolating the embryoblast or inner cell mass results in destruction of the blastocyst, which raises ethical issues, including whether or not embryos at the pre-implantation stage should be considered to have the same moral status as more developed human beings. To create adult female diploid germ cells requires aborting a cloned embryo at around 7 to 8 weeks after fertilization.

Another scientific ethical problem is the creation of artificial chromosomes. This is for instance necessary to create possible Y chromosomes in female sperm. Because as we all know, female DNA only consists of two X chromosomes. It is already known that creating artificial chromosomes developed in laboratories can pick up various genetic mutations and irregularities. Even when the method creates healthy offspring, scientists question how many generations would have to be observed before they are considered genetically ‘safe’. How can we justify experimenting with DNA when we know that there are chances of mutation.

Utilitarianism
Utilitarianism might give some solutions to the ethical problems of female-sperm. Utilitarianism is, as the term already says, based on the principle of utility. This theory is founded on two principles. The first principle says that whether an act is right or wrong depends only on the results of that act. Secondly, the more good consequences an act produces, the better or more right that act. According to Jeremy Bentham, founder of utilitarianism, ethics needs to be able to measure good versus bad. He came up with a way to measure this with certain units of measurement: Hedons (pleasure) and dolors (pain), as determined by several categories. For instance by the category of intensity, which measures how strong the pleasure is. (Julia Driver, 2009).

John Stuart Mill, build further on this theory and came up with a more specific version of hedonism. He
distinguishes between intellectual and sensual pleasures. Intellectual pleasures qualitatively better than sensual pleasures (not only in degree, but in kind). According to Mill, it is better to be an unhappy human than to be an unhappy pig (David Brink, 2007).

We have two variants of utilitarianism. The first one is act utilitarianism. This theory isolates the act. For instance, when you steal beer from the supermarket it realizes huge pleasure for you and minimal pain for the supermarket. It doesn’t matter what would be the consequences if everybody would steal. Only the consequences of that particular act matters.

The second variant is rule utilitarianism. This theory is about the consequences of a particular rule. It matters what would happen if everybody would steal a beer from the supermarket. What if it was allowed to steal? In this case, we look at the consequences as if the act was a rule.

**Deontology**

A second ethical theory that might help us in the ethical female-sperm debate is deontology. Comparing utilitarianism to deontology, we see huge differences. Deontology doesn’t focus on the consequences, but judges the act itself. For instance, human beings may never be used for one’s own advantage, no matter the consequences. According to Kant, who developed this theory, we have to ground our ethics on our reason. That is why he comes up with the categorical imperative. This is a rule, which implies that we must only act according to that maxim whereby you can at the same time will that it should become a universal law. Also, the same maxim counts for every similar act. For instance stealing isn’t a righteous act, because if stealing would be the maxim, there would be no property of anyone to steal. Stealing would become impossible as universal law because of its inconsistency. Thus, stealing can never be justified. This seems very similar to rule utilitarianism, but the main difference is that rule-utilitarianism counts for all the people together, not just for one individual (Larry Alexander, 2007).

**Approaching the ethical problems**

Cloning is by many scientists considered an unethical method. However, as discussed before, this doesn’t count for therapeutic cloning. Because this method not only helps to create female-sperm, it can also help to cure a lot of diseases. This is why, when we argue in line with utilitarianism, the hedons gained from therapeutic cloning are of a huge amount. When applying act utilitarianism, the amount of hedons are huge for the individuals. When applying rule utilitarianism, a lot of people get hedons because they can be cured. Also when we apply deontology to the case of therapeutic cloning, to make a rule out of therapeutic cloning to cure people isn’t logically inconsistent. But how about the dolors? The ethical costs of this method are found in the use of the kind of cells they use in therapeutic cloning.

There are two broad types of stem cells: embryonic stem cells, which are isolated from the inner cell mass of blastocysts, and adult stem cells, which are found in various tissues. The creation of female-sperm needs embryonic stem cells and aborts these cells in the process. The ethical problem of using embryonic cells lies in the fact that you have to abort a living substance. When we use act utilitarianism on this case, we can say that the pleasure of creating a biological child of your own is a lot more than the pain of an early-stage embryo of a couple of weeks old. Also, the possibility of curing someone with a disease using this method is a huge advantage. However, using rule utilitarianism it seems like you have to look at the situation as if killing was a rule. Of course this leads to an incredible amount of dolors for the whole society. But it is important to realize that we are not talking about a full-grown human being. Using the argument of Mill, intellectual pleasures are qualitatively better than sensual pleasures (not only in degree, but in kind). An early-stage embryo can’t have intellectual pleasures and the parents who can create a biological child can. Therefore, their hedons are of a higher
amount than the doleurs of aborting the early-stage embryo. This counts as well for act- as for rule utilitarianism.

When we look at the ethical problem of using embryonic cells deontological we seem to the same kind of problem. According to deontology, you may never use human beings for your own interest. In this case, the early-stage embryos are clearly used for the interest of creating a biological child with female-sperm. The problem seems to lie again in the question if an early-stage embryo may be considered a human or not. To create adult female diploid germ cells it requires aborting a cloned embryo at around 7 to 8 weeks after fertilization. The latest abortion statistics show that about 55% of all legal abortions happen in the first eight weeks of pregnancy (CDC, Alan Guttmacher Institute). One can argue that cloning for female-sperm is as ethical (from the point of view of the embryo) as abortion, if not more so, since the goal of female sperm is to create life, not end it as in abortion. However, when we get to the categorical imperative, there seems to arise an inconsistency. To say that it should be a rule to kill all early-stage embryos, would kill mankind. After all, we all been early-stage embryos at one point. However, we are talking about embryos at a pre-implantation stage here. This also turns out to revolve on a discussion whether we are talking about human beings or not. Since the latest statistics show that the majority of abortions in the first eight weeks are legally, we can carefully say that we are not talking about human beings yet.

Then we have the problem of creating artificial chromosomes. How can we justify experimenting with DNA when we know that there are chances of mutation? Scientists have to observe not only one result, but have to observe generations before they can consider the method ‘safe’. This is besides an ethical problem also a time consuming problem. When we don’t take the time to observe the other generations, it is possible that creating artificial chromosomes would lead to very dangerous mutations. This has more doleurs than the birth of a biological child can give hedons, because if the biological child isn’t healthy, this leads to a lot of doleurs. In the worst case, this mutation could lead to the spread of a very contagious lethal disease, which would lead to even more doleurs. This counts for act- as well as for rule utilitarianism, because in both ways a lethal disease gives more doleurs than the birth of a biological child can give hedons, especially when the child isn’t healthy. When we wait to use artificial chromosomes until we observed a lot of generations, this gives us an amount of doleurs because it is so time consuming. Applying act utilitarianism, the time consuming experiments may be not worth one biological child. However, when we apply rule-utilitarianism, the possibility for every same-sex couple to reproduce gives more hedons then a few time consuming experiments can give doleurs. A lot of people are helped with the technology and only a few scientists spend their time on it. Because the technology is meant to be used by more than one person, It might be fair to say that rule utilitarianism is the best solution here.

When we look to this case in a deontological point of view, we should consider if the rule of creating artificial chromosomes leads to logical inconsistency. When research of this technique isn’t done properly, this could lead to inconsistency. If there arises a lethal contagious disease due to a mutation in the genes, this would lead to everybody dying. This again would lead to not having even the possibility to use artificial chromosomes. When we make it a rule that every technology should be observed until it is safe to use, this doesn’t lead to inconsistencies. This approach can avoid the ethical problem. When research of this technique is done properly and it turns out to be safe, then setting creating artificial chromosomes as a rule also doesn’t lead to inconsistency. Then there is no reason of not using the technology following deontology.
Any solutions?
To conclude, we have seen a lot of ethical obstacles regarding the creation of female-sperm. The first and second ethical issue are very related, because the huge disadvantage of therapeutic cloning is the use of embryonic cells. When using act- and rule utilitarianism, it turns out that the creation of biological children gives more hedons than aborting an early-stage embryo could give chores. When we look at the issue deontological, we have to decide if the early-stage embryo could be considered a human or not. The common belief is that embryos at the pre-implantation stage don’t have the same rights as full grown human beings. Looking at the embryos this way, ethically problematic aspects can be avoided.

The third scientific ethical problem is about the danger of creating artificial chromosomes. The risk of genetic mutations is without observing future generations way to high and is therefore not justifiable by either utilitarianism and deontology. This ethical problem can be solved by a lot of experimenting and observations. When also the generations after the offspring with artificial chromosomes are observed the level of risk decreases enormously. At this point the creation of artificial chromosomes gives us more pleasure than pain, because the pleasure gained by same-sex couples to reproduce is higher than the pain of a time consuming experiment. When we apply rule utilitarianism, this can therefore be justified. Also deontology can give justification at this point, there is no inconsistency in making the use of artificial chromosomes a rule when the technique is safe or in making it a rule to observe the technology until it is safe.

Both utilitarianism and deontology can give ideas on how the ethically problematic aspects can be avoided or even solved. Still, the subject remains very complex and it shall take at least some years before this technology can be developed completely. This is due to a lot of scientific problems, but also to some social ethical problems which are not discussed in this article. In my opinion, the utilitarian and deontological approach reduce the amount of ethical issues and even give some solutions for several scientific ethical problems. Only time can teach us when (or if) this technology will ever be introduced in society, until then we can only hope (or disgust). (This essay was written earlier for another course, but on behalf of the relevance, was chosen to be included as a revised version into the magazine.)

Sources
Infertility often has very negative effects on people’s life. The inability to reproduce feels for a lot of men like a failure and can cause a lot of psychological complaints, like anger and depression (Dhillon et al., 2000). This is why a lot of social studies investigated the relation between infertility and well-being. What is the connection between fertility and well-being and does infertility bring the quality of someone’s life in danger? This will be the main concern of this article. Also, does the lab-on-a-chip fertilization test of Loes Segerink improve our well-being?

This article will first investigate the effects of infertility on the well-being of people, but particular on the well-being of men. Because well-being is a very broad concept, there will be used three criteria to measure the quality of life. Secondly this article will look at well-being in relation to the fertility chip. Because the initiative of this chip was to make it an ‘at home test’, this article will investigate its future implications on the subject of well-being.

Three mediating effects of infertility
According to recent research, infertile couples undergo a lot of stress and emotional distress. This is in the first place caused by the experience of infertility, but also because of its investigation and its treatment (Dhillon et al., 2000). Infertility has indirect negative effects on the quality of life of individuals as well as of couples. To measure the effect of infertility on well-being, three criteria will be used that are considered to be related with infertility. These criteria are self-esteem, internal control and interpersonal conflict (Abbey et. al., 1992). They will serve as a criterion when it comes to infertility and its effects on the quality of life.

Self-esteem is defined as a person’s emotional evaluation of his or her own worth. It contains a judgement of oneself and also an attitude towards the self (Hewitt, 2009). Someone’s self-esteem is of incredible importance to a person’s well-being. Infertility has a huge effect on the self-esteem of people. For instance a lot of men feel less masculine when they are infertile and say that they are ‘shooting blanks’. Although women are mostly regarded as the most distressed when a couple is infertile, men seem to experience greater distress when it turns out to be that the diagnosis of infertility has to do with their sperm production or other male factors (Dhillon et al., 2000, 702). The feeling that they are less masculine then a fertile man diminishes their self-esteem. Also, the ability the reproduce is for a lot of people an element of their personal identity. When this ability is
taken from them, it feels to them like a personal failure that diminishes their self-esteem (Abbey et al., 1992, 409).

The second effect of infertility is located in internal control. Control refers to the belief that people have of who or what determines the outcomes in their life (409). The more people believe that they determine personally what happens in their lives, the more they feel like they have internal control. It turns out to be that perception of internal control has rather positive effects, like satisfaction and improved performance. In contrary, lack of control causes negative effects and overall bad performance. When a person discovers that he or she can’t procreate, this comes often as a shock. People felt their whole life like they could become parents if they would like to and suddenly this dream collapses into hard reality. Most people feel very helpless about their lack of control over future childbearing (409). They have the idea that the future of their possibility to procreate is in the hand of physicians. The infertility treatments are controlling them and their whole life revolves around doctor’s appointments (409).

The last criteria considers interpersonal relations. Research has shown that social support helps to reduce stress. It helps even more if the support is from a loved one (Kalat, 2003, 383). Although social contact can be of great value, in the case of infertility, significant others often try to help but actually say or do things that are perceived unhelpful to the receiver. Because of a lot of shared stress, partners of infertile persons often express negativity and disapproval (Abbey et al., 1992, 409). It is hard to be responsive to one and another when you are both in crisis. It is easy to fall into a misunderstanding that makes the situation even worse. The infertile person as well as the partner feel both physically and emotionally put under pressure. Therefore, they cannot fulfill each other’s needs as in a normal situation. This causes often interpersonal conflicts. Also, it has been suggested that male infertility causes even more stress for both partners in comparison with female infertility (Dhillon et al, 2000, 702).

The Fertility Chip

According to Segerink, the idea of the lab-on-a-chip fertility test was initially to let people perform the sperm test at home. This was the perspective of her promotion research, of which she still thinks is possible. However, her current research focuses also on other values who should be done in the lab. The method would at least need to be validated by using it in the lab which would maybe require 15 years. She states that the test must first be able to prove itself in the lab before it can be applied at home. If the results are positive, the sperm chip can ultimately be performed at home.

The Lab-on-a-chip fertility test might play a big role in the case of well-being when it comes to infertility. Currently, when the sperm of a man needs to get tested, he has to take his semen in a special container within an hour to the hospital. This is in the first place very uncomfortable and maybe even embarrassing, but also very time consuming. Mostly, a man needs to let his semen checked a couple of times. This means that he has to to the the same routine for multiple times for a couple of weeks. According to Segerink, the sperm chip can improve this; “Parameters of the semen quality that are normally determined in the hospital laboratory can be measured with microfluidic devices in an objective way making point of care diagnostics possible. With microfluidic devices a shift toward at
home analysis can be made, thereby reducing the costs and making it more patient friendly. Additionally, more measurements can be performed over a period of time such that a better statement of the semen quality is obtained. This information can lead to a better treatment decision of the gynaecologist, thereby improving the care of the couple that is childless by default” (Segerink et al., 2012, 3). With the lab-on-a-chip fertility test, a man can take the same kind of test as done in a laboratory at home. This saves him a lot of visits to a hospital. It is also more objective and less time consuming to analyze the semen in comparison to an analysis in the hospital. In short, the fertility chip seems to improve multiple negative situations. But what happens when we apply the fertility chip to the three criteria we used? Let’s put it to the test.

The first effect of infertility was the diminishing of self-esteem. Does the fertility test take this effect into account? The self-esteem of a man is is mainly damaged by the feeling that they are less masculine as other men. This feeling is caused by failure in their sperm production or by other factors who are considered as masculine. Because of the decrease of physician’s appointments, it might be possible that the attention of infertility also decreases. It could be that a man is less aware of his infertility, because a take home test doesn’t take as much time as hospital visits. This means that he could be less occupied with the fact of his own infertility. On the other hand, it is important to realize that such claims also depend on the final design of the test. For instance, if the sperm chip would show the results to the patient immediately after every test, it could be the case that he is even more reminded to his inability to reproduce. If the results would be only visible for the physician, this would be again a whole other case. Also, the diminishing of self-esteem lies mostly in the feeling losing masculinity. The test can’t change the fact that a man is infertile or not. So would it have any effect on self-esteem, this would be probably very little. Because the sperm chip isn’t quite in the phase of home testing yet, it is not possible to make real claims about the relation with self-esteem. This would require further research when the test is introduced as an at home application.

When we consider internal control, the fertility chip does seem to improve our well-being. A lot of infertile people feel very hampered by the way that they have to cope with infertility. The control lies most of the time in the hands of physicians. When an infertile man has to come to the hospital to get his sperm checked, this was a very time consuming and also an uncomfortable appointment. The idea of an at home test is to reduce these problems. The control who was in the hands of physicians before, seems to get more into the hands of the patient. When an at home test could be used, the man can control the environment of the test. Also, he doesn’t have to make sure he takes his container of semen within an hour to the hospital. The procedure from ejaculation to test results can be mostly done by himself when and where he is most comfort. Because of this increase of internal control, it is very plausible that the sperm chip can improve the well-being of a man in this criteria.

Finally, how does the sperm chip interact in
interpersonal conflicts? A lot of the conflict between the infertile person and his or her partner is caused by stress. The other way around, support of a loved one could help to decrease stress (Kalat, 2003, 383). It seems like in the case of infertility, the amount of stress is too much to cope with whereby the dealing with stress ends in a vicious circle with even more stress for both partners. This means that to break the circle, a decrease of stress should be found in something else than in the social relationship with the partner. If one manages to decrease the stress, this should also decrease the interpersonal conflicts. There are several things someone can do to decrease stress. An example of this is adaption and psychological coping such as stress management. A way to manage stress is to control the stress. A person has to deal with the thing that is causing the stress. This is only possible when it is in something which the individual has control over (383). Therefore, it seems that to deal with stress and interpersonal conflict, is to get more internal control. As shown in the previous section, this is something that the sperm chip could provide. Although we are only talking about a small part of extra internal control, this is still a positive effect on well-being.

Currently, the sperm chip mainly focusses on the aspect of internal control. When using the sperm chip, the life of the patient and his or her partner doesn’t revolve around appointments with the hospital as much as before. This increases the feeling of internal control. On the subject of self-esteem, there doesn’t seem to be an increase of well-being. A man still has to cope with his feelings of diminished masculinity and the sperm chip doesn’t seem to be able to solve this. However, further research could shed some more light on this. The criterion of interpersonal conflict is very much connected with the coping of stress. As research has shown, the coping of stress has to do with controlling stress and controlling the things that make you stressed out. Therefore, the third criterion is very much related to the criterion of internal control. To conclude, the lab-on-a-chip fertility test would allow its user to gain more internal control and therefore increase his well-being. However, if the lab-on-a-chip fertility test wants to improve people’s well-being on a more complete level, it might be useful to take every criteria of well-being in account. For instance in the realization of the design.

Conclusions and future recommendations

Sources
ACKNOWLEDGEMENTS

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Anton Nijholt is a computer scientist and retired professor at the University of Twente, the University of Nijmegen, McMaster University (Canada), and the Vrije Universiteit Brussel (Belgium). He was also a scientific advisor of Philips Research Europe. He initiated a study in the Human Media Interaction group at the University of Twente.

Daniel Davison is a PhD student at the University of Twente in the Human Media Interaction department. With a background in computer science he now studies social robots in educational settings.

Dennis Reidstra is an assistant professor at the Human Media Interaction group. He is currently working on interactive playgrounds, using computer-mediated games to improve rehabilitation through physical therapy, and using social robots for educational purposes.

Don Ihde is an American philosopher of science and technology, and a post-phenomenologist. He is a distinguished professor of philosophy at the State University of New York at Stony Brook. Ihde is the author of thirteen original books and the editor of many others.

Merijn Bruijnes is a PhD student at the University of Twente in the Human Media Interaction department. The topic of his PhD research is social signals in interactions between humans and artificial agents.

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What I admire most in others is the irony, the capacity to look from far away and not to take things extremely serious” – Jorge Luis Borges

The impact caused by the massacre of Charlie Hebdo has brought a media debate about humour. However, it is clear that from Shakespeare to Cervantes, humour is a sign of identity of modern societies, and the evolution of it is a reflection of our own society. But because of its paradoxical nature, it is one of the most ambivalent concepts that exist. On the one hand, humour can play with funny contradictions, but on the other hand it can be harmful. Consequently, we can see that humour is capable of the worst and the best. Does humour have limits? Charlie Chaplin makes a condition for humour to be against the strong but not against the weak (Chaplin, 1936). Groucho Marx distinguishes between irony and humour. If you say “I’ve had a perfectly wonderful evening, but this wasn’t it” but you say it to a host it will be irony, but if you say it to the public will be humour (Marx, 1962). Comte-Sponville, a contemporary French philosopher writes, “You can joke about everything but not in the same way, a joke of a Jew will not be funny in an anti-Semitic’s mouth (…) the humour heals but the irony can kill” (Comte-Sponville, 1995). Furthermore, not all the irony can be cruel, the Argentinean author Borges explains “What I admire most in others is the irony, the capacity to look from far away and not to take things extremely serious” (Borges, 1962). One can see the difficulty of explaining humour; one can see the difficulty of explaining humour, but no one can deny that humour is immersed in our daily life.

Humour in the Modern World
In the contemporary techno-scientific world, humour is being interpreted in an even more complex way, because it is being implemented in computers, video games, even robots, and a long list of other examples. Additionally, over the past few years, robots have become one of the biggest fields of study and they are being used in healthcare and education, as well as information points or as housekeepers, among various other places and uses. Moreover, one of the things that they have in common is that they are in constant relation with human beings. Therefore, engineers started to consider social aspects that make humans feel comfortable around robots, machines with which we can interact.

Hence, the development of the last years brought a shift from the traditional industrial machines into social robots. But then, what qualifies them for being good robots? Considering the multitasking and efficiency as well, they are in continuous contact with
people and thus, they should have good communication skills. This indicates that robots should be social, polite, friendly and to possess an appropriate sense of humour (Niculescu, Van Dijk, Nijholt, & Li, 2012).

What Can You Learn From This?
In these articles our focus is on social aspects and humour in robots as both are an important part of our communication and our society. The topics that we analyse among these articles on funny social robots start with a philosophical reflection on what humour is; we also study the requirements for computational humour, implications and future applications of the Turing test, ethical aspects of responsibility and trust are also being considered. Finally, we also write about the relation between robots and well-being in our modern society.

In summary, we think funny social robots can have positive effects on human-robot interactions and because it is a topic that has not been considered in depth. We aim to give an overview of the importance of verbal and non-verbal humour and the influence of these interactions with robots in order to consider it for future applications.

Are you still interested? Please read our articles and enjoy!

Sources
Where science has not yet advanced, science fiction movies show the way.

Robots, funny or not, social or asocial, can be found often in science fiction movies. In those cases movies serve a dual purpose. The obvious one is the one for entertainment, having a good time watching a movie that is based on fictional events. The other one, and often not acknowledged adequately, is as an inspirational basis for scientists, engineers, architects, and anthropologists. When certain fictional and unprecedented ideas are getting visualised, the viewer can comprehend, associate or even question the case that is presented. Even if the presented science fiction can be unscientific, it still raises the question on whether and how this can be actualized.

Science fiction viewers often notice a number of funny, more or less, robots that are shown on movies despite the fact that the topic of computational humour is not generally known to the public. Computational humour had its first conference only in 1996 in Amsterdam (Nijholt & Hulstijn, 1996). Nonetheless, funny robots were present in science fiction movies years back. They play either a supportive role for the main human characters to accomplish their tasks and missions, or are the sole residents of planets in an apocalyptic distant future. Their characteristics in movies often resembles more
human aspects and in frequent cases the robots have their own humour.

Two of the most notable examples are the famous robots in the popular Star Wars movies from George Lucas (1977) named R2-D2 and C-3PO. C-3PO was the golden robot that had the ability to speak a great number of languages. R2-D2, however, had no verbal language characteristics and was just able to produce some simple sounds. This is already a crucial distinction between these movie robots. C-3PO was a robot that processed thousands of languages among alien civilizations, whilst R2-D2 was not able to communicate with a human language based system. Though the behaviour of R2-D2 was diversified in the story, any humorous aspect was just in a matter of context, movements and repeated sounds. Despite this crucial difference in the verbal and non-verbal aspect they both managed to produce humorous incidents. This distinction illustrates that humour has multiple aspects and is not necessarily based on language alone, but can include multiple and differentiated factors like the context, movements, and situational awareness.

We can grasp this difference in-depth by looking at silent movies where the movies did not include any sound performance at all, either verbal, non-verbal, or bodily sounds. The most notable example of this are the silent movies of Charlie Chaplin, in which a tremendous amount of humour was not spoken or written language. The structure of the humour was based on the actor’s facial and bodily behaviour, expressions, or in general in reactionary movements in his innocent fights. Charlie Chaplin and his producers have offered genuine laughter without the audience being able to even hear their sighs (Halperin, 2011).

In the more recent movie called Interstellar, directed by Christopher Nolan (2014), one robot was having a supportive but crucial role. The robot TARS, which was responsible for a number of functions on the spaceship, was also programmed with humour capabilities. Since the technology was quite advanced humans were able to adjust the level of humour that the robot was displaying. It could be adjusted to, for example, 100% or 65% based on the desired level of humour by the humans around it. This raises two important matters. The first one is the sociological use of a humorous robot. There is a need for humorous robots that can be functional but also being able to produce humour based on situational awareness, understanding the situation and the need for what kind of humour is required. A second aspect is that TARS’ humour was adjustable. Jokes have become an
adjustable variation, algorithms that can be calculated of and for a number of aspects. This presupposes that humour can be a specified program, a product that can be adjusted to fit the needs of spacemen and spacewomen.

Besides the technical parts, science fiction movies provide us examples where we can perceive the type of humour that is used. Once more, in the silent movies of Charlie Chaplin a second aspect which we can comprehend is the type of humour that has been used in movies. Charlo, one of the roles that played by Chaplin, was a victim of stronger men or of the general situation. He was fighting against the odds in a devilish but good hearted way. Firstly, in many cases the humour was expressing an incongruent behaviour of either side where, for example, Charlo was expected to do one thing but did something different. Secondly, there were also instances of the superior relations between the roles, where the innocent and harmless kicks were changing sides. Lastly, there were those cases where humour was used as a mean for relief; escaping the unfortunate situation. While in the Charlo series theories as incongruity, superiority, and relief theories of humour were used, in Interstellar the jokes were based on the relief theory of humour. TARS with his programmed humour had the task to lighten the atmosphere for the stressed astronauts.

In the end, humour has always had an important role in movies. More and more developments make their entrance in the field of entertainment as science advances. The line between science fiction and real cases becomes thinner and thinner. Nowadays we try to create robots that are able to engage in humorous discussions not too far away from the robots in Star Wars. The same happens with the prominent example of the NAO robot of Heather Knight (2010) where the robot can respond in sometimes shallow yet promising ways. TARS inspires the way of how a funny social robot could be used and in what fields robotic humour can apply. Once more, science fiction movies can provide access to other’s imagination but can also drive current scientist’s and engineer’s motives.

Sources

Images
Humour is epiphanic, it exists in that momentary revelation which lies beyond conventional reasoning, defying its authority and uncovering the evanescent reality of its own internal logic.” – Professor Evelyn Fishburn

To begin with, we have to understand the most fundamental mechanisms of humour in order to implement it in robots. But, what is humour? How is created? This article aims to understand and summarize the most fundamental characteristics of humour.

Etymologically, the word “humour” comes from the Latin word “humere” which means “bodily fluid” used to express different mental mind dispositions; as Hippocrates already understood, humour has a therapeutic effect. This led, in the 16th century to the word “humour” as a mood or state of mind. During the late 16th century is when we start to use this word as “the quality of being amusing or comic” (Oxford Dictionary, 2015).

Nevertheless, the importance of humour is indicated since the ancient Greece, where human being was defined as “homo ridens” (man laughing), highlighting the fact that laughter distinguishes us from the rest of the species (Aristotle, 350 B.C). However, in the last centuries, humour has also been an important field of study in academia and specially, on sciences. Freud for example, considered humour as an important part to relieve tensions; it affects body and mind (Freud, 1905). The philosopher Henri Bergson has similar ideas, but he considers it as a purely social mechanism. He describes humour in different aspects as comics, social role, as gestures, or even human imagination (Bergson, 1924). He affirms that laughter have a moral role and create better social individuals. Bergson referred to “mechanical inelasticity” because like the machines, humans who cannot adapt to different or unexpected situations can lead to funny aspects. Bergson even divided humour into four categories: Language, logic, identity and action.

Humour is defined among philosophers, psychologists and sociologists in many different ways. Evelyn Fishburn, professor at the University College London, explains that “humour is epiphanic, it exists in that momentary revelation which lies beyond conventional reasoning, defying its authority and uncovering the evanescent reality of its own internal logic” (Fishburn, 2001). Furthermore, she affirms that the most important perspective of humour is based on a shared knowledge of cultural context. Thus, it is needed to be immersed in the culture, or at least to understand it, to be able to see what has been changed, and thus to see
why it is funny. This suggests that the same joke can be seen from different perspectives, and it can therefore have different reactions.

Main Theories of Humour
There are many theories of humour that intend to explain what is humour, which social function it serves, and what is considered as humorous. In academia it is usual to mention three of them: superiority theory, incongruity theory and relief theory. However, there are also other theories such as general theory of verbal humour or the computational-neural theory of humour.

Firstly, superiority theory is based on Hobbes. He has seen laughter as the way of resemble superiority among others. He affirms that “the passion of laughter is nothing else but a sudden glory arising from sudden conception of some eminency in ourselves, by comparison with the infirmities of others” (Hobbes, 1651). The fundamental idea is that humour expresses superiority feelings over people; therefore there are always winners and losers on jokes.

Secondly, relief theory is influenced by superiority theory. It begins with Shaftesbury, who considered that laughter releases animal spirits that have built pressure inside our nerves (Shaftesbury, 1709). This reminds the Greek meaning of “humour” as a mental disposition of the mind. Furthermore, this idea was taken by Freud who considered that laughter could get rid of nervous energy, for example certain types of emotions, as sexuality or desire.

Thirdly, the incongruity theory is one of the most famous, which affirms that humour is the perception of something incongruous, something that violates our mental patterns and expectations. This theory distinguishes between the first part of the joke in which is created the expectation, and the second part that violates that expectation. Thus, the incongruity theory explains that the ending is incongruous with the beginning of a joke; it shows that there exists a cognitive shift or effort to change a particular situation.

Alternative Theories of Humour
Alternatively, more recently it is proposed the general theory of verbal humour (GTVH), and the computational-neural theory. The GTVH was conceived by Attardo and Raskin, for them humour is the incongruities expressed between semantics. According to them, semantics allows generalizations of different opposites, and the more abstract generalizations simplify things considerably, and there is when humour is created. (Raskin, 1985). Raskin uses the following example for these jokes: “Is the doctor at home”? – “No, come right in”. According to Raskin, the joke is compatible with two opposites: doctor is at home or the doctor is not at home; in other words “the patient comes to the doctor’s house to see the doctor” versus “the patient comes to the house not to see the doctor” (Raskin, 1985).
Moreover, Suslov proposed the computational-neural theory in 1992, he affirms that humour has a biological origin based on a malfunction of the consciousness made by incongruities; it is a natural way of releasing incongruities in our brain. Furthermore this theory shows equally verbal humour and non-verbal humour (visually), the last is referred for example to caricatures.

**Conclusion**

Most of the theories of humour are about analysing humour and not about generating it. More recently the visual (non-verbal) joke is also finally being taken into account after years of being ignored. However, the first four mentioned theories are mostly about jokes but not so much about non-verbal humour. Overall, these theories show that humour does serve many functions essential to human needs. It can relieve certain mental frustrations (relief theory), it can make you feel superior and likely to be seen (superiority theory). In addition to the evolutionary functions of laughter, humour plays an important role in social interactions, as the superiority theory suggests, as well as influencing people’s perceptions of others as fail jokes or tension in social situations. We consider that the framework of humour should be studied if we want to to able to successfully influence emotional states. This can be associated with numerous positive outcomes including well-being.

Sources


As we learn more about humour and social robots there will likely be more old theories and insights that can contribute in a fresh, new way.

New technologies inevitably end up teaching us more than we thought we would learn beforehand. Human creativity regularly discovers new ways of interacting with the world around us. Whatever may be invented, you can rest assured that there will be some unintended and unforeseen ways of using the invention.

This text discusses two ways in which funny social robots can give us new insights. One way is through using an existing theory in a different way than was originally intended; this theory being the Turing Test. The other way is through creating something that has no specific goal and then simply observing what happens and what we can learn from that; this has also been called “stupid design”. This will be elaborated on later on in this text.

The Turing Test
In 1950 Alan Turing wrote a paper called “Computing Machinery and Intelligence” which first asked the question whether machines can think. With “thinking” being too much of a challenge to define successfully, he instead formulated a question that was closely related and is more answerable, namely: “are there imaginable digital computers which would do well in the imitation game?”

The Turing test is an adaptation of the Imitation Game, a three player party game consisting of one woman, one man, and one interrogator (who can be either male or female). During the game, the interrogator is in another room and will ask questions to both subjects. It is then the interrogator’s task to determine based on the responses from the subjects which of them is the man or the woman. The questions and answers must be communicated through a neutral medium, for example with passing notes. The man and the woman have a specific task of their own as well though. The man has to try to deceive the interrogator into thinking he is actually the woman, whereas the woman has to assist the interrogator in making the right choice.

Now that a game is set up, replace the man with a computer or digital agent, replace the notes with a type of computer-mediated communication, and play the game several times. If the interrogator picks either participant, the human or the computer, an equal number of times then it may be said that the computer is intelligent. There is a small distinction that must be made when it comes to the purpose of this test. Common understanding is that the Turing Test is made to determine whether a computer can deceive an interrogator into thinking the computer is a human. The actual purpose, however, is to determine whether
There is no need for robots to fool us into thinking whether or not they are human when it comes to humour. They only have to be funny, whether or not we think of them as human beings.

There are several weaknesses to the test, though. Imitation is done partially through intelligent behaviour such as being able to carry on a conversation. There is, however, also unintelligent behaviour that we could consider very human, such as making mistakes when talking or typing, or being susceptible to insult (Saygin & Cicikerli, 2002). The other side, inhuman intelligent behaviour is also a possibility. For example, take a digital agent that can solve a problem that is practically impossible for humans to solve.

John Searle (1980) also argued that external behaviour is not a sign of intelligence or that the machine is thinking or even simulating thinking. He uses the Chinese Room argument to show that the Turing test can be a good practical or operational definition of intelligence, but it does not necessarily indicate a mind or consciousness.

Another mistake is that humans quite easily fall into the anthropomorphic fallacy, otherwise known as the pathetic fallacy. Interrogators ascribe human traits to non-human objects. We see this in people talking to their cars or when we describe natural forces having intentions or desires. This human tendency makes it easier for the robot to fool the interrogator (Shah & Warwick, 2010).

Rather than having computers imitate human beings by a display of intelligence, with funny social robots there also exists the possibility of focusing on humour instead. Humour is something that we generally consider to be uniquely human. If humour is to be implemented in artificial intelligence and social robots then it makes sense for imitation to be standard by which we measure their success. There is no need for robots to fool us into thinking whether or not they are human when it comes to humour. They only have to be funny, whether or not we think of them as human beings.

**Stupid Design**

Another way of getting a fresh perspective on a new technology is by failing to design a specific function. For example, placing a robot in an educational context without it being designed for education could lead to unforeseen interactions with people. Users would expect the robot to help them, yet the robot, lacking the appropriate programming to meet that expectation, would just talk about whatever the users talk about.
The ensuing dynamics can teach researchers a lot about the way people interact with robots and how situations, context, and expectations can shape these interactions.

An interview with Dennis Reidstra (2015), a researcher at the University of Twente’s Human Media Interaction department, about his research with what he called “stupid design” or “asocial robots” gave a glimpse of the various things that could happen when robots do not act as expected. For example, robots that turned away, avoided eye contact, or generally just seemed to willingly ignore people during an interaction made users feel uneasy and surprised. If this, however, was the expected behaviour of the robot, then in all likelihood there would be no hurt feelings. Much research still needs to be done to fully grasp how humans interact with social robots, and this “stupid design” can be a great tool for that endeavour. Reidstra called it a great way to find problems to solve, though it is not great at finding any answers.

**Future Research**

In the future it remains to be seen what kind of a social robot we would like to work with. Would we want a robot that is marginally good at a broad range of tasks, or would we want to have one that exceptionally good in a very narrow field of application?

The Turing test, when used to determine humorousness rather than intelligence, has a future ahead of itself. It matters less whether it can imitate human intelligence and instead can focus on mimicking human humour. The drawbacks of the anthropomorphic fallacy could in this scenario actually be beneficial. Ascribing human characteristics to a funny social robot may make them all the more appealing and humorous. Moreover, the distinctly human unintelligent behaviour and inhuman intelligent behaviour that robots and artificial intelligence could show can be an additional source of humour, rather than being framed as a deficient imitation of intelligence.

Both the Turing test and stupid design offer possibilities of renewed application and use. As we learn more about humour and social robots there will likely be more old theories and insights that can contribute in a fresh, new way. Future research and development of funny social robots can therefore produce much more than just witty soft- and hardware.

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The Humorous Computer Scientist

Not every slip on a banana peel guarantees humour
– Anton Nijholt

Theories of humour intent to explain what humour is, and its main characteristics; they show how, through language, we are able to play with humour. It appears as incongruous situations, depending on cultural or psychological circumstances that make it ambiguous, but it also relieves us from certain emotions. Nonetheless, according to the computational-neural theory, and Bergson’s ideas, we do not only have jokes but non-verbal humour it is also important.

Nowadays, humour has grown from human characteristic into a technological tool; it is being used in design, computers, video games, robots and so on. But then, how can we generate humour?

We have interviewed Anton Nijholt, famous computer scientists, and retired professor at the University of Twente. He is specialised in computational humour. Nijholt starts explaining that there is a human-computer interaction research group at the UT, where it is being researched the natural language dialogue systems and natural language interfaces. Furthermore, it has been expanded to face expressions and behavioural sciences, like smiles or laughter, which are highly important in human interaction. This research group has attended to conferences on computational humour and participated with many other scientists, including the famous Marvin Minsky.

The Importance of Humour

Nijholt affirms that humour is much more than just telling jokes, he highlight that “There is not so much joke-telling in the world (...) Jokes are constructed, they are artificial. You have to say: well now I am going to tell a joke”. The computer scientist continues explaining that if we consider the incongruity theory, we will be able to create different humour situation without the necessity of making jokes; for example while having a conversation, it is possible to have humorous remarks. He also pointed out that his interests are focus on non-verbal humour, but this is not just physical. There are, according to him, more situations that you can consider to laugh at, he gives the example of a bicycle going around cars, he affirms “This is something strange, unexpected and can be funny”. Thus, the Dutch scientist is explaining that there are different possibilities, rather than just semantic jokes, if we want to implement humour into a machine.
He follows explaining that incongruity theory can be the most interesting theory on a funny machine; it has a “cognitive point of view, then you need cognitive effort to understand a particular situation, there is always a cognitive shift”. Nijholt even asks, “What makes this shift to be funny? (…) The situation can be confusing because you don’t understand it”. He considers this shift as “creative and productive” and he sees that these incongruous situations can be generated in the machine. But in order to do this, he considers artificial intelligence (AI) as an important constituent. Thus, if one wants to create these humorous situations, machines will have to “understand everything that is going on (…) everything can go on in a joke, no limit there”.

**Being careful with humour**

On the contrary, during the interview, the side effect of humour arises. Based on previous arguments, in which we see how humour can affect the behaviour of people, then, how close is humour to manipulation? Companies might push people in certain directions, and some ethical aspects may arise and must be considered.

**Positive effects**

In addition, Nijholt explains in one of his articles that in our modern society, the development of social media produce a constant multitasking behaviour, which allow us to have more incongruous and therefore humorous situations (Nijholt 2015). Nonetheless, the computer scientist explains that in AI, the most common examples are at the lexical level with “pun riddles” (Brinsted & Ritchie, 1994) or funny abbreviations (Nijholt, 2015). Although his observations tend to affirm that we have to distinguish from certain environments “it helps us to choose and combine techniques to achieve certain effects (…) it can help us to design certain humour
styles that can be adopted by an environment” (Nijholt, 2015). He continues saying that in the future, engineers will have to take into account the preferences from their clients and “this leads to designed environments with different characteristics and personalities. And, in the future, they can be designed with different kinds of senses of humour” (Nijholt, 2015). He also point out that “feelings of superiority and relief may be harder to address from a research point of view than detecting or generating incongruities” (Nijholt, 2015).

**Six areas of development**

In 2012 it took place in Amsterdam the third international workshop on computational humour. Oliviero Stock, professor and researcher at the university of Trento, in one of the abstracts of this conference, proposed six areas for the development of computational humour (Nijholt, 2012):

Theory - theories are needed to describe the creative process of humour.

Evaluation - there are different attitudes to humour. This is why it is especially important to have evaluation for human behaviour. Thus, we will have a better effectiveness on automatic realizations.

Humour production - it is a “realistic challenge” to study the ways in which we can create verbal humour.

Recognizing humour - it is also realistic to recognize simple forms of humour.

Multimodality and new forms of humour – multimodality should be studied, instead of just verbal humour, and in that way, improve the potential of new devices (which have different ways of interaction)

Sociality - As Nijholt and Freud mentioned, society is extremely important; it can create a distinction on humorous roles. The study and understanding of the context will be central to have favourable effects of humour.

**Conclusion**

Through humour we can generate positive emotions and trust, which can make humans more aware and more likely to spend time with the machine. However, we can notice that not every humour is appropriate; it depends on social and cultural circumstances. Nijholt reminds that we can find humour in language and incongruous situations, but we can implement non-verbal humour with much more interesting results. The human-robot interaction should go hand in hand with the ability of humour, and thus we can achieve much more interesting results.

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Humour then becomes not only a hedonistic factor, but also a safety factor for both users and robots, and a sign of social intelligence.

Essential to the “Turing test” is how the artificial intelligence is perceived by the participants. The AI has to be perceived to be as “humanlike” as possible (Turing, 1950). As humour can be seen as very human behaviour, it can be theorized that this would significantly improve the chances of an artificial robot or agent to pass this famous test. To see if this is plausible, this article will focus on how humour can contribute to the “human likeness” of artificial agents and (social) robots. This will be done by discussing three articles related to this question. The first article (Dybala, Ptaszynski, Rzepka, & Araki, 2008) will be used to show that humor does increase the human likeness in artificial agents (chatterbot). The second article (Bartneck, Kanda, Mubin, & Al Mahmud, 2009) will discuss how to increase the animacy of more physical robots. The last article (Bartneck, Verbunt, Mubin, & Al Mahmud, 2007) will discuss why this human likeness an animacy do matter for robots and artificial agents in a bit different test, the article will discuss the willingness of the user to “kill” a robot.

Modalin versus Pundalin
In the first article a comparative experiment had been conducted between the use of two question-answer systems or chatterbots. These two chatterbots were Modalin and Pundalin (Dybala et al., 2008). In this experiment Modalin is a freely talking keyword-based conversational system. The user decides a conversation topic and then the system extracts related sets of words based on keywords detected in the user’s contribution to the conversation (Dybala et al., 2008). The system used real time Goo search bits to create word associations. Apart from that it could also check the “naturalness” of presented sentences using the Internet. To sum up, Modalin is a system that answers user’s sentences with a modality-added sentence that (should) relate to the topic at hand. (Dybala et al., 2008). Pundalin on the other hand was a merging of Modalin and a joke generator named “PUNDA Simple”, a simplified version of PUNDA Japanese pun generator. This system was programmed similar to Modalin. It was additionally programmed to extract base words from the user’s speech and transforming it using Japanese pun phonetic generation patterns. With the patterns it creates a phonetic candidate list (for puns). The system that decided how many jokes Pundalin made was quite straightforward: every third turn of the conversation a pun would be made.

The impact of humor on the performance of the chatterbots was checked in two evaluation experiments, with the non-humorous Modalin as the
baseline and humorous Pundalin as the main system. The two methods were first person (users) focused evaluation and third person (non-user) focused evaluation. In the first person evaluation the results showed that they considered Pundalin significantly more humanlike than Modalin, This means that they probably understood it in a commonsensical way as, more or less, “behaving in a way humans do” (Dybała et al., 2008). From the third person perspective, the human likeness was tested in a less explicit way. However, it could be concluded that Pundalin was perceived as slightly more humanlike than Modalin.

Designing Animacy
In the article “Does the design of a robot influence its animacy and perceived intelligence?” (Bartneck et al., 2009), an experiment is conducted on how people perceived different signs of robot embodiment in terms of animacy and intelligence. The robots used in this experiment were the ICat and the Robovie II. In a between-participant experiment both robots were tested on the named factors. The participants were required to fill in a questionnaire in order to gather background information about the experience they had with the robots. Next to that the animacy of the robot was tested by letting the participant fill in another questionnaire containing items based on related semantic concepts. Lastly different video recordings were used to measure the animacy of different parts of the robot by measuring the amount of time the participants looked at it.

The results showed that for the perceived animacy the improved realism did not add much to the previously held beliefs of the participants. However, it showed that the higher the perceived intelligence, the higher the perceived animacy. This seems to underscore that the behaviour is more important than appearance for animacy. However, the results also showed that the ICat, which was designed with facial expressions, seemed to attract more and longer attention from the participants than the Robovie II. Because of that information the authors conclude that there should be more research in robotic facial expression.

To Kill a Mockingbird Robot
The last article to mention turned the test for human likeness around completely. In order to test the human likeness of robots there was experiment devised to measure the willingness of people to “kill” a robot. First the participants were asked to rate the robots as smart or stupid, they let participants fill in a test about the robot’s behaviour. After this evaluation they were asked to destroy the robot (either taking it apart with a screwdriver or smashing it to bits with a hammer). The results of this experiment were quite interesting.

Robots that were rated more “stupid” were hit three times more often compared to the “smart” one. Given more participants, also, the number of pieces (resulting from hitting the robot) might have been influenced significantly. Overall, the user’s destructive behavior measured by number of hits and number of pieces resulted in a prediction accuracy of 76%. By looking at the destructive behavior alone, the model was able to predict the robot’s perceived intelligence, as rated by the participants, with an accuracy of 76%. This is well above the 50% chance level. (Bartneck et al., 2007). With this data alone one should be hesitant to draw conclusions, though. The assumption is that if the participants perceive the robot as being more intelligent and hence more alive, then they would be more hesitant to kill it and consequently cause less damage. However, given that a participant experienced the robot to be intelligent and/or alive, they could have made a “swift kill” to prevent any extra suffering. Such strikes can result in large damage to the robot and therefore many broken pieces. On the other hand, the participants could have also tried to do just enough damage to destroy the robot, this way they could keep the destruction at a minimum level (Bartneck et al., 2007). As a final observation, all of
the participants showed classical distress symptoms during the destruction of the robots (all the participants giggled or laughed), not much unlike the behaviour of participants in the Milgram experiment (Milgram, 1974). This can then be interpreted that the participants found the robot humanlike enough to be distressed by their own destructive behavior.

**Conclusion**

To come back to the focus of this article, the human likeness and the relation to humour, we can conclude that humour as a basis for human likeness does matter. From the Modalin versus Pundalin example we can see that humor does significantly contribute to the human likeness of robots and artificial agents. Human likeness here can be interpreted as “in the way as humans do”. From the second article we can conclude that the outward appearance of robots and artificial agents does matter less than the perceived intelligence. The results were a bit ambiguous because even though they were not important for the perceived intelligence, the facial expression of the ICat did attract prolonged attention of the users. Lastly we can conclude from the “To kill a mockingbird robot” article, that this perceived intelligence is again highly correlated with perceived human likeness. Participants were more destructive towards robots when they perceived it as less smart and thus less human like and less animate.

Putting this together one can conclude that humour is an important factor for designing robots and artificial agents, even if it would just be for its protection. Humour of the agent correlates highly with the perceived intelligence, which in turn correlates with animacy. This might also help an AI robot or virtual agent to perform better in the Turing test. Apart from that, these factors contribute to the behaviour of humans towards the agents. The distress seen during the destruction of the robots, shows that robots can be considered humanlike enough to avoid harming them.

This attitude is vital for the acceptance of robots and artificial agents into domestic settings. Humour then becomes not only a hedonistic factor, but also a safety factor for both users and robots, and a sign of social intelligence. Both factors contribute towards the possibility of domestic robot use (Young, Hawkins, Sharlin, & Igarashi, 2009).

**Sources**


In previous articles we have seen the prerequisites of designing a robot that is planned to have a social use. Technical parts, like voice pitch or facial movements, may be largely unnoticed by an audience. But, the means of transferring humour are essential factors to computational humour. This can be distinguished into two categories: verbal humour and non-verbal humour.

The study of non-verbal humour has a close relation to verbal humour. However, non-verbal is multilayered and more complex; it requires some of the concepts that are used in verbal humour but in more demanding processes. Instances of non-verbal humour are the humorous acts that require a combination of movements, expressions, context and so on. In the end, a concept of the combination between non-verbal and verbal humour on a robot would be for example: if a robot trips on the floor and consequently discredits its unfortunate situation (e.g. “I hate my life”).

The Case of STANDUP & Other Examples
A sole focus on verbal humour requires a different structure. An interface that a user can view and has phrases or sentences with mixed punchlines can be programmed by a plain algorithm. An example of this algorithmic use of computational humour is the System To Augment Non-speakers Dialogue Using Pun or just STANDUP (Ritchie, Manurung, Pain, Waller, Black & O'Mara, 2007). Its general purpose is to help kids with verbal problems in a fun, interactive learning context. The software was built in the programming language Java and generates puns by using the concept that two words sound similar but are not synonyms. An instance of this is the following:

What kind of tree is nauseated?
A sick-amore.
- (Ritchie et al., 2007, p. 91)
To the ones that have spent some time in programming the above example will seem rudimentary. As the researchers for STANDUP program refer to their article, they uploaded a database of keywords which would be used for riddles and answers. Consequently, there are some preconditions that apply to the riddles that are generated, like a phonetic relation between words, or not repeating the same riddle to the same user. The overall concept includes the idea that certain words can be drawn from databases and correlated with other words that have similarities in some level, as happens with synonyms-homophones. As the authors state in their article concerning the difference between jokes, the program “involves slightly different phrases which originate from the same semantic material expanded and realized in varying ways” (Ritchie et al., 2007, p.94). In their discussion, they state that the STANDUP software can produce approximately one million jokes.

Other examples have already been put forth in previous articles like the chatterbots Pundalin and Modalin which used databases with keywords to provide answers (Dybala, Ptaszynski, Rzepka, & Araki, 2008). A second example is the one of HAHAcronym, the first European program on computational humour (Stock, Strapparava, 2003). Using incongruity theory there is a mismatch on the meaning of the acronyms and its sentence structure.

In this example a similar lectual structure is used, while the meaning is changed. The overall program was evaluated positively by a number of participants and was considered funny (Stock, Strapparava, 2003). In the HAHAcronym case while it was expected for the abbreviation ESA to mean European Space Agency, yet it produced something that is indeed related in lexical structure but is semantically fundamentally different.

Analysing the pun produced by STANDUP software concerning the sick tree, it can be noticed that the incongruity theory of humour is applied. In this riddle-pun we expected an answer about the genre of trees. Instead we received an answer that sounds like the word sycamore, a tree, but while it sounds the same, the semantic is different. In previous articles the essence and importance of incongruity theory for computational humour have been developed. As mentioned already in the General Theory of Verbal Humour, humour can be achieved when there is a semantic incongruity between sentences (Raskin, 1985).

Deepening the research, a group of researchers have made a computational model on the incongruity theory on puns, in which they conclude that ambiguity and distinctiveness on the semantic level is crucial for the funniness of puns (Kao, Levy & Goodman, 2013). This results in a problem of added difficulty since ambiguity in algorithms is difficult to implement successfully. Algorithms may have results that are produced statistically at random, but to create an ambiguous result requires a new level of research.

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Japanese pun is funny or not (Dybala, Rzepka, Araki, & Sayama, 2012). The cultural aspects of verbal humour can easily be seen in cases when a translation of a funny quote from a movie results in an unfunny punchline. Differences between cultures is a challenge for the field of verbal humour which may be overridden using a combination with non-verbal and verbal humour.

**Conclusion**

Examples like STANDUP and HAHAcronym are used to generalise a crucial aspect of computational humour. Also are noted the cases where problematic aspects have come forth, like the cultural differences of puns and the ambiguity that is necessary for successful jokes. However, verbal aspects of humour remain a fundamental field of research for computational humour. The reason for this is that while non-verbal humour can find application in robotics as a side issue, there is software that could use some verbal aspects to lighten the situation. Let’s imagine for instance, a driver finishing her overwhelming day. She gets in her car and says to her GPS “Tell me the fastest way to go home”, for which the GPS software, using relief theory of humour, responds: “At last, we will go to rest”.

Sources


SIGNIFICANT DETAILS: EYE GAZE, VOICE PITCH, AND FACIAL MOVEMENTS

The importance of unnoticed movements and nods to convey a message.

An important factor on computational humour, and in social robots in general, is the design of the robot. Much like the comedy movies, a vast amount of humour is a result of a combination of jokes with movements and expressions. In order for scientists and engineers to achieve convincing jokes and genuine laughter of the audience, certain attributes have to be added. The reason for this is so that the audience focuses on the jokes instead of unpolished technical aspects. Scientists have given an effort to replicate some behaviours of humans that are intuitively considered as signs for cognitive processes. Consider for example signs that the discussant pays attention to the discussion.

On the required relation that needs to be structured among robots and humans to produce acceptable jokes, some basic characteristics that have been used are: a) the eye gaze and its aversion from the debater, b) voice pitch: on which the depth of the voice may result to different feelings towards the robot, and c) face fuzziness: the general movement of facial muscles that take place in a conversation. Each of the above issues are known to differ the level of intimacy among humans, and lately between humans and robots.

Eye Gaze
Eye gaze is crucial for intimacy between discussants (Kleinke, 1986) and intimacy is crucial for humour (Hampes, 1992). From this point of view, the reasons on how people perceive certain robotic behaviours is relevant for the study of developing computational humour. There have been numerous studies that focused on the degree to which eye gaze affects human relations and the way that this should be implemented on robots. One such experiment was conducted in 2001 (Vertegaal, Slagter, Veer, & Nijholt, 2001). The experiment showed that eye gaze can show whether...
partners of a conversation pay attention to what the other person discusses about.

A more recent experiment by Sean Andrist and his team elaborated on the aversion of the eye gaze and the way that this could be implemented on robots (Andrist, Tan, Gleicher, & Mutlu, 2014). On previous studies has been found that eye gaze and its aversion to different directions play a multi-layered role on human interactions: a) the aversion of eye gaze of the speaker is considered as an instance of a cognitive process, for example evaluating a case or a clue, b) aversion is considered as a sign of intimacy from speaker to speaker c) floor management, which means that in spite of the speaker having averted her gaze she still holds the ground of the conversation (Andrist et al., 2014). Each of the above are used in a similar pattern to indicate that robots might have intentionality when they refer to something. The implementation of the data was embodied on a type of robots named NAO which was able to read its fellow discussant with a Kinect device and react appropriately (Stark, 2012). NAO is a social robot already used in the case of computational humour by Heather Knight (2010).

The analysis of Andrist and his team showed that the eye aversion and total head movements were perceived as intentional motions for the robot to have some cognitive process over the issue being discussed. A further point was that robots with gaze aversion were considered more creative than others that were not programmed in a similar way. Finally, that robots that were using gaze aversion were less likely to be interrupted compared to others that did not use gaze aversion.

**Voice Pitch & Fuzzy Face**

A different study was done on the significance of voices on robots (Niculescu, Dijk, Nijholt, & See, 2011). Specifically on how the voice pitch affects the way that the behaviour of a robot is evaluated. The background for this experiment were the numerous findings on the way that voice pitch affects human’s relations with others when the voice is perceived as attractive and the known social benefits that result from this. An introduction to the topic can be found by Zuckerman and Miyake (1993) where they question what makes an attractive voice.

The research of Niculescu et al. (2011) included a robot which was playing the role of a hotel receptionist. Twenty-eight participants evaluated the robot based on their interaction with it. The experiment used one robot but the voice was altered to a higher (Olivia) and lower pitch (Cynthia) to evaluate the hypotheses. Due to limited resources, they used the same robot, but with small alterations of the appearance and a different voice pitch. The study revealed that users preferred the high-pitched voice of Olivia over Cynthia as a social robot in matters of personality, appearance, and behaviour.

Another interesting field of research is the facial movements and their importance as a supplement to non-verbal communication. One prominent example to our older readers might be the robot called Kismet (Breazeal, 2002). Kismet was programmed to show expressions moving fake eyes, eyebrows, and so on. Kismet was produced in the late 1990’s by Cynthia Breazeal and it was one of the first well-known examples of facial expressions on robots.

A system that would implement a pattern of facial movements is necessary for achieving high levels of human-robots interaction. One relevant study was about the generation of facial expressions and head movements that will be based on a fuzzy system (Nijholt, Heylen, Poel, & Bui, 2001). Their intentions were to make a 3D map of facial expressions and implement them on different varieties of robots. They supported the idea that besides a level of linguistic capabilities, robots should have convincing facial movements if they were to be functional on different tasks that could be held from social robots like commerce.

**Conclusion**

In this article a few basic concepts were introduced that to a certain extent are requisite for the social aspect of social robots. The reason that this overview primarily concerns basic concepts is that small things like voice pitch are of great importance for a robot to be convincing. However, looking at the bigger picture, modern robots have evolved from the point of robots
Kismet was the first well-known robot that had facial expressions like Kismet. In early 2015, we can find social robots that can or will be held responsible for a number of tasks such as keeping a hotel clean and operational (Moon, 2015). In addition, these robots resemble to a great degree human movements while engaging in social tasks.

As will be presented in another article of this magazine, there is a standard point where humans, as a species, feel uncomfortable with the image of something that resembles humans and simultaneously is not. This phenomenon is called Uncanny Valley, and was introduced by Masahiro Mori (1970). Following this concept it is not surprising that Heather Knight chose to use a NAO robot for her concept on stand-up comedian robots. A robot that instead of resembling to a human being, operates on some basic functions that will make it achieve its task.

Sources
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Images
Funny social robots may approach the Uncanny Valley in various ways. Not only will they oftentimes look like us, they will move like we do, and even have social interactions the way we do.

One aspect that most social robots will share is that they will often look like human beings. It is likely that they will not do so exactly, but in a more abstract way. Just like us, social robots will often have legs, feet, arms, hands, a torso, a neck and a head. They will even share characteristics of our faces, displaying at least two eyes and a mouth placed on their head similar to the way we look. Generally, this is a good thing. Robots with humanlike features can more easily elicit a social response from its users and can even have a positive effect on acceptance (Duffy, 2003; Goetz & Kiesler, 2002; Venkatesh & Davis, 2000). If an artefact displays humanlike behavioural characteristics such as facial expressions or emotions, people also respond more positively than they would towards an artefact with a purely functional design (Reeves & Nass, 1996; Krach et al., 2008; Riek, Rabinowitch, Chakrabarti, & Robinson, 2009; Eyssel, Hegel, Horstmann, & Wagner, 2010).

This similarity can also go too far, though. Masahiro Mori (1970) proposed a hypothesis stating that as the appearance of a robot becomes more human, the emotional response of its observers is also increasingly empathic and positive. However, there is a point at which this positivity turns to strong revulsion. From there, as the robot’s appearance continues to become more and more human, the emotional response turns positive again and can even approach levels of empathy we see among humans (Mori, 1970). In this generally upward curve is then an area of strong revulsion towards the robot and this area has been called the Uncanny Valley.

**Explanations**

There are various theories that have been proposed to try and explain the cognitive mechanism that occurs. Below are a few examples of these theories. One of these theories is related to mate selection. As a robot becomes more humanoid, evolved cognitive mechanisms kick in that avoid potential mates with low fertility or ineffective immune systems (Green, MacDorman, Ho, & Vasudevan, 2008).

The mate selection theory has a few close resemblances with the pathogen avoidance theory. This theory states that as an organism looks more like a human being, the stronger our aversion becomes towards its defects. This is because defects may indicate disease and more human-looking organisms...
are more closely related to human beings from a genetic standpoint, which may increase the probability of contracting bacteria, viruses, or other pathogens (Rhodes & Zebrowitz, 2002).

Another theory relates to the violation of human norms. If an entity appears to us as sufficiently non-human it is easier for us to notice its human characteristics because we anthropomorphize it in a rough way. However, as soon as an entity looks almost human, it will elicit a model of a human other in us and with that come much more detailed normative expectations. Suddenly its non-human characteristics become more noticeable. So in other words, a robot in the Uncanny Valley is no longer judged by the standard of robot trying to be human and doing fairly well at it, but it is being judged by the standard of a human being that is at that point failing miserably at acting like a normal human being (MacDorman & Ishiguro, 2006).

It is also possible for the Uncanny Valley effect to occur due to conflicting cognitive cues. For example, when we see a humanoid figure displaying robotic movement, this can lead to perceptual tension because the cues we experience are conflicting in category membership. This leads to psychological discomfort, or eeriness. This theory is supported by behavioural (Burleigh, Schoenherr, & Lacroix, 2013) and neuroimaging studies (Saygin, 2011), as well as mathematical modelling (Moore, 2012).

Critique
There are of course also criticisms concerning the Uncanny Valley hypothesis. Hanson, Olney, Percira, and Zielke (2005) for example show that uncanny entities may appear anywhere in a spectrum ranging from very abstract all the way to the perfectly human entity. This also supports the idea that the Uncanny Valley may arise from issues of psychological categorization, since some specific aspects of a robot can be considered to be so humanlike that it elicits the Uncanny Valley effect.
Another criticism is that the Uncanny Valley effect consists of a very heterogeneous group of phenomena, involving multiple and possible overlapping sense modalities (MacDorman & Ishiguro, 2006; MacDorman, Green, Ho, & Koch, 2009). Someone’s cultural background can then also have a significant influence on how humanoid robots are perceived.

It could also be that the Uncanny Valley is a generational effect (Newitz, 2013). The argument is that younger generations may avoid the Uncanny Valley due to their familiarity because they are more used to robots and social behaviour from digital or otherwise technological agents.

Other Uncanny Effects
Jamais Cascio (2007) argues that a similar kind of Uncanny Valley effect could come up when human enhancement goes beyond a perceived norm of human behaviour, capacity, or appearance. As humans move to “transhumans” or “posthumans”, they will increasingly be considered as not uniquely human anymore and be viewed positively. In the transition period there may be another Uncanny Valley effect. Even people that have plastic surgery done to change their appearance to that of a doll, or in general just have a lot of work done can sometimes also fall into this category of effects. People feel a sense of eeriness come up when viewing these cases.

Avoiding the Uncanny Valley
The Uncanny Valley effect may be avoided by matching design elements in human realism (Ho, MacDorman, & Pramono, 2008). This means that certain expectations of the user should be met. A robot that looks very humanoid should also move in a humanoid fashion, since it will be expected that something that looks human will also move in a human way as well. Matching appearance and motion has been shown through neuroimaging studies to be very important (Saygin, 2011). In the same way appearance and performance should also be matched. If something looks like a basic household appliance people will generally not expect too much of it in terms of performance. Similarly, if it looks very humanlike, people will have higher expectations (Goetz, Kiesler, & Powers, 2003). Neuroscientists note that when the brain’s expectations are not met, it will produce a prediction error, also contributing to the Uncanny Valley effect (Saygin, 2011).

Hanson et al. (2005) also found that good design can postpone the moment we encounter the Uncanny Valley. However, questions were also raised regarding how good of an idea it is to make robots in our own image (Saygin, 2011). Keeping a few aspects of a robot non-human on purpose may help us feel good in interacting with them without limiting performance.

Conclusion
We have seen that modelling robots after humans can bring various benefits. We become more empathic towards them, therefore taking greater care of them, and we are more likely to accept them. Their appearance also greatly influences how we think they will act. Funny social robots may approach the Uncanny Valley in various ways. Not only will they oftentimes look like us, they will move like we do, and even have social interactions the way we do. All of these aspects will have to be in tune for a social robot to be truly effective and accepted. With many theories proposing explanations for the Uncanny Valley phenomenon, more research and development into social robots is likely to present us with more interesting insights into our own perception.
Sources


Image
Natural language processing is one complex way of human-computer interaction

The reader will have acquaint by now a basic background on the components that a robot must have to be social. Natural language processing is a way of computers understanding and interacting with the language that humans use. Natural language processing has two ends. One is for computers to decipher the sounds to digital bits and the other one is to respond in a language that humans understand. A recent but well known example of this are the various types of GPS software that can hear the command for the destination while the driver does not have to touch the interface. Another example is Siri, a software produced by Apple Inc. Siri can hear and respond in a relevant way to a number of questions by using a user’s location and drawing statistical data from the company’s database (Nusca, 2011). Many users have posed questions anticipating a funny outcome like the following:

User: Siri, have you ever loved someone?
Siri: Not as such. But I did have strong feelings for a cloud-based app once.
- (Lang, 2013)

Nonetheless, for a social robot to be funny it also has to process what humans have understood. A direction towards that direction is the example of Heather Knight and her use of a NAO robot produced by a company called Aldebaran Robotics. The aforementioned robots are built with a sufficient number of functions, in matter of design and in matter of software. Among others it applies to eye gaze, a balanced voice, certain movements according to its surroundings, and can identify different humans (Discover the working of NAO, n.d.). Heather Knight introduced her project on a NAO robot at a public speech on TEDx (Knight, 2010). According to the researcher the robot can evaluate its jokes, by listening to the laughter of the audience. She also used a visual analysis: if the individuals of the audience enjoyed the joke they could use either a green card or a red card to show that they did not enjoy the joke. This way the robot using machine learning can learn whether the joke was successful or not.

As Heather Knight notices on a different article, if a comedian does not leave space for audience to laugh she is either socially unintelligent or she wants to regain the lead of the conversation after she was interrupted with the audience’s laughter (Bans, 2013). This can become obvious on the first presentation of her work at TEDx in 2010, where the robot says the
Siri was one type of software that made natural language processing accessible to many.

Humorous Intent

On the article concerning verbal humour, examples are mentioned like HAIIAcronym and Standup that produce natural language. A machine using algorithms can place certain lectual categories at certain places in a sentence. As mentioned before, natural language processing has two sides: first, a robot has to be able to process and decode certain human languages, and secondly, respond as programmed. A future development would be for a robot to understand whether there are jokes included in someone’s text or speech and then respond appropriately. It requires a combination of modelling and detecting humor to improve the situational awareness of the robot on the matter of computational humour.

Towards that direction is the paper “Computational Models for Incongruity Detection in Humour” (Mihalcea, Strapparava, & Pulman, 2010) that is dedicated on the issue.Modelling humour focuses on the components that are necessary for a concept to be humorous. For instance, using incongruity theory of humour a combination of semantic data sets were correlated with specific punchlines. A correlation of similar semantic data sets might be achieved with two different ways: the first is knowledge based i.e on the semantic context of sentences. The second are named “joke-specific features” (Mihalcea et al., 2010, p. 367) which include polysemny and other linguistic components. Nonetheless, in their research they concluded that out of 150 set-ups with four different punchlines for each, only one had a humorous effect, which can be read as the initial point of a larger field of research.

Besides modelling humour, recognizing humorous intent requires a more in-depth analysis. On the article “Towards the recognition of humorous intent” (2005) Taylor and Mazlack provide an insight on the topic. Basing their research on short texts and using the
incongruity theory of humour, they examine whether the texts can be computationally recognised as humorous, while another aspect is the recognition of the intent behind the joke.

As they state, when it comes to the recognition of humour, a text is humorous on the cases where the first part of the text can have two potential meanings (e.g. differences in sound or context) and the punchline grasps one of them. For example, the authors call us to assume that there is a discussion about athletic clubs. There is a linguistic schema activated which can lead a conversation. The linguistic schema is that the discussion has a topic on athletic clubs. In the following example, it is used the assumption that there is a discussion about kids in athletic clubs:

--Do you believe in clubs for young people?

--Only when kindness fails.
- (Taylor & Mazlack, 2005, p. 2168)

The text is humorous because the meaning of the first part refers to athletic clubs while the punchline refers to clubs that belong to the category of baseball bats and so on. While the text has the necessary incongruent parts to result to a potential humorous outcome there is also a certain intent. If the computer was using only topics from youth and athletic clubs, then performing an incongruent joke as in the example is considered intentional. Using the same example the reader can understand the difference between humorous intent and humorous text. Presenting their argument, the authors state that if the text was presented on a speech about child abuse, then a different schema would have activated, the one of abused children which would result in a less humorous text. The intent, that the authors refer should not be mistaken with actual humanlike intent. Rather, if the machine was aware that the speech was about athletic clubs and then producing the said incongruity, then it would categorized as intentional.

As Anton Nijholt argued, this would be extremely useful as it can be used in numerous appliances for transforming the relation that humans have with machines and their environment in general. An integration of a successful humorous model could be used in video games, or in any other artefact that operates in smart technology (Nijholt, 2014).
In other words, a first reason on why modelling humour would be beneficial, is that it would increase the social aspect of social robots and machines as a whole, directing them to be better candidates for a number of appliances. A second reason is that modelling a highly complex function such as humour would be a promising aspect on modelling other aspects of human nature like sadness and anger. After all, modelling humour and programming algorithms so as machines to have intent or situational awareness will make them more useable and accepted by human society.

Sources

Images
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Taking all aspects together it can be concluded that the pun making Pundalin was seen as a much better chatterbot than its neutral counterpart Modalin.

One question that might be asked is: would adding humour to social robots or artificial agents improve their social performance? For an assembly line robot this would probably be unnecessary, however according to Nijholt social robots would significantly benefit from humour. Nijholt states: “humor should be incorporated in computer-mediated communication and human-computer interaction systems” (Nijholt, 2002, p. 5). Whether humour can improve a robot’s social functioning was also explored in the interview with Daniel Davison, a PhD researcher in the human media interaction research group at the University of Twente. Currently he is doing research for implementing robots into educational settings. Regarding the effect of humour in this setting, Davison was positive that this could enhance the social performance of the robot. For this he proposed that the robot could have a programming for “small talk”: “they need some kind of bond, the child needs to have kind of an idea of what the robot can mean for him. What suggestions the robot does, if it’s correct or incorrect, things like that. So they need to form this common ground. And I think that through a kind of small-talk that this could be achieved. So the robot might tell something about himself, make a couple of jokes, like that, to try and form this relationship” (Davison, 2015). This small talk programming was also to be found as effective for establishing trust (Bickmore & Cassell, 2001), this might of course prove useful within an educational setting.

However, before continuing we must establish what kind of social performance we are supposed to improve through humour. Since humour is a social activity, this social context will be the basis of the performance we seek. So the first step of this social performance will be cooperation with a humorous programmed robot. The second step will be the evaluation by the users. And for the last step, taking the theme of well-being into account, we will take on the ability of invoking positive emotions.

First Step: Cooperation
Humour can be an interesting way to improve cooperation between robots or artificial agents and their users. An important factor in accepting robots into our (work) environment is fun. Here fun can be a result of humour (Young, Hawkins, Sharlin, & Igarashi, 2009). However, working together with a robot requires more than just accepting the robot. Humour seems to play an important role here.

Goetz and Kiesler (2002) conducted an experiment to
find if a more playful/humorous programming might increase the cooperation with a robot. They found out that the playful robot outperformed his non-playful counterpart in everything except cooperation. On this scale the serious robot made its users spend more attention on their tasks. However, this might also be a result of the specific task.

In the study “Matching robot appearance and behavior to tasks to improve human-robot cooperation” (Powers, Kiesler, & Goetz, 2003) a different relation was found. In this study was explored if a robot’s overall appearance (including behaviour) could influence cooperation. One of the aspects they studied was again the playful versus serious programming. For this situation was hypothesized that a playful robot could elicit more compliance and cooperation if the task involved was considered entertaining or fun. In their comparative experiment they found a significant confirmation of this hypothesis, the funny playful robot elicited significantly more compliance in a fun task. Even when compared with the increased cooperating the serious robot got in the serious tasks, the humorous robot did significantly elicit more compliance (Powers et al., 2003).

Second Step: Evaluation by the User
Evaluation by the user is also an important factor for assessing the performance of social robots and artificial agents. Whether humour could be used to improve a robots functioning in an educational setting was already asked during the interview with Davison (2015). Huan & Szafir (2001) did earlier investigate a similar question in their article “No joke: examining the use of humor in Computer-mediated learning”. In this study they found no significant increase of memorization of the learned task for the users, but they did find that instructor robots with a humorous programming where liked significantly more (Huan & Szafir, 2001). Here it can be seen that humour does not necessarily improve task performance, but can be linked with perceived performance instead. When we go a bit further and look at a situation where the whole performance is dependent on user evaluation, we come back at the Modalin versus Pundalin case. In this case where two chatterbot agents were compared, Pundalin with a humour programming and Modalin without, they found that users overall rated Pundalin far more intelligent and “human like” (Dybala, Ptaszynski, Rzetka, & Araki, 2008). This better evaluation was confirmed and expanded in two other studies. First it was found that the users not only liked the Pundalin more, they perceived Pundalin as more interesting, had more relevant conversation and they wanted to have longer dialogue with the Pundalin (Dybala, Ptaszynski, Rzetka, & Araki, 2009). The second part went a bit further in their evaluation research, for they asked if the users would like to have Pundalin as a friend. This question was answered positively by most of the users (Dybala, Ptaszynski, Rzetka, & Araki, 2010).

Third Step: Positive Emotions
The last step will highlight the performance aspect related to well-being; or the ability to inspire positive emotions in users. This ability was already hinted at in the results of the article “Cooperation with a robot assistance” (Bickmore, & Cassell, 2002). Furthermore to establish the relation of humour with this ability was the main objective of the “humoroid” articles (Dybala et al., 2009; Dybala et al., 2010). The results for the 2009 article were that the users not only liked the Pundalin more, but during the interaction the users showed more positive emotions towards Pundalin (approximately 75% of the emotions were positive) (Dybala et al., 2009). The 2010 experiment was more conclusive, since they added the dimensions of general emotiveness, valence change (positive and negative), and arousal level. With this information one can conclude that Pundalin was not only rated better, but also enhanced the positive emotions of its users (Dybala et al., 2009).

Conclusion
Taking all this information into account we can formulate quite a convincing answer to our question: does adding humour to social robots or artificial agents improve their functioning in a social setting. From the first step to this answer we can conclude that within tasks that were already perceived as being enjoyable a humorous robot does stimulate improved cooperation and longer attention, as shown by the article of “Matching robot appearance and behavior to tasks to improve human-robot cooperation” (Powers et
From the second step could be concluded that humour significantly increases the user’s evaluation of the humorous agent or robot. This was shown to be true in an educational setting, however, the Pundalín chatterbox was the most prominent example because it was not only rated as more intelligent and friendly, people also wanted to continue their dialogues with Pundalín, and they wanted it as a friend. Pundalín then takes us to the third and last step, namely eliciting positive emotions in the user. It was shown that because of its humorous programming, Pundalín was capable of stimulating far more positive emotions than its neutral counterpart Modalín. Taking all the aspects together it can be concluded that the pun making Pundalín was seen as a much better chatterbot than its neutral counterpart Modalín.

Looking back on the interview with Davison, we can conclude that his idea of humorous small talk would be more than viable. Research shows not only that this actually is the case, humour does also helps a lot in improving a robot’s social performance. This information suggests that humour could not only be an improvement for educational robots, but also social robots in general.

Sources
Davison, D. - PhD. student at the Human Media Interaction department at the University of Twente (February 18th, 2015). Interview about robots in educational settings helping children do a learning task.
Small talk and humour have the potential to significantly improve the user’s trust in the robot

During the interview with Bruijnes, a PhD researcher on the interaction between humans and artificial agents, he stated that he felt weird while using his “Shopbot”. Shopbot is a remote-controlled robot equipped to be able interact with its environment, an example of telepresence technology. In the interview it was stated by Bruijnes that this weirdness was not because of the novelty of the experience or weirdness in controlling the robot, it was because “it doesn’t feel like other people respect you” (Bruijnes, 2015). According to Bruijnes people tend to push over the robot or cover the robot’s camera when they have a chance. In this situation, according to Bruijnes, people seem to distrust the robot. When asked if humour could solve this, Bruijnes was unsure. One possibility to overcome this would to make the robot more “humanlike” by boosting its perceived intelligence. This “human likeness” makes people less destructive or aggressive towards robots (Bartneck, Verbunt, Mubin, & Al Mahmud, 2007). However, this effect does not say anything about trusting the robot. A strong case could be made though, for the boosting effect of humour on trust. Hampes (1999) has shown that there is a strong connection between humour and trust, therefore one could ask if humour also is important for improving trust. The main question of this article will be: can the problem of trust be overcome with the implementation of humour in the design of the robot.

Building Trust
In the much quoted article “the relationship between humor and trust” (Hampes, 1999) a case was made for a significant relation between humour and trust. This significant relation was explained by mediating factors such as extraversion, stress reduction, and self-esteem (Hampes, 1999). Especially the extraversion factor is important for this relation. This extraversion factor can be divided into four main components: warmth, gregariousness, assertiveness, and positive emotions. These four components all seem to be closely related to trust (Nijholt, 2002). This gives an interesting view on which humour style should be used, since it rules out more antisocial or aggressive styles. The humour style implied here is affiliate humour (Kuiper & McHale, 2009).

Two other factors, stress reduction and self-esteem, are also relevant for the building of trust. Self-esteem can be associated with self-enhancing humour (Kuiper
People with high self-esteem seem to trust others more easily. This can be explained by their belief in being able to handle intimacy with others. This ability for handling intimacy might be beneficial for improving trust, because intimacy is an important factor of trust.

The same goes for stress reduction which can be associated with the result of positive humour. People with better stress reducing strategies are better at dealing with stress which in turn seemingly allows for a quicker build-up of trust (Nijholt, 2002). One of the most straightforward examples of this is laughter. Laughter has been hinted at as being able to significantly reduce physical stress (Bennett & Lengacher, 2006).

This information can be used to show how humour and trust are closely related, but how do you implement this into a (social) robot? For it was not that the people around Shopbot were not capable of trust, it was that they perceived Shopbot as (possibly) scary and unwanted. The article “Relational agents: a model and implementation of building user trust” (Bickmore & Cassell, 2001) discusses what would be needed for programming a robot (or virtual agent) in such a way that it would invoke trust from its users. The article stated that people perceive agents with humour as more competent and cooperative, which is always a boon when you want positive evaluations. Together with several other factors, (but mainly) humour was taken as basis for an approach to test generated trust with a conversational agent. This generated trust was measured by the constructs intimacy, solidarity, closeness, familiarity, and affiliation. These traits can again be related to humour, or more specifically the affiliate humour style (Kuiper & McHale, 2009). Here trust was not measured directly, because trust was seen as a factor that results from a high scores on the measured constructs. It was hypothesised that when these factors were put into use together, a growth in reported trust would emerge from the interaction (Bickmore & Cassell, 2001).

To test the hypothesis a conversational agent was programmed to be able to have “small talk” with their users. Small talk is here theorized as a task that employs all the aforementioned constructs to build trust (Bickmore & Cassell, 2001). The results of the small talk conversations showed that all users experienced the small talk as more natural. More importantly, however, a significant relation between trust and user personality was found. This significant relation was mainly found in the increased trust by extravert users. Introverted users did not particularly seem to gain any increase in trust through small talk, however for extravert users it seemed almost mandatory to have small talk to improve trust.

**Conclusion**

This brings us back to the situation encountered by Bruinjes and his Shopbot: how can people get to trust robots through humour? As worked out above, it can be concluded that trust is a characteristic highly dependable on extraversion. Extraversion from the user, but also extraverted traits programmed in the robot. The traits that can create trust that are related to humour are warmth, gregariousness, assertiveness, and positive emotions. All of these traits seem to fit very well with a specific kind of humour: affiliate humour.

Another way of showing that trust can result from
humour is by implementing small talk programming. This small talk is built up of factors that again closely relate to (affiliate) humour. This small talk has the potential to significantly improve the user’s trust in the robot. Taking all of this together we can conclude that humour can improve trust. Hampes (1999) already found that humour and trust are related, but now we have also shown that humour can be used by robots in a similar way. One form of this trust strengthening humour would be a humorous small talk program; a program that uses a conversational style that incorporates affiliate humour, which allows for feelings of closeness and familiarity. With such a program it could be a lot more pleasant for Shopbot or other robots to venture into a world where people trust them and allow them to be close to them instead of pushing them over or covering their sensory input.


Bruines, M. - PhD. student at the Human Media Interaction department at the University of Twente (February 12th, 2015). Interview about human-robot interaction, taking as an example police interrogation robots.


Not only does humour improve psychological wellbeing, it even increases wellbeing on a physical level. One cannot ignore humour when researching and discussing wellbeing.

Recently the study of wellbeing has seen a big growth in scientific and non-scientific research. This research relates often towards factors that would improve psychological health. Factors of wellbeing include happiness, life-satisfaction, and mindfulness. However, besides this there is one often overlooked factor, namely humour. This article will give a short exploration on how humour is related to wellbeing. The first section of this article will be about how humour styles are related to wellbeing. The second section will be about the relation between humour and physical wellbeing, and the last section will be about humour as an indicator for personal growth.

Humour Styles & Psychological Wellbeing
In the articles “Individual differences in uses of humor and their relation to psychological wellbeing” (Martin, Puhlik-Doris, Larsen, Gray, & Weir, 2003) and “Humor styles as mediators between self-evaluative standards and psychological wellbeing” (Kuiper & McHale, 2009), the concept of humour as a factor for (psychological) wellbeing is presented. These articles are a continuation of each other and they show that certain types of humour may be adaptive or maladaptive to the wellbeing of individuals. These types of humour are: affiliate, self-enhancing, aggressive, and self-defeating. Both of these studies found that there is a high construct validity among the humour styles. Moreover, affiliate humour was found to be correlated with higher psychological wellbeing.

For affiliate humour it was stated that this style of humour correlated positively with several aspects of psychological wellbeing, these aspects were cheerfulness, self-esteem, social intimacy, femininity, and psychological wellbeing in general. Apart from that, this affiliate humour also correlated negatively with factors that undermine psychological wellbeing, such as depression, anxiety, seriousness, and overall bad mood. Taking this all into account it was concluded that people who are used to employing an affiliate style humour appear to be socially extroverted, cheerful, emotionally stable, and concerned for others (Martin, et al., 2003).

Taking the positive self-evaluative standards into account, it can be concluded that an affiliate humour style has an indirect but nonetheless significant mediating effect. Higher scores on positive self-evaluative standards were followed by significantly
higher levels of affiliative humor. This in turn in turn, predicted significantly better scores on social self-esteem and significantly lower scores on depression. (Kuiper & McHale, 2009).

Laughter might also have influencing effect on moderating the hormones epinephrine, norepinephrine and cortisol, these are aptly named “stress hormones”. This effect is important for the significance of the

**If stress and negative emotions can suppress the immune system, why can’t laughter and feelings of trust and hope promote healing, even prolong life?**

**Humour & Physical Wellbeing**

In the articles “Humor and laughter may influence health II & III” (II: Bennett & Lengacher, 2006; III: Bennett & Lengacher, 2008) the relation between humour and physical wellbeing is presented. The part II article starts by stating “if stress and negative emotions can suppress the immune system, why can’t laughter and feelings of trust and hope promote healing, even prolong life?” Laughter is believed to act as a coping mechanism to reduce stress, improve self-esteem, and reduce psychological symptoms related to negative life events (Bennett & Lengacher, 2006). The same article goes on to show that humour does strongly correlate with perceived physical health and as a coping mechanism for health problems. Because of the difficult nature of assessing this construct they conclude that better and more rigorous research is needed. In the follow-up article, the authors go more in depth in laughter, stress and anxiety.

In their literature research on laughter they conclude that it can contribute to physical well-being. Laughter first of all immediately increases heart rate, respiratory rate, respiratory depth, and oxygen consumption. This is then followed by a period of relaxation during which muscles relax and heart rate, respiratory rate, and blood pressure decrease.

The results of their analysis shows a significant correlation between humour and personal growth, only sense of humor, as a factor of humor appreciation, could predict the emotional well-being (Herzog & Strevey, 2008) , and moreover, the strength of the correlations seemed to suggest that humor appreciation was a better indicator of personal growth (Herzog & Strevey, 2008). Additionally in this article, it was concluded that this personal development supported by humour had a direct positive effect on
social relations for positive uses of humour. All of these effects combined give a strong argument that humour is an important predictor of personal growth, which in turn is an important part of well-being (Herzog & Strevey, 2008).

**Conclusion**

This exploration gives us information on how to relate humour to well-being. Humour as part of well-being seems to be influential in several aspects. Firstly, humour seems strongly linked to psychological well-being. Affiliate humour, associated with humour applied in a social positive way, improves self-esteem, cheerfulness, and social intimacy and seems to decrease depression and anxiety. Also humour can also be seen as an indicator of personal growth. This implies that humour not only contributes to, but also results from psychological well-being.

Secondly humour also strongly correlates with physical well-being, as presented in the two related articles. Laughter improves bodily functions related to coping with stress (respiratory function, oxygen consumption, blood levels, muscle relaxation, and hormone levels) and hints at possibly improving immune function and health outcomes.

From this we can see that humour does increase well-being in a two ways. Not only does humour improve psychological well-being, it even increases well-being on a physical level. With this information, one can conclude that humour and well-being are strongly connected, therefore one cannot ignore humour when researching and discussing well-being.

**Sources**


WE COULD, BUT SHOULD WE?

Your scientists were so preoccupied with whether or not they could that they didn’t stop to think if they should.

- Dr. Ian Malcolm (Jurassic Park, 1993)

The latter part of the above quote from the movie Jurassic Park (1993) will be addressed in this text. With all the technological advancements we have made already and that we will continue to make in the fields of artificial intelligence, computational humour, and social robots, the question must be asked of whether or not we’re doing the right thing. Will these technologies add significant benefits to our lives or could they pose great risks?

Several issues come up regarding the ethics of humour and social robots. Making someone laugh for example builds trust (Hampes, 1999). Some of the main ethical concerns that come up are about trust, privacy, responsibility, and well-being.

There are a number of ways we can look at a technology to determine how ethical its use is. One way is to take things to the extreme and see what happens. Another is to compare the technology we are discussing to another, roughly similar technology. More unique to this technology, however, is that we can also compare funny social robots to humans. Since the technology is still largely in its infancy, there are currently mostly questions, rather than answers. This text aims to explore some of the situations and aspects of social robots that need to be taken into consideration when trying to find answers to questions relating to ethics.

Trust

We already know that it is possible to elicit trust regarding a certain technology by adding certain human-like features, such as behaviour (Bartneck, Kanda, Mubin, & Al Mahmud, 2009) and humour (Dyballa, Ptaszynski, Rzepka, & Araki, 2008). Social robots already show potential for application in a broad number of situations. Take, for example, social robots as a teaching aid for children or as an aid to police in interrogations, as Daniel Davison (2015) and Merijn Bruijnes (2015) mentioned respectively during interviews that were conducted. Other possible uses involve care robots keeping lonely seniors company (Tamura et al., 2003). Social robots are thus capable of taking on various roles, such as that of peers, teachers, friends, or assistants. In each situation there are different social dynamics at play; a person would interact differently with a robot that is supposed to be your teacher than you would with a robot that is supposed to be your peer.
The different roles a social robot can play and the various ways in which trust can be built should have us consider how desirable such situations are. How much do we want to trust a social robot or make them elicit trust? Would we want them to be in positions of power where we would have to obey them, such as the teacher role? Or would we always want robots to obey us instead? In the extreme case we would trust them to the point of depending on them and perhaps even feeling comfortable enough to trust their suggestions and advice.

Another concern regarding trust is manipulation. If the social robots around us become proficient enough in social interaction that could give them the opportunity to influence our mood and behaviour. Knowing which things to say or do to inspire trust, joy, or comfort or to avoid distrust or anger, for example, sets us up for deception.

Large amounts of revenue of certain tech companies comes from Internet-based advertising. What if the same tech companies produce social robots or artificial intelligence that will push you towards buying certain products or services? In other words: what if you are manipulated towards something that is not primarily in your own interest but in someone else’s? Then again, we all know people that are convinced of a certain product or service and that advise us to purchase the same thing. Advertising then merely becomes more advanced by precisely and intentionally influencing our emotions.

Privacy
Another unique aspect about social interaction with robots is that unlike human beings, robots are easily equipped with technology to record everything they see, hear, or do. None of the people around us can, without technological aid, produce such an easily verifiable picture of what we did throughout an interaction. Could this pose a threat to our privacy? If interactions are indeed recorded, what if the robot or artificial intelligence is hacked? Or what if it gets a virus or has malware installed on it? With social robots being able to inspire trust with only moderate effort, would it not also become too inviting to divulge personal information?

Some of the concerns that come up regarding robots may also apply to humans though. Through a virus, malware, or plain programming, it would be possible for a robot to share personal information against a user’s will. A human being, even a friend, is capable of doing the exact same thing. The main difference, though, is the degree of accuracy and verifiability a human and a robot bring to the table, with the robot winning on both counts.

Current technology already keeps track of quite a bit about us as well though. Many smartphone users have location services active at all times, not to mention the amount of personal information they store and share online. Ten or twenty years ago we might have considered sharing such information to such a degree unfathomable. With the added capacity for social robots to record different types of personal information, we have to ask ourselves the question of how much more of our personal life we want to openly share with technology.

Responsibility
Suppose a social robot gives us some advice, a suggestion, or answers a question, but somehow gets it wrong and makes a mistake. Some mistakes can have serious consequences. Imagine your navigation system pointing you in the wrong direction. In the case of a social robot, who would we consider responsible for the mistake? Would the programmers or manufacturers be responsible? Or would the users be responsible by blindly trusting their robot, not verifying its output?
To some degree we always delegate responsibility to our devices. We trust our navigation system without constantly keeping a map handy to verify every direction. We trust our e-mails to arrive without checking to see if they actually did. In case something does go wrong, however, it will sometimes be based plainly on faulty programming and sometimes it will be the users wrongly using the technology. Mistakes that come up out of social interactions can be a bit trickier, though.

To harm us emotionally as they can help us. Feeling like the robot responds to us and even having a few laughs together makes us feel better. Just as easily, however, the robot could be unresponsive, insult us, or bring up something that makes us sad. This may not even be due to any kind of intent, but mere misinterpretation can cause this, just as sometimes our friends unwittingly respond in distressing ways.

Aside from the behaviour of a robot, our well-being can also be influenced by our emotional attachment to a robot. There was an autonomous walking robot that was supposed to take care of landmines by stepping on it, thereby getting that limb blown off, and then walking on with its remaining limbs. The test was stopped because a colonel could not bear watching a crippled, burned, and scarred machine dragging itself forward to another landmine with its last leg. He named the practice inhumane (Garreau, 2007). A household vacuuming robot called Roomba even gets treated like something more than a robot. Some users will actually clean the house themselves instead of letting the robot do it, so that the robot can get some rest (Sung, Guo, Grinter, & Christensen, 2007). The fact that a robot is autonomous and can move around on its own seems to give us the idea that it has agency (Schutz, 2011). Feeling empathic towards these robots, even if they are basic and non-social, is already influencing us on an emotional level. When it comes to our well-being, we must take into consideration that these emotions are unidirectional in nature.

**Feeling like the robot responds to us and even having a few laughs together makes us feel better.**

Because social interaction depends so heavily on interpretation, the line between manufacturers and users as the cause of a mistake blurs. Maybe the manufacturer got everything right, but the user misinterpreted the robot. For everyone to responsibly interact with a social robot requires the awareness that robots are not responsible for their actions in the same way humans are.

**Well-being**

There are already social robots being deployed in elderly homes to help relieve feelings of loneliness (Tamura et al., 2004). If social robots can make us feel better and can play a role in improving our quality of life, not implementing or allowing social robots in our lives could then deprive us of the possibility for greater happiness. The fact that social robots, and perhaps especially funny social robots, can improve our quality of life with relatively little effort does display how easily we allow them to influence our well-being. It could therefore be just as easy for them
Future
With social robots already being implemented in various areas of life, there remains little doubt that we encounter them more and more over the next few years. In order to successfully interact with them, minimizing risks and damage to our quality of life and to maximize their use and utility, we have to keep in mind how much we want to depend on them and to what degree we will let them influence our moods and behaviours. So far there have not been many, if any, technologies that can do what funny social robots can do. What they are capable of, how we perceive them, how we interact with them, and the extent to which they can influence our emotions will have us returning to these questions regularly.

The topics in this text were only a brief exploration of some of the various questions, concerns, and views related to the ethics of humour and social robots. The question we have to ask ourselves, as with any option we have, will the benefits outweigh the risks? Funny social robots show great potential in improving our lives, but only time will tell how well we can live with machines mimicking humans so extraordinarily well.

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All the things we take for granted in our daily social interactions are suddenly placed under a microscope as we try to learn more about improving social robots.

Reading well over a dozen articles on various aspects of one subject can be a bit much. Perhaps a small summary is in order. The previous articles explored some of the philosophical, sociological, and technological aspects of funny social robots. Humour and robots were explored both separately and combined.

Humour
There are various theories attempting to explain various kinds of humour. Superiority theory was developed by Hobbes in 1651 and views humour as a means of expressing superiority of others. That explains why jokes always have winners and losers. After that, Shaftesbury developed relief theory in 1709 and saw humour as a way of getting rid of certain feelings and pressure. Freud expanded on it by stating that humour allows us to say the things we want to but that are generally not socially acceptable. One of the most famous theories of humour is incongruity theory. It explains that humour is for a large part dependent on expectations and starting with one thing and ending incongruously with the beginning of a joke.

We also discussed the work of one of the more well-known researchers on humour, namely Anton Nijholt at the University of Twente. He considers incongruity theory as one of the most interesting theories of humour to explore and to possibly apply in social robots. It was during an interview with Nijholt that many of the article topics came up. For example, if someone is funny we are more likely to trust them.

Social Robots
Both the verbal skills and non-verbal skills matter when it comes to how we interact with social robots. The degree to which they direct their “eyes” at us and their surroundings influences greatly how human-like we think they are. We also prefer robots to have a higher voice pitch rather than a lower one. Even the way they move matters. Seeing robots have facial movements or bobbing their head while walking makes us perceive them as more lifelike or human-like.

Also, as soon as robots get to move around a bit and show what we perceive to be autonomous behaviour, it becomes easier for us to empathize. We will find ourselves naming our robots, sometimes taking over some of their tasks to reduce their work load and effort, or calling certain ways of treating them inhumane.

Funny Social Robots
The research and development of funny social robots...
gives us a broad range of new areas to study. This technology offers us the chance to revisit older ideas such as the Turing test and shed new light on them, and also gives us new ways in which we can improve our overall well-being. Not only do humour and companionship, even if it is robotic, offer us psychological benefits, they also aid in our physiological health.

Science fiction movies give us a glimpse of what a future with funny social robots could look like. We get to fantasize about possible roles they could fulfil, as well as give current developers and researchers something to aim at. The movies already show some parts of what we know from research. For example, we know that when social robots start using puns while interacting with us, we start to like them more. We even want longer conversations with them and increasingly start viewing them as possible friends. We have also seen how that will work up to a point. When social robots look and behave like us, we start liking them more. However, when they show too many similarities in either appearance or conduct we suddenly lack the same enthusiasm. The line between robot and human must be clearly observable in order to make us feel at ease.

The new possibilities that open to us with the advent of funny social robots also begs the question of whether this development is a good thing. At an unconscious level we attribute certain characteristics to robot, such as agency, and through a few small behaviours and social skills we already start trusting this technology. This could set us up for manipulation and deception. On the other hand, our well-being can also quite easily be positively impacted by the presence of funny social robots.

**Future Developments**

It is quite possible that funny social robots raise questions that were never before asked. Up to this point we have not had many, if any, technologies that could so closely resemble human beings, either aesthetically, kinaesthetically, socially, or intellectually. Social robots offer a level of companionship unlike any other technology we have seen so far, thereby prompting comparisons to humans to a much greater scale than we have witnessed before. Due to the strong ties humour has with social behaviour, we may even end up not ever even talking about funny social robots anymore. Robots displaying social behaviour would already include humour, since a robot without humour seems oddly deficient in some kind of way, just as a human being without any capacity for humour might be called socially awkward. The importance of humour makes it more and more likely to be integrated as a crucial component of what it means to be truly social.

As the research and development of funny social robots continues, a huge number of questions are just waiting to be answered. Creating an artefact that so closely resembles human beings in so many ways offers us a chance to shed a different light on what it means to be human and how we function. All the things we take for granted in our daily social interactions are suddenly placed under a microscope as we try to learn more about improving social robots. Both the number of possible applications as well as all of the related fields of study are practically endless, though we still have a long way ahead of us in both areas.
Sustainable Energy
ACKNOWLEDGEMENTS

We, as authors of the articles on Sustainable Energy, would like to thank our interviewees who have kindly helped us and have given us interesting insights in their work. We are grateful for their enthusiasm, information, and help.

Nirvana Meratnia is associate professor in the Pervasive Systems group at the University of Twente. She is currently involved in the Go Green project as the supervisor of a PhD student in the project, and as the technical manager, which means that she is involved with administrative affairs like reporting to financiers and the organisation of meetings with the advisories and end-users.

Abeer Seikaly is an architect and cultural innovator. She has built a foundation of interdisciplinary skills that span architecture, design, art, fashion, and textile design. The 'Weaving a Home' tent is a typology of her physical explorations of creating iterations of flexible structures.

Gerard Smit is full professor in the CAES (Computer Architectures for Embedded Systems) chair. He focusses on energy efficiency in two areas. He is involved in projects to increase energy efficiency of ICT systems and projects that aim to use ICT systems to make other systems more energy efficient. He is involved in the Lochem and Meppel Energie projects as a researcher, aiming to make energy management in Lochem and Meppel more efficient by means of ICT systems.

Suzanne Vosslander is a teacher at the department of Cognitive Psychology & Ergonomics at the University of Twente. She is involved in the Lochem Energie project as the supervisor of (pre-)master students that do research in the project.

Matthew Maroon is the Senior Director of Product Management at Aquion Energy. With the product management team he works to establish a cohesive plan for the company to build and deliver products that bring value to their costumers.
n recent years, the concept of sustainability has become increasingly ubiquitous and compelling. Although the concept has a long history, it has garnered greater attention and clout in the last century as literature, media, and pundits disseminate the multitude of socio-environmental factors at stake in the sustainability movement. Businesses, developers, policy-makers, technologists, et cetera are escalating their attempts to appear “green,” yet as the scope of sustainability rhetoric increases, so it becomes increasingly ambiguous and vague. Sustainability seems to oscillate between social and environmental emphases, indicating the extent to which both these aspects influence the concept. The concept and deployment of sustainability has important ramifications ecologically, socially, and philosophically, and as it becomes increasingly ubiquitous, so it becomes pertinent to examine the term closely.

Although the criteria of sustainability or “greenness” seems to shift depending on the source espousing them, it is apparent that central to the concept of sustainability is the management and production of energy. As fossil-fuel energy becomes increasingly scarce and unstable, solutions point to optimizing energy management and/or supplanting fossil-fuel as the primary source of energy. This general objective is answered in a litany of different approaches, including (but not limited to) integration of Information and Communication Technology (ICT), also known as smart technologies and resource production and collection, also known as generative technologies. Since people's homes and living habits constitute a significant drain on energy, many researchers have directed their projects at optimizing energy use in private homes. Using various sustainable living research projects within and without the University of Twente and scholarly works for reference, we ask: what are the varied approaches to energy production and management in private sustainable living and how do these approaches strive to maximize wellbeing?

The increased attention on the term sustainability has not led to increased clarity. As scholars readily acknowledge, the definition of sustainability, if defined at all, depends on the context in which it is deployed (e.g. Meyer & Helfman, 1993:569). For our purposes, we seek the comparison of specific terms frequently deployed in sustainability rhetoric; first and
foremost, sustainability itself. Interestingly, this definition is rarely limited to an ecological function, but also includes (or even necessitates) social benefit. The use of sustainability in the context of social benefit frequently operates from a foundational concept of wellbeing. Wellbeing, like sustainability, is an ideal to which many strive but few can define. We contextualize different approaches to wellbeing within different approaches to sustainability, illustrating the extent to which these definitions inform the outcome of research. We classify different approaches under the terms high-tech versus low-tech. Even the conception of these terms differs depending on the orientation of the research, further indicating the variety of conceptions of technology and approaches to maximizing wellbeing. Through direct comparison of the terms sustainability, wellbeing, and high-tech/low-tech, we strive to clarify the foundational assumptions through which sustainability research is conducted.

Our objective is not to consolidate these definitions, but rather to explicate their diversity. Through comparative analysis, we seek to clarify implicit and foundational assumptions which inform research in private sustainable living. Most of our own research is conducted through interviews, compelling the researchers to consider and define these terms themselves. We directed our attention to the Go-Green Project, operated by UT's Pervasive Systems department; the Lochem and Meppel Energie Projects, operated by UT's Computer Architecture for Embedded Systems; the Weaving a Home Project, operated by Abeer Seikaly; and Aquion Energy, operated independently out of Pittsburgh, Pennsylvania. Using interviews, publications, and background research in related fields, we created a detailed picture of the differences in foundational assumptions, research practices, and intended results for various approaches to energy management and/or production in private sustainable living.

In-keeping with philosophy of technology literature, we will evaluate ethical issues that arise within these various approaches, the efficacy with which these approaches maximize social welfare, and illustrate the extent to which these foundational assumptions inform the particular manifestation of research, design, and use. The ethical issues under examination include the use of Information and Communication Technology (ICT) in smart management systems, and ramifications for privacy and security. We will also inquire into the extent to which the physical environment influences, or even determines, behavior. Using a variety of philosophers of technology, like Heidegger and Borgmann, we will evaluate the extent to which these approaches promote wellbeing. These philosophers work from their own set of definitions and methods, particularly for wellbeing, which can be compared with the definitions upon which the researchers are working. Using scholars like Heidegger, Borgmann, and Verbeek, we can explicate how the context of these technologies inform the particulars of their manifestation. The foundational assumptions and objectives, as well as the technological challenges, all influence the outcome of technological research. Our project here is to explicate these influences and, in doing so, clarify and optimize them.
CASE PROFILES

GoGreen
Greener house through a self-learning, privacy-aware user-centric energy-aware wireless monitoring and control system

Goal: “The aim of the GoGreen project is basically develop solutions for an energy efficient home. What makes this project different from other ones is that we are not only looking at reducing energy consumption, we are looking at the trade-off between reduction of energy consumption and comfort. So the goal is basically to have solutions which on the one hand reduces energy consumption and on the other hand does not reduce the user's comfort.” (Meratnia, Interview, 2014)

Primary Challenges: Privacy and security, energy-efficient networking, optimization, real test sites, and end-user involvement (i.e. companies, energy suppliers, energy managers)

Duration: 2011-2015

University Department: Pervasive Systems (PS)

Collaborations: Novay, Saxion, Technical University of Delft, and University of Twente, PTC Remote Management/Service and Ambient Systems

Interviewee: Nirvana Meratnia, Technical Manager

Website: http://www.utwente.nl/citit/research/research_projects/national/iop-gencom/go-green/

For Further Information: See “Smart Homes” on page 174

Weaving a Home
Creating a technical, structural fabric that expands to enclose and contracts for mobility while providing the comforts of contemporary life

Goals: (Seikaly, interview, 2015)

• Research geometrical concepts and principles - materials, structures, patterns and processes that manifest in nature. • Utilize research results in geometry to help develop concept designs.

• Tackle the question of living spaces by exploring and creating new forms that will act as a catalyst to propelling the momentum of some form of revival in living and experiencing architecture and design and its impact on the evolution of culture and society.

• Define design principles/values/ethics that the tent upholds based on the areas of impact we (my team and I) hope to achieve.

• Participate in the empowerment and advancement of social interaction and cultural progression

• Engage in creating our own environments in order to live in dignified states. Community building.

Primary Challenges: Structuring the work process, responding to regional conditions

Duration: Indefinite

University Department: Unaffiliated with the UT

Collaborations: Confidential, but includes engineers and NGOs, among others

Interviewee: Abeer Seikaly, architect and cultural innovator of Weaving a Home

Website: http://www.abeerseikaly.com/weavinghome.php

For Further Information: See “Generative Technologies” on page 166
Lochem Energie

*Integrating ICT into Local Energy Production and Distribution*

**Goal:** “All electricity produced must also be consumed. Currently, the maximum production capacity of sustainable sources may not exceed the minimal electricity demand. As such, supply of sustainable energy can only be limited. In this pilot, solutions from technical innovations will be demonstrated, as well as the possibilities to influence human behaviour. An existing network environment (which is the current situation in the Netherlands) will be made intelligent. Also the chosen solution needs to be scalable” (Website, 2015)

**Primary Challenges:** Lack of exact technical equipment, bankruptcy of investor

**Duration:** 01/2013-01/2016

**University Department:** Computer Architecture for Embedded Systems (CAES)

**Collaborations:** Locamotion B.V., Alliander N.V., Coöperatie LochemEnergie, University of Twente, Eaton Industries BV., Trianel BV

**Interviewees:** Gerard Smit, Chair of CAES & Susanne Vosslamber, Psychology supervisor

**Website:** [http://www.utwente.nl/cit/research/research_projects/national/topsectors/lochem_energie/](http://www.utwente.nl/cit/research/research_projects/national/topsectors/lochem_energie/)

**For Further Information:** See “Smart Grids” on page 170

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Meppel Energie

*Developing a hybrid smart grid for urban districts*

**Goal:** “Over the next twenty years, Meppel will develop a unique residential area with 3,400 homes, called Nieuwveense landen. An important target for the development of this district is that future residents should receive optimal comfort at the lowest cost and minimal environmental impact.” (Website, 2015)

**Primary Challenges:** Increased housing prices, changes in system type (reduction of size, different types of houses), user-involvement networking, optimization, real test sites, and end-user involvement (i.e. companies, energy suppliers, energy managers)

**Duration:** 01/01/2013 – 31/12/2015

**University Department:** Computer Architecture for Embedded Systems (CAES)

**Collaborations:** University of Twente, Rendo duurzaam, Municipality of Meppel, i-NRG, Delft University

**Interviewee:** Gerard Smit, Chair of CAES

**Website:** [http://www.utwente.nl/cit/energy/projects/meppel.html](http://www.utwente.nl/cit/energy/projects/meppel.html)

**For Further Information:** See “Smart Grids” on page 170

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Aqion Energy

*CLean and sustainable saltwater batteries that outlive and outperform traditional battery chemistries*

**Goal:** “Build the world’s only sustainable energy storage technology that is specifically engineered to deliver peak performance and cycle life when paired to renewable energy resources such as wind and solar. Our (Image and Subheading from Website) objective is to build high quality batteries at a competitive price and to enable widespread adoption of renewables in lieu of traditional power sources such as diesel generators” (Maroon, Interview, 2014)

**Primary Challenges:** Technical developments, expenses, competition

**Duration:** Indefinite

**University Department:** Unaffiliated with the UT

**Collaborations:** Advanced Technology Ventures, Bright Capital, Constellation Technology Ventures, Foundation Capital, Bill Gates, Kleiner Perkins Caufield & Byer, Prelude Ventures, Shell Technology Ventures, Total Energy Ventures, Yung's Enterprise

**Interviewees:** Matthew Maroon, Senior Director of Product Management at Aqion

**Website:** [http://www.aquionenergy.com](http://www.aquionenergy.com)

**For Further Information:** See “Generative Technologies” on page 166
The core concept in discussing any sustainable technology is that of sustainability itself. This pervasive and ambiguous term has changed over the time of its deployment, and as its use has increased, so has its scope. Most scholars agree that the term was originally deployed in a largely economic sense (i.e. Brasher & Wiseman, 2008:353; Goodland, 1995:3). However, the contemporary use of sustainability includes broad public-sector commitments issuing from regional and national governments, the United Nations, the World Health Organization, and many other major players, each with their own definitions and agendas. The most frequently cited “prototype” definition comes from the United Nation's Brundtland Report (1987) which states: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (excerpt, Goodland, 1995:4). This definition hardly concludes discussion, though, as many find it difficult to apply. As Jickling (1994) notes, this definition “had become for many a vague slogan, a bold platitude, susceptible to manipulation and deception. For some it is logically inconsistent” (231). Dissatisfaction with the definitions coming from the public-sector has spurred a multitude of efforts to define and operationalize the term. This includes private-sector commitments, like those of “websites and environmental reports for Walmart, Honda, and countless other multi-national companies [which] all herald their commitment to sustainable development” (Ross, 2009:33). When a company like Walmart deploys the term sustainability, it seems apparent that this definition differs from that held by a public-sector organization like the WHO or UN. Meyer and Helfman (1993) caution, “The definition of sustainability depends on the context in which it is used (Brown et al. 1987) because the implications of the concept vary depending on context (Shearman 1990)” (569). Crucially, this increased application has multiplied competing definitions rather than consolidated them. Despite increasing use and increasing ambiguity, sustainability is generally understood as having three core values: economics, environment, and society (i.e. Bostrom, 2012; Goodland, 1995; Wiseman & Brasher, 2008). The issue of resolving different priorities and competing agendas remains highly contentious. Hence, even within the fields of economic, environmental, and social sustainability, there exists a wide range of priorities worthy of individual inquiry and clarification.
Despite increasing use and increasing ambiguity, *sustainability* is generally understood as having three core values: economics, environment, and society.

*Economic Sustainability* refers to a range of approaches for maintaining various forms of capital (man-made, natural, and social). Scholars often distinguish between “strong” and “weak” economic sustainability. One definition of “weak” economic sustainability is: “sees the human use of the environment as a purely economic problem. An economy is sustainable if the value of economic output is nondeclining over time” (Gowdy, 2000:27). This contrasts with “strong” economic sustainability which “sees sustainability not only as an economic problem but also a problem of maintaining essential, non-replaceable, and nonsubstitutable environmental features” (Gowdy, 2000:27-28). While “weak” economic sustainability can integrate concerns regarding man-made, natural, and social capital, it evaluates this capital stock in totality, while “strong” economic sustainability asserts that these stocks must be maintained independently due to their independent value (Spagengberg, 2005:48). This shift to “strong” economic sustainability has allowed for the integration of social and ecological concerns into the broader concept of sustainability itself.

*Environmental/Ecological Sustainability* covers approaches which prioritize the preservation of natural resources and systems. These approaches range from competing to integration with economic sustainability. Environmentally-oriented definitions range from that of American ecological economist Herman E. Daly who defines it as “development without throughput growth beyond environmental carrying capacity and which is socially sustainable” or the World Wildlife Fund’s definition of “improvement of the quality of human life within the carrying capacity of supporting ecosystems” or Jonathon Porritt’s definition “the capacity for continuance into the long-term future, by living within the constraints and limits of the biophysical world” (excerpts, Goodland, 1995: 4; Borland & Lindgreen, 2012:2). These definitions share a recognition of the co-dependence of environmental and social welfare. Scholars urge that ecological research is critical for “detecting change, guiding and evaluating policy and management decisions, and designing sustainable systems” (Meyer & Helfman, 1993:570). Environmental sustainability augments the objectives of economic sustainability by adding ecological factors as intrinsically important. Attention to ecological aspects like topsoil, groundwater, forests, fisheries, biodiversity, climate change, and resource extraction is the defining feature of environmental sustainability. Interestingly, few scholars address environmental sustainability independently of social and/or economic welfare. Goodland (1995) summarizes “Environmental sustainability seeks to sustain global life-support systems indefinitely (this refers principally to those systems maintaining human life)” (6). The over-arching agenda of human welfare makes it difficult to disambiguate environmental sustainability from social sustainability.

*Social Sustainability* addresses and operationalizes sustainability in the context of human welfare. Although economic sustainability is aimed at promoting human welfare through the indefinite growth of capital, social sustainability takes into account a broader set of social goals. Due to the broadness of its potential applications, social
sustainability is susceptible to much the same ambiguities as sustainability as a whole. Bostrom (2012) notes “Such conceptual imprecision and interpretative flexibility is often seen as both a strength (in that it encourages communication among different and disagreeing actors) and a weakness (in that people must constantly elaborate what they actually mean when they address social sustainability) (e.g., Davidson, 2009; Dempsey et al. 2011)” (4). Components like population stability, intergenerational justice, equality, diversity, tolerance, social infrastructure, and engaged governance as well as more applied agendas like equitable urban planning, fair trade certification, land stewardship, human-animal relations, sustainable tourism, among others are all part of the enterprise of social sustainability (Bostrom, 2012; Goodland, 1995, 5). The diversity of different components is what makes social sustainability difficult to consolidate into a single definition. Depending on the context in which it is conceived, the agenda of social sustainability shifts from broad programs to promote human welfare to context-specific attempts to improve humans lives.

The economic, environmental, and social dimensions of sustainability all interact and co-constitute one another. Yet, sometimes their priorities, agendas, and appeal compete. In clarifying one’s particular approach to sustainability, one gains insight into particular priorities, target audiences, related literature and projects, and a closer look at the particular form of wellbeing that coheres with one’s view of sustainability. Within the cases, we see a variety of definitions for sustainability, with varying degrees of emphasis on human wellbeing and varied approaches to operationalizing these ideas. While some perspectives focus primarily on resources (prioritizing environmental sustainability), other perspectives focus on the relationships between humans and energy consumption (prioritizing social sustainability), and yet others focus on developing a viable product in the emerging “green” market (prioritizing economic sustainability). This diversity of foundations underlies the diversity of technical solutions, the development of which are informed by the goals of the project. Even within the same project (i.e. the Lochem project), there can be different approaches to sustainability, indicating how these ideas can be utilized without definitional consensus. Below, we explore the diversity of sustainability definitions within our five case-studies, all of which focus on the private living context.

Sources
Applications in the Cases

Within our cases, there are various commitments and definitions of sustainability. We explore here some of the specific responses to the question: “how would you define sustainability?”

**GoGreen:** “One of your questions in the list you sent me is related to whether sustainability is an economical or social concept, but what I want to focus on is that you cannot separate them so this cost benefit thing is very coupled to money and also the comfort, so the social aspect and the user aspect is very integrated in that whole concept” - (N. Meratnia, 2015)

**Meppel:** “For Meppel, sustainability would be that they can provide them with easy energy using the heat network, some solar panels, and the waste-water treatment for biogas. So if you take that solar panels and biogas are sustainable, then in principle, they should be able to run sustainably” (G. Smit, 2015)

**Lochem:** “For Lochem, the situation is different because there is no local heat network, some people have that, some people don't have that. They do have a lot of solar panels and eventually people want to produce how much local energy they use, as in sufficient for their home use. For Lochem, sustainability would be that the total local energy produced is sufficient for total energy consumption” (G. Smit, 2015)

“Sustainability is about the interaction between the human and energy and the technology and between those things it's about using durable energy sources in an effective way but also at the same time reduce energy usage. So not just changing from fossil to bio fuel and maintaining energy use at a stable level but actually reduce the usage of people and use green energy is stead of fossil energy. But the interaction between human and energy and the technology that can help with the goals to achieve sustainability” (S. Vosslamber, 2015)

**Aquion:** “I personally define something to be 'sustainable' by nearly the dictionary definition: something that is sustainable is able to maintain itself at a certain level or rate. So, a sustainable battery is a battery that is able to deliver more value to society than it takes to create. This can be measured in a number of ways — the way Aquion has elected to measure our product sustainability is by the Cradle to Cradle Product Innovation Institute five criteria:http://www.mbdc.com/cradle-to-cradle/c2c-framework/ (Material Health, Material Reutilization, Renewable Energy, Water Stewardship, and Social Fairness)” (M. Maroon, 2015)

**Weaving a Home:** “When I think about the word sustainability, I think about continuity, resourcefulness, growth, holism, accessibility. It is a collection of many concepts that all interlace to promote harmonious and healthy living. Good design upholds sustainability and both beauty and functionality are integral to the promotion of sustainability. Sustainability is also a system of positive actions that link together to forge positive evolutionary outcomes for the advancement of society” (A. Seikaly, 2015)
AN INQUIRY INTO APPROACHES TO WELLBEING

Nearly all sustainability rhetoric contains an implicit or explicit reference to human wellbeing. Therefore, the next step in attaining a more comprehensive understanding of sustainability is an inquiry into different concepts and uses of the term wellbeing. Like sustainability, this term is common, invested with a high degree of moral clout, and yet highly contentious and ambiguous. For example, in an official report released by the United Kingdom's government, Mainstreaming Sustainable Development (2011), they state: “The coalition Government is committed to sustainable development (SD). This means making the necessary decisions now to realize our vision of stimulating economic growth and tackling the deficit, maximizing wellbeing and protecting our environment, without negatively impacting on the ability of future generations to do the same” (2). “Maximizing wellbeing” is considered an integral part of the sustainability enterprise, comprising the social branch of the three pillars of sustainability. Similarly, in a letter issued by the Dutch government, they state “Sustainability has become a major factor in companies’ competitiveness. It is also a prerequisite for human wellbeing” (“A Green Growth Strategy,” 5). In this passage, sustainability is conceived as a means to wellbeing, and not a means in itself. The interrelation of sustainability and wellbeing is not exclusive to Western governments, either. Taking a rather different approach, the “Twelfth Five Year Plan (2012-2017): Faster, More Inclusive, and Sustainable Growth” of India states “Conservation of life forms (and their habitats such as nesting/spawning sites), and integration of their environment with human well-being is important” (117). While these official statements on sustainability prioritize wellbeing in different ways and identify it in different relationships, they indicate the extent to which these two concepts are interrelated and central to policy-making. Even in statements all issued from central governments, the deployment of wellbeing differs, and one can assume that conceptions are even more diverse within the private-sector and among individuals.

Despite its centrality, wellbeing has a long and contentious history of different, competing definitions and agendas. Within philosophical discourse, there exists competition between hedonistic and eudemonic wellbeing. Hedonistic wellbeing or the “hedonic assumption” is that “that human nature is driven by the maximisation of individual pleasure” (Wiseman & Brasher, 2008:355). This is not simply a neutral, philosophical stance, but “is also at the core of the dominant political paradigm of our time: neo-classical
economics with its associated view that the only reliable way to assess pleasure is through the ways individuals exchange money for goods and services in the marketplace” (Wiseman & Brasher, 2008:355). While few neo-classical economists might acknowledge that their ideas are grounded in this particular conception of wellbeing, their priorities and objectives imply such a conception. These authors indicate how different conceptions of wellbeing inform different sets of goals. Eudemonic wellbeing takes a more systematic approach to “ways in which we are able to flourish, find meaning, and fulfill our potential” (Wiseman & Brasher, 2008:355). This approach entails defining an ideal state and prescribing a methodology to reaching it which may not cohere with individual desires. It is characterized by invocations of broader social responsibilities and an emphasis interpersonal relationships, often associated with Aristotle and also Buddhist, Islamic, and indigenous traditions to name a few.

Correspondingly, within the social sciences subjective and objective wellbeing compete for primacy. Even within these categories, varying definitions, focuses, criteria, and measurements make consolidation into a single definition seemingly impossible. Definitions of wellbeing can be generally divided between individual wellbeing and collective or social wellbeing. The hedonistic and subjective conceptions of wellbeing focus on the individuals, while eudemonic and objective wellbeing prioritize systems and collectives. Psychologists Ryff and Singer (1998) illustrate this connection when they begin “The Contours of Positive Human Health” with a discussion of “Aristotle's notion of eudaemonia, for example, described the highest of all human goods as the realization of one's true potential. John Stuart Mill distinguished between the happy pig and the unhappy Socrates in an effort to define more noble features of human existence than simply feeling good” (Ryff & Singer, 1998:2). They use the philosophical justifications for eudemonic wellbeing to formulate a set of “key goods” central to psychological health. They conclude “that the key goods in life central to positive human health are, primarily, having purpose in life and quality connections to others; and secondarily, possessing self-regard and mastery” (Ryff & Singer, 1998:2). This taxonomy even includes “self-mastery,” indicating the eudemonic priorities over the hedonistic. In direct response to Ryff & Singer's (1998) formulation of objective wellbeing, Diener, Sapyta, & Eunkook (1998) state “the study of subjective well-being pays more attention to people's values, emotions, and evaluations, and does not grant complete hegemony to the external judgments of behavioral experts” (33). This focus on the individual and his/her experience of pleasure is typical of both the hedonistic and subjective stance. The primary difference in the philosophical and social-science use of these notions is that social-scientists must substantiate their criteria with quantitative or qualitative analyses, while philosophers can invoke rationality and logic in a looser methodological framework.

However, even within the social sciences, the underlying conception of wellbeing influences the way the research is conducted. Diener et. al. (1998) illustrate this when they describe how “Ryff and Singer turn to philosophers, psychologists, and other experts in terms of defining well-being. In contrast, we argue that we should also turn to people's own reactions in evaluating their lives” (Diener et. al. 1998:35). Even within the more methodologically strict social-sciences, definitions of wellbeing are diverse enough to entail different approaches to research, which in turn influence varied criteria of wellbeing and prescribed methods for attaining it. Even within subjective wellbeing, these authors provide four different evaluational methods, “Preference satisfaction – based on fulfilling our desires; Flourishing accounts – based on the satisfaction of certain psychological needs; Hedonic accounts- based on how we feel; Evaluative accounts-based on how we think and feel” (Dolan, Peasgood,
White, 2006:7). This diversity shows how different definitions of wellbeing entail different approaches to research, which in turn informs different goals and prescriptions.

To illustrate an application of wellbeing, take the UK's Department of Environment Food and Rural Affairs (DEFRA), which commissioned an enormous report on different definitions, forms of measurement, and operationalizations of wellbeing. The writers of this “Review of Research on the Influences on Personal Well-being and Application to Policy Making” describe how “The specific requirement for this project was to ‘review the evidence relating to the causative factors associated with various concepts and components of well-being’, with a special focus on personal well-being’ (Dolan, Peasgood, & White, 2006:7). This indicates the extent to which defining and operationalizing wellbeing is perceived as indispensable to sustainability overall. Already, the government's directive indicates a bias towards subjective wellbeing. Yet, one can assume the government does not subscribe to an entirely hedonistic conception, because some individual desires may go against the security of the state. So although these approaches share a similar focus on the individual, they do not entail the same goals. The authors readily acknowledge how “Different policies may result from a focus on one account of well-being compared to another. Similarly, different implications may be drawn from the use of one type of measure within a given account. We therefore consider a number of ways in which the measures of well-being may differ within an account and across studies” (Dolan, Peasgood, & White, 2006:7). They illustrate how the underlying assumptions regarding what wellbeing is and how it should be assessed has a strong impact on how policies and prescriptions are formed. In their review of relevant literature, they assessed 153 different psychological and economic studies, indicating the importance and diversity of this term. This is only one attempt to clarify and operationalize wellbeing, but it exemplifies the huge quantity and diversity among different conceptions, and the influence these conceptions have on goals, policies, and behavior.

Sources
State Secretary for Infrastructure & the Environment, the Minister for European Affairs & International Cooperation, the Minister of Economic Affairs, Agriculture & Innovation and the Minister of the Interior & Kingdom Relations to the House of Representatives. (2011) “Letter on the Sustainability Agenda: A Green Growth Strategy for the Netherlands.
Applications in the Cases

Within our cases there were a few different understandings of wellbeing, each influencing how the project was operationalized. Here are responses we received to the question: “how would you define wellbeing?”

GoGreen: “Of course wellbeing is one of the terms that you can define in different applications differently. In public health, for instance, wellbeing has a very different meaning than talking about it from an energy perspective. But you can define this term for this project from the comfort point of view. And this comfort point of view is not only the feeling comfort or the user requirement of comfort in terms of satisfaction but also in terms of quality of services that it gets. If he/she wants the water temperature whatever when he/she takes a shower and this is a quality of service, wants that temperature, should receive that. Satisfaction in terms of meeting its requirements, and one of these requirements is of course saving money, or saving energy if you’re really eco-friendly. And this is from a very individual point of view, but then if you scale that up, you can say the sustainability of the wellbeing of a neighborhood depends on the sustainability and wellbeing of every individual, then you have the whole community also sustainable. So you can just generalize this concept” (N. Meratnia, 2015)

Meppel: “In Meppel, it’s more heat-driven, they should be within a certain comfortable range. So they want an acceptable package of heating options. There’s also a discussion now about making the rooms a bit bigger. One of the problems is that if you build a very well insulated house, that might be good for winter but not for summer, so we also need cooling. Also, optimal temperature for behavior varies throughout the day. So most people need more heat when they are just sitting around watching TV or something, while they need less in the morning. So that is for the Meppel project, it’s more or less heat-based, based on what the RENDO company can provide” (G. Smit, 2015)

Lochem: “So for Lochem, the project is based on the energy corporation wanting to be as self-sufficient and renewable as possible. So renewable energy is really the priority. That’s the difference between the Lochem project, everyone we’re involved with is a member of the energy corporation and together they started it so they are very involved in this project” (G. Smit, 2015)

“It’s difficult but, a state… with in which one is feeling well and satisfied how one lives. Doesn’t really fit with the project. Happy with the way you live or something…. the example with the energy management system I think such a system can contribute to the wellbeing can help the user in their daily life by taking action for them and making their life more comfortable. I think the human needs to accept it but actually want the technology to help and promote wellbeing. So in the project it is part of it but only if the human accepts it” (S. Vosslamber, 2015)

Aquion: “Not applicable” (M. Maroon, 2015)

Weaving a Home: “Well being is waking up in the morning and looking forward for the day to unfold. It’s being happy and fulfilled, content and healthy. It’s living in a beautiful environment and continuously working to maintain the beauty of that environment. When we take care for our surroundings, it will take care of us and vv” (A. Seikaly, 2015)
Since the crux of these articles is concerned with sustainability in the context of technological application, it is also important to define some relevant terms for technology. Unlike our approach to sustainability, we are not focused on the broader, more abstract concept of technology as a whole, or so-called “Technology-with-a-capital-T.” This is because all our relevant applications would fit within the vast majority of definitions of Technology, and we are more concerned with negotiating diverse and conflicting definitions than explicating consensus. Therefore, we turned to more applied terms, those of high tech and low tech. These terms are often used to distinguish different technological approaches to sustainability on a variety of levels, including policy-making, marketing, economic evaluation, and a number of other sectors. High tech is a particularly relevant term because it is contained within the University of Twente's main motto: “high tech, human touch” and the in-university research projects all strive towards different standards of high tech. It is therefore necessary to understand what is meant by high tech in a variety of contexts and the different approaches to assessing technological intensity.

In order to understand what high tech means in a specific context, one must first understand how it is measured. Eurostat defines three approaches to evaluating high tech: sector, product, and patent. They enumerate how “the sector approach looks at the high-tech manufacturing sector, the medium high-tech manufacturing sector, and the high-tech knowledge-intensive service sector, focusing on employment and economic indicators... the product approach considers whether a product is high-tech or not and examines trade in high-tech products... the patent approach distinguishes high-tech patents from others and also defines biotechnology patents” (Bold added, Eurostat, 2015:1). While a policy-maker might be concerned with national-level industries, and therefore focus on sectors or patents, a marketer might be concerned with the viability of his/her products, and therefore take a product-based approach. So scholars, marketers, policy-makers, technologists, and other related parties have a variety of approaches available to them by which to evaluate high tech, each producing a somewhat different narrative based on their goals and interests.

One well-known attempt to define high tech comes from the Organization for Economic Co-Operation and Development (OECD). They have been developing a definition for high tech since Thomas Hatzichronoglou's (1997) “Revision of the High-
Technology Sector and Product Classification” for the International Standard Industrial Classification Review 2 (ISIC 2). He defends the OECD’s attempt to define high tech when he writes “In order to analyse the impact of technology on industrial performance, it is important to be able to identify those industries and products which are most technology-intensive, through criteria allowing the construction of special internationally harmonized classifications” (Hatzichronoglou, 1997:4). He therefore gives both a sectoral (industry-based) taxonomy which is split into four classes (high, medium-high, medium-low, and low technology) and a product-based taxonomy, which provides only high-technology products. Although these approaches result in different taxonomies, they are both based on “direct R&D intensity and R&D embodied in intermediate and investment goods” (ISIC Rev. 3, 2011:1). Even without going into detail about how R&D intensity is measured, it is still apparent that this is only one particular approach out of many. Tong (2005) cautions, “When it comes to productivity of R&D, opinions diverge” (217), indicating that this is hardly an uncontroversial foundation. So while the OECD attempts to diversify its foundational assumptions to both sectoral and product-based, they still necessarily made some negotiable pre-suppositions about how to make measurements. The OECD authors even caution, “The technology-intensity classification is relative. Many manufacturing activities could be considered ‘high-technology’ but by looking at direct R&D intensities we are classifying according to relative recent R&D performance. Also, ‘high-tech’ industries can produce a variety of products ranging between ‘low-tech’ and ‘high-tech’” (ISIC Rev. 3, 2011:1). Nonetheless, the OECD definition is frequently cited and relates closely to definitions from other policy-making perspectives. Their sectoral approach delineate high tech industries as: “Aircraft and spacecraft; Pharmaceuticals; Office, accounting and computing machinery; Radio, TV and communications equipment; Medical, precision and optical instruments” (ISIC Rev. 3, 2011:1).

Various approaches and resulting taxonomies have enough in common that certain trends are apparent regardless of which taxonomy an author deploys. One trend is that both national, private, and consumer interest in high tech industries and products is on the rise, particularly in developed and developing nations. The Eurostat definition on high tech describes how “High-tech industries are expanding most strongly in international trade and their dynamism helps to

<table>
<thead>
<tr>
<th>Source</th>
<th>Approach</th>
<th>Taxonomy</th>
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<tbody>
<tr>
<td>OECD</td>
<td>Product</td>
<td>Aerospace, computers-office machines, electronics-telecommunications, pharmacy, scientific instruments, electrical machinery, chemistry, non-electrical machinery, armament (Hatzichronoglou, 1997:4)</td>
</tr>
<tr>
<td>OECD</td>
<td>Sector</td>
<td>Aircraft and spacecraft, pharmaceuticals, office/accounting/ computing machinery, radio/TV/ communications equipment, medical/precision/ optical instruments (ISIC Rev. 3, 2011:1)</td>
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improve performance in other sectors. Investment in research, development, innovation and skills constitutes a key policy area for the EU as it is essential to economic growth and to the development of a knowledge-based economy" (Eurostat, 2015:7). In a product-based analysis by the OECD, they produced these tables (above) on the imports and exports of high tech products in OECD countries.

These graphs show the significant increase of exports and imports in high tech products from 2000-2006, particularly in the Netherlands. As noted in the report, the same top-five importers are also the top-five exporters (Eberth, 2008:10), indicating the extent to which some highly developed nations are committing themselves to high tech development. This coheres with the University of Twente's commitment to research and development in high tech sectors (i.e. ICT) and individual high tech products (i.e. zero-energy ICT sensors and actuators).

This focus on high tech products and industries is not exclusive to highly developed, Western nations. In Zhao & Yang's (2012) study of Chinese high tech innovation, they note the importance of high tech development while also acknowledging the differences within the Chinese context. They describe how “unlike developed countries, China’s economic system is in a transitional period. In such a special period, the development of China’s high-tech industry is significantly distinct from that of developed countries” (Zhao & Yang, 2012:291). Nonetheless, their rhetoric seems to mirror that of Eurostat (2015) when they describe “The high-tech industry, with characteristics of high growth, large driving forces and high value added, is a strategically leading industry in the national economy, playing an important role in industrial restructuring and transformation of the economic development pattern” (289). Although these authors speak from different contexts, they seem to agree on the social and economic value of high tech industries and products. There is an assumption that investment in high tech industries and products will lead to greater viability in a globalized market, economic growth, and also “better and well-paid jobs, greater social cohesion and a smart, sustainable and inclusive economy” (Eurostat, 2015:7). This passage illustrates the connection between the rhetoric of sustainability, wellbeing, and high tech. High tech is viewed as a particularly viable approach to attaining the sustainability which promotes wellbeing.

Since the University of Twente displays both a commitment to high tech and sustainability, it is
important to identify how these concepts interact. In the “High Tech, Human Touch: Facts and Figures 2014” the UT states “One self-evident aspect of this [education] is the importance of raising people’s awareness of sustainability” (5). Between the title and this statement, it is clear that these ideas are interrelated in the research performed. This is not exclusive to the UT, as our two unaffiliated case-studies also had definitions of high tech in which their approach qualified. This means that out of our five cases, no one subscribed to a low tech operationalization of sustainability and wellbeing. This further emphasizes how high tech is the prioritized approach to solutions for sustainability and wellbeing. However, we see from the cases below that even within the UT, there is no consensus on the meaning of high tech or its precise relationship to sustainability and wellbeing. Some projects, like the GoGreen project, use a definition of high tech in which it enhances user-comfort, cohering with their social sustainability and hedonistic/subjective wellbeing. In the Lochem and Meppel projects, on the other hand, the definition of high tech has to do with the controllability and optimizability of the technical system, also cohering with the more environmental sustainability and eudemonic/objective wellbeing trends identified in the previous sections. Despite the increasing commitment to these terms apparent among the UT and outside of it, we see an array of diverse interpretations and operationalizations, each informing the particular shape that the technological development takes. This is not necessarily problematic to the UT, as it makes a more diverse, and therefore more adaptable, basis of operation wherein one technical solution fails to appeal to its target-users and another approach/solution fills that niche.

Sources
Applications in the Cases

What *high tech* means and how it is operationalized varies significantly among these projects, so here are the answers we received to the question: “how would you define *high tech*?”

**GoGreen:** “A low tech energy management system I would define as a system which is not intelligent and not aware of the user. And of course high-tech is the opposite of that. You may have a very high-tech from the technology point of view, so you may have a lot of sensors and IT solutions in place, but then either if it takes over control from the user, then it is not high tech, then it is very low tech from the user perspective. Also if it is something that the user all the time has to interact with, that is also very low tech. The high tech is something which is intelligent in some way and this intelligence is coming from adaptation, monitoring, optimization, so the definition does not really have to do with technology in the sense of expensive equipments and stuff like that, it is more on the functionality” (N. Meratnia, 2015)

**Meppel:** “Let’s take the example of charging an electrical vehicle. A low-tech system would be that you don’t control anything, you just use it and it self-operates. A high-tech system could be that you control the charging of all the vehicles so you can strategically spread the loads or something” (G. Smit, 2014) This also applies to Lochem.

**Lochem:** “Technology interacting with other technology, humans can have a say or interact with it but the system does not need human to function so automated. System adjusts itself in situations instead of human adjust the system, so a self functioning system with minimal human interaction is a high tech system. (Automated) … A low tech system is a system that interacts between human and technology and needs humans to function so opposed to the high tech system. (Not automated)” (S. Vosslander, 2015)

**Aqion:** “I would define a ‘high tech’ system as anything that measures and actively makes decisions on how best to respond based on those measurements. For example, Aqion has a product class that contains a battery monitoring system. This battery monitoring system measures key attributes of the battery (temperature, voltage, health, etc.) and reports these metrics up to a higher level controller. This high level site controller will make real time decisions on how to respond to the system needs based on the information it receives from the battery monitoring system. … I would define a ‘low tech’ system as one that reacts passively to what is asked of it. We have products with no sensing that will simply respond to a demand for power without determining if the product is in a position to deliver that power or not” (M. Maroon, 2015)

**Weaving a Home:** “It’s important to go back to the pure definition of technology first which is: craft, weaving and making. For me, a high tech system involves a complex set of things/ideas that are harmoniously linked to form a simple and intuitively interactive and user-friendly whole. I don’t believe that high-tech is constrained to the technological revolution that has taken place in the last 50 years. It think the concept high-tech is a timeless concept. I think a basket is high tech” (A. Seikaly, 2015)
Generativity is the process of creating something in a novel way or re-shaping that which already exists (Kotze, 2005). It applies to everything from genes to values, to technology, energy, heat and electricity. Within the context of sustainable energy management in the private home, especially the generation of heat and electricity takes centre stage. Electricity defines our modern world, whether we are at home or at work, indoors or out on the street. Wherever we go, we bring our mobile phones or laptops, we turn on the lights when it goes dark, we turn up the heat when we are uncomfortably cold, and by pressing a few buttons we hear our favourite band playing its music. Nowadays, the importance of electricity extends even to the use of our cars and bikes, and vital modern developments like the computer and smartphone would probably not even exist. In the future this will increase only further.

However, it is not only our appliances that have developed in recent decades. The way we generate heat and electricity has evolved as well. This article only scratches the surface of the history of energy generation technologies, but does provide an account of the development of such technologies and the culmination of this process up to the sustainable energy technologies of tomorrow. The article discusses in more detail three case studies that concern energy production and energy storage technologies. The storage element of generative technologies is an important element of the energy grid of sustainable energy technologies, for the storage element partly determines the capacity of the energy distribution grid. This is especially important in the case of energy generation from sustainable resources, since they are intermittent in their production of energy and not perfectly tuned with energy use. This article, therefore, discusses the heat and power generating Combined Heat and Power system, the Weaving a Home project which is a technology that combines energy generation, distribution and use, and the energy storage technology of Aquion Energy.

The roots of electricity generation lie in the 19th century in the works of men such as Alessandro Volta, Michael Faraday and Benjamin Franklin. Franklin’s research into the nature of electricity, for instance, resulted in the development of the lightning rod. The widening understanding of electricity coincided with the development of the steam engine and the use of gas for fuel and lighting. Later on, electricity was also used for lighting and traction power, the latter one accelerating the growth of electricity generation.
The evolution of electricity generation technologies continued with the development of reciprocating steam engines, steam turbines, hydropower energy, the spark-ignition and diesel engine, and wind turbines. These technologies ran mainly on coal, oil or gas and provided the bulk of the power generation capacity. From the 1950s on this also included nuclear power, but from the 1970s on countries began to seek alternative ways of generating electricity since they were extensively burning oil and the oil prices were vastly increasing. In that time there was also a widespread concern for the influences on the environment and people wanted a reduction in environmental emissions. Alternative energy generation technologies that were developed as a result were technologies such as wave power, geothermal power, biomass energy and the combined cycle plant that combines gas and steam turbines, with the most important technologies being solar and wind power. But it was not until the end of the 20th century that these latter technologies were both technically and economically viable. Nowadays, the new alternative sources of energy are fuel cells, heat in tropical seas and offshore wind farms.

Renewable energy technologies convert natural phenomena into forms of energy that can be marketed, distributed and consumed. These natural phenomena can be, for instance, the sun, the wind or waves. They hold massive energy potential and are thus valuable resources for the generation of renewable energy. They are, however, generally diffused and not fully accessible, with distinct regional variability and intermittent productivity (Kalogirou, 2004). Due to these features of renewable energy sources that make them uncertain and inaccurate, the capacity to store the energy is an important element of the energy grid. Combining such energy sources with some form of sustainable energy storage increases the value of the generated energy, helps to maintain the stability of the energy grid, and enables the grid to deliver energy during peak periods of demand even when energy is not generated. The storage of energy, thus, offers significant benefits for the generation, distribution and consumption of renewably generated energy.

Three examples of generation technologies are the “CHP systems”, the “Weaving a Home” project of Abeer Seikaly and Aquion Energy’s “Aqueous Hybrid Ion batteries”. The Combined Heat and Power (CHP) systems generate energy from a range of possible sources, renewable or conventional. It is used in the Meppel Energie project to generate electricity and heat from biogas. The Weaving a Home project combines renewable energy generation, distribution and utility into one sustainable and mobile home. The Aqueous Hybrid Ion batteries, then, are an example of sustainable energy storage.

**Combined Heat and Power systems**

In the Meppel Energie project (for a short description see Case Profiles on page 152), energy for the homes is generated by Combined Heat and Power (CHP) systems. In such systems multiple forms of useful energy are sequentially or simultaneously generated in a single and integrated system. CHP systems consist of a heat engine (the component that drives the whole system or prime mover), a generator, a heat recovery component and electrical interconnection. The prime mover can be a variety of engines, including a steam turbine, gas turbine, diesel engine, or fuel cells. Most often the mechanical energy from the prime mover is used to drive a generator to produce electricity, but it can also be used to drive rotating equipment such as pumps, fans, or compressors. The heat or thermal energy that is produced at the same time can be used in direct process applications or indirectly to produce steam, hot air, hot water, or chilled water for cooling a system in process.

In the case of the Meppel project the prime mover is an engine that runs on biogas that is formed in the process of the burning of biomass. A waste water treatment produces this biogas on which the prime mover in the CHP runs. It is basically a gas-fired power plant which produces both heat and electricity. The heat and electricity is then transferred to homes through distribution grids.

**Weaving a Home**

“Weaving a home” innovates the architectural concept
of tent shelters. As Abeer Seikaly, an architect, cultural innovator and the designer of the tent homes, puts it, the structures are built from a technical fabric that contracts to a mobile size and expands to form an enclosure that provides the comforts of contemporary life. In her designs, Seikaly aims to explore underlying themes and principles that address questions relating to living spaces.

The Weaving a Home tent shelter provides for needs of people in motion. The needs that the tent shelters can cover are for instance heat, running water, electricity, and storage capacity. According to Seikaly, the duality between movement and settlement for people is a fundamental essence of being human. Her tent shelter is a home for the people on the move, aiding them to feel human by feeling rooted in the environment, wherever this environment may be.

The lightweight, mobile, structural fabric has a natural form, function, and movement and forms a scalable whole in which structure and fabric are intertwined. Structures in the tent can open and close, making it suitable for all seasons. Double layers in the fabric can be utilised for storage and on the top of the tent is a tank fitted for water storage. Through the vertical tubes in the fabric, water rises to the tank from a water source under the influence of solar radiation, a process called thermosiphoning. The fabric can also convert solar radiation to energy to be stored in a battery, making it possible to use appliances like a lamp or radio.

It remains, however, questionable whether integrating energy generation, distribution, and utility into one technology that provides the comforts of contemporary life is still feasible, when taken into account that the technology is designed to be used by refugees. Although providing refugees with the comforts of contemporary life is a noble initiative, supplying such tents to refugees, for one, will be a costly business, certainly more costly than conventional tents. However, the technology provides a greatly ambitious but very interesting peek into the future of tenting and, possibly, of refugee housing.

Aquion Energy

Aquion Energy’s Aqueous Hybrid Ion batteries are modular and scalable energy storage systems that come in an environmentally friendly package. As Matthew Maroon of Aquion Energy explains, Aquion Energy is a company that builds the sustainable energy storage technology that is specifically engineered to deliver peak performance and cycle life when paired to renewable energy resources such as wind and solar energy. It is Aquion Energy’s objective to build high quality batteries at a competitive price and to enable the widespread adoption of renewables in stead of traditional power sources such as diesel generators.

The batteries provide high performance, they are safe, sustainable and cost-effective, and can be used for long-duration stationary applications on a global scale. The battery is based on saltwater electrolyte battery technology, using abundant and non-toxic materials and low cost manufacturing techniques. On top of that the materials used are environmentally benign, without corrosive acids or noxious fumes. Aquion Energy aims to increase the use of renewable power and tries to meet the global energy storage challenge.
The batteries enable new possibilities for energy storage, from application in small cell phone towers to large commercial, industrial and military customers. It can be deployed as an off-grid workspace, powering lighting, air-conditioning and small electronics, or in microgrids to enhance the stability and efficiency of the grid by decoupling the generation of the energy from the load. This latter aspect is particularly useful for electricity production by intermittent renewables like solar panels. The ability to store energy generated on site increases the utilisation of this energy, reducing costs, ensuring power quality, and serving as an uninterruptible power supply during an outage. On top of this, the energy storage allows for better energy management because users can avoid peak demand charges in case they are connected to a power grid by shifting energy use to off-peak hours. The batteries also allow for energy storage on a grid-scale, augmenting or replacing generation, transmission and distribution as they can decouple energy services from a particular fuel source. The implementation of batteries on a large scale then makes the grid more reliable and flexible, facing the challenges of peak hours, outages and load shifts.

However, it does not raise awareness of people’s energy consumption. While energy consumption steadily increases, this technology withdraws it from view, precisely due to what it aims to be good at, namely heightening the quality of energy management. It might reinforce the view of energy as a commodity because it is always available, steady, and reliable. Therefore, it does not contribute to people’s realisation that energy consumption is vastly increasing. Even though these salt water batteries can strongly advance the transition to renewable energy, even renewable energy needs a power grid and other resources to be made available to the public. The energy problem, therefore, cannot simply be solved by making every necessary technology a sustainable technology. Steps have to be made to focus attention on the problem of energy consumption as well as energy depletion. Still, Aquion Energy’s Aqueous Hybrid Ion batteries is an important and reliable actor in the power grid for renewable energy sources.

Sources

Images
http://www.abeerseikaly.com/weavinghome.php
http://www.aquionenergy.com/energy-storage-technology
SMART GRIDS

The electrical grid of tomorrow’s private sustainable living

Smart grids are one of the technological developments in response to the ever-increasing demand for electricity and numerous other economical ecological and social factors. The European Technology Platform (E.T.P., 2006:12) argue that the three driving factors toward smart grids are: the internal market, security of supply, and the environment. The internal market evolves through a regulatory framework which promotes economic growth while forcing prices to lower, security of supply to increase as the availability reliability and capacity of the existing grid are upgraded, and the integration of novel energy generation technologies enabled through smart grid technology (E.T.P., 2006:12). With the expectance that electricity consumption will keep steadily increasing, the need for more efficient ways to manage the traditional electrical grid becomes evident. Smart grids focus on the conservation of energy, thus the efficient management of existing power grids through ICT systems, including integration with energy generators based on renewables. To give a clear explanation of what a smart grid entails a common definition by Scott et al. (2008) defines, “A Smart Grid generates and distributes electricity more effectively, economically, securely, and sustainably. It integrates innovative tools and technologies, products and services, from generation, transmission and distribution all the way to customer devices and equipment using advanced sensing, communication, and control technologies. It enables a two-way exchange with customers, providing greater information and choice, power export capability, demand participation and enhanced energy efficiency” (Bakker, 2011:22, cf. Scott et al, 2008). Ribeiro, Polinder, & Verkerk (2012) recapitulate this definition as, “The whole system of central and local energy generation, transmission and distribution, and enabling intelligent control and information systems is called a smart grid” (Ribeiro, Polinder, Verkerk, 2012:35).

Using ICT systems to control energy flow of buildings for energy efficiency is only partially novel, as large buildings already have such systems applied when using technologies like ‘sophisticated climate control.’ One author describes, “the novelty of smart grids however is the aim to include buildings and their appliances into an overall manageable ICT system” (Bakker, 2011:5). The essential difference in the smart grid and the traditional grid becomes evident in its communication capabilities. A clarifying explanation comes from Gungor et al. (2011) when they write, “there are two types of information indispensable. Firstly the flow of information from sensory technology and electrical appliances to smart meters
and secondly the flow of information from one smart meter to another and to utilities data centres” (Gungor et al., 2011:530). This two way communication changes the way customers use and perceive the electrical grid and its suppliers to a more customer-centric relation. Gangale Mengolini and Onyekw (2013) argue that “The traditional paradigm of passive distribution and one way communication and flow between suppliers and consumers is being replaced by a new paradigm of active distribution that is bound to dramatically alter the role of the consumer.” (Gangale et al., 2013:621). Through literary review it becomes apparent that the recent developments of smart grids change the relation between supplier and user as well as the relation between consumers and their home appliances or general energy usage. Amin and Wollenberg argue that “On a system level, each agent in a substation or power plant knows its own state and can communicate with its neighboring agents in other parts of the power system (Amin & Wollenberg, 2005:40)” indicating that not only do the relations change with the introduction of smart grids, but also that “AI” units take over communicative roles of the supplier. This change in relations also changes stakeholder relations, resulting in an increase of stakeholders involved in the electrical grid namely; “governments, regulators, consumers, generators, traders, power exchanges, transmission companies, distribution companies, power equipment manufacturers and ICT providers” (Bakker, 2011:23).

TRIANA, a smart grid control strategy developed at the University of Twente can give a more specific insight into technical engineering challenges of the smart grid. Bakker (2011) explicates five technological challenges faced when developing a smart grid which translate in five main technology sectors: (1) Sensing and measurement: Includes the monitoring of home appliances and weather to forecast load and potential output of generative technologies, enabling balanced generation and usage while respecting transmission limitations, example technologies are advanced metering infrastructure (AMI) e.g. Smart meters. (2) Integrated communications: Communication of information from sensing and measurements devices towards the operators and management information back to the actuators it involves creating a homogeneous communication infrastructure. (3) Advanced components: contains three main technologies, Distributed generation (DG), as explained in the article on generative technologies (page 163), Distributed storage (DS) as explained in the Aquion case in the generative article, and Demand Side management (DSM) of devices with the goal to modify the consumption pattern of consumers. (4) Advanced control methods: Includes technologies that control stability flows of electricity, and assure the maximum utilization of transmission assets, is furthermore involved with control methods regarding the integration of renewable generative technologies, and protection of the grid. (5) Improved interfaces & decision support technologies are developed to assist different grid operators; data mining in this is central at which data is attained through measurement equipment. This data is used to assess forecast consequence and to provide presented by advanced visualization tools to make adequate decisions. These five main technological challenges are attacked by the TRIANA strategy which aims “to create a Smart Grid solution and exploit all optimization potential, the introduced technologies need to be monitored and synchronized to each other” (Bakker, 2011:26). This is done through the introduction of “mathematical optimization techniques and a combination of, 1) local online forecasting, 2) global offline planning and 3) local online control.” (Bakker, 2011:32). Local forecasting is done on device level; a freezer for example can be controlled by looking at its freedom to control. This results in a forecasting model of devices,
where according to Bakker (2011), “the forecasting model of a device can be seen as a function F(I, Fp) → O, where I is the input for the forecast model, Fp are the forecast model parameters and O the forecasted output values” (Bakker, 2011:43). The function serves to map the input and output of a device; however, this mapping is too rough of an estimation, and changes in input or changes between input and output are dynamic.

To solve this problem neural networks are used as a mapping function. Neural networks are “computational models based on biological neurons which can learn, based on given training examples, (non-linear) relations between the input and the output,” (Bakker, 2011:43). Within a neural network three types of neurons exist, in which each neuron performs one task in relation to its neighbour’s input. The three types are “input neurons which receive input from outside the network, output neurons which send data out of the network and hidden neurons whose input remains within the network” (italics added, Bakker, 2011:44). An example of a neuron can be seen in figure 2. A multi-layered feed-forward network of neurons is used to forecast properly and in application resulted in heat-demand forecasting for groups of micro-CHP appliances. “Micro-CHP is a system that consumes natural gas and produces heat and, as a by-product during the heat production, electricity” (Bakker, 2011:47). Each house in a micro grid functions as a neuron in the neural network enabling scheduling freedom and accurate forecasting models. The second step (global planning) of the TRIANA strategy planning is enabled through the output of the first step (local forecasting), such that the scheduling freedom can be used by a controller to reach the goals of the grid. The controller can assess the hierarchical structure of the TRIANA method to exert control over nodes as seen in figure 1. In the second step, planning, global controllers make use of the hierarchical structures, local or global algorithms, and heuristics to optimize electricity streams to a certain objective. This enables the controller to forecast periods of time. Building new controllers can adjust certain profiles set up by the initial controller, leading to an iterative distributive process, led by a global controller. The result of the planning step is to create a profile of energy use for the next day (Bakker, 2011:34). This profile is input for the third step, real-time control, using the combined information about the status of devices within a grid, real-time control algorithms are used to decide activity and consumption of an appliance or generator. Three inputs are taken into account when making decisions: first, online signals from planning are used, and second it can use real-time signals from the grid controller based on the status of the grid to respond to fluctuations caused by generative technologies. Third, the local/building controller works around forecasting errors to provide comfortable service even in problematic parts of the grid (Bakker, 2011:34).

To explain Smart grid technologies in relation to practical applications and developments, there are two applied cases of the Triana strategy, namely, the Lochem and Meppel energie projects, in which created two communities suitable for smart grid testing. Gerard Smit, Head of CAES, describes how they “predict several hours ahead what the energy consumption will be, and we do this for all the houses, then at the central level we try to match, as much as possible, the production, in this case the electricity and heat, and the consumption” (Smit, Interview, 2015). The two projects also provide insight into the integration of sustainable energy generation methods. As Smit (2015) puts it, “in Meppel where they built new houses there is a waste water treatment and they produce biogas. The idea is that this biogas is transformed and supported by the centre of Meppel and there is a CIIP. To summarize it is a gas-fired
power plant or energy house which produces both heat and electricity and our work now is to transfer it to homes through distribution grids” (Smit, Interview, 2015). When looking back at the definitions of smart grids, the definition of Ribeiro et al. (2012) seems fit perfectly when linking it to this applied explanation of tasks. However, no real explanation is given of the role of the customers and users, as explicated by Gangale et al., (2013), in his paradigm of active distribution (Gungor et al., 2013). Susanne Vosslamber, a psychology teacher involved in Lochem Energie focuses on Human Factors research, shedding light on the customer engagement in the smart grid application. Examples of these issues in smart grids would be, according to Vosslamber (2015), “automated systems that turn the washing machine on/off when the price of electricity is high/low and the question was for example do users even want that? And on which devices do they want the automated switch” (S. Vosslamber, Interview, January 28, 2015). Questions like this reveal the depth of this new customer-supplier relation procreated by smart grids, as optimization of user devices is one of the core components of energy savings in the smart grid. This human factor focus can be seen as an application of the forecasting model at which psychology research funnels optimization of these forecasting models.

When assessing both applications of smart grid, one can see an increasing focus towards learning about users and their preferences (S. Vosslamber, personal communication, 2015). This is a logical step as forecasting models need to be constructed within the practices of the users. The focus on users is grounded in the design of the smart grid by TRIANA, and provides input for the “neural network” of the smart grid. Customer feedback is crucial in successful creation of a smart grid, which focuses on the right balance between demand and production (Mengolini and Vasiljevska, 2013:21). Smart grids are a rather broad concept with hundreds of possible applications; the technical problems and solutions presented by TRIANA show the complexity of technical features and strategies. Social issues such as customer engagement, stakeholder relations, among others explored in this article, show the connection between the way engineers designed the technology and how this design actually fits a ‘real’ environment. Also, these cases indicate the role of social science in forming input for forecasting activities. A different approach will be introduced in the next technology, smart homes, which focus exclusively on this human-centred approach by creating an active virtual environment. These assessments of smart grid technologies enable the stage for ethical debate, explicating how information about human behaviour and personal data is transferred and therefore liable to privacy and security infringement. This information gathered through smart grid systems is communicated through smart meters; a later article will dig into the problems and issues arising from smart meters and the other ethical issues related to the discussed sustainable ‘smart’ technologies (page 177).

Sources
An inquiry into human life for sustainable living

A nother technical concept arising from the integration of ICT into the electrical grid is the smart home, in contrast to the smart grid which reaches from micro to macro level focusing on usage and appliances, the smart home focuses more on the relation between user and home appliances. To gain better insight in what the concept smart home entails, through literature study we define the concept. One of the primary authors writing about the concept “smart home” defines it as “a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond (Harper, 2003:31)”. This explicates the fact that smart homes focus lies mainly on user comfort, or as Blumendorf (2013) puts it, “Smart homes in today’s literature mainly address the integration of Information and communication technologies (ICT) into domestic dwellings, smart homes still mostly aim at the simplification of daily routines and processes and at making life easier and more comfortable for the inhabitants (Blumendorf, 2013:154)”. This focus on user comfort does not only separate it from other developments in the “smart” energy sector, but also indicates the importance of users in this new paradigm of communication. Apart from smart homes as a tool for user comfort, smart homes can also be put in use for energy savings and more efficient management of energy streams. Blumendorf (2013) explicates this, stating that “In addition to the increasing level of comfort, smart home technology aims at the facilitation of more sustainable ways of living and can be a feasible way to tweak existing buildings. This ranges from increasingly efficient household appliances, cars, computers, etc. to new building materials and production processes and computer-based optimization” (Blumendorf, 2013:154). Thus Smart homes have a dual role, one in common with the overall smart grid namely optimization of energy processes and a focus on the user comfort in terms of simplification of daily processes. Wilson, Hangeaves and Hauxwell-Baldwin (2014), agree upon this view and explicate that there are three views evident in literature in which the smart home can be analyzed. Firstly the functional view which sees smart homes as an improvement in managing energy demand. Secondly the Instrumental view which sees the smart home as a means for reducing energy demand in households, and thirdly the socio-technical “view which sees the smart home as a foundation for the integration of digital technologies into everyday’s life.
Now the question that arises is; how do smart homes aim to achieve these optimization processes in demand and this simplification of everyday life’s practices? Brdiczka et al., (2009) argue that “the focus should be on sensing and responding to human activity. Human actors need to be identified and their current activity needs to be recognized. Addressing the right user at the correct moment, while perceiving his correct activity, is essential for correct human–computer interaction in augmented environments” (Brdiczka, Langet, Maisonnasse & Crowley, 2009:588). These amplified environments relate to smart homes, explicating the importance of the context, activities and situation. Furthermore Brdiczka et al., (2009) elucidate the fact that “in order to become context-aware, computer systems must thus construct and maintain a model describing the environment, its occupants and their activities” (Brdiczka et al., 2009:589). This model of the environment forms the smart home, these models according to Blumendorf (2003) can be described as “acting autonomously and being proactively based on artificial intelligence” (Blumendorf, 2013:154). This all together gives a clear image of what a smart home entails; it somehow forms an environment which is controllable through human learning. Through this extensive knowledge of the home environment, persuasive computing can be used to form models in which both energy usages is reduced, and user comfort is enhanced. ICT technologies in this case again form the central nerve system of the smart home. At which great effort is put at creating an ICT system which does not use excessive amount of energy itself, to enable energy savings through smart homes. This system tends to automate home appliances in a way which it takes of pressure of the user and turn off electric devices based on the context, activities and situation of inhabitants inside the smart home. Studies by Harper (2003) however show “what people want interactive technologies to provide is not automation, so much as communication, or as we like to put it, social connectivity” (Harper, 2003:4).

To see how these conceptions of a ‘smart home’ function in application, the focus moves to applied examples of smart home technologies. A researched application of a smart home researched at the University of Twente is the Go-Green project. The Go-Green project is a research project focusing on developing solutions for an energy efficient home using ICT technologies or as Meratnia (2015), puts it “The goal is basically to have solutions which on the one hand reduces energy consumption and on the other hand does not reduce the user's comfort” (N. Meratnia, personal communication, 2015). They aim to achieve this goal through live optimization and prediction with a focus on human activity within the home dwelling. This goal and means seem to fit the definitions given in the first paragraph, the question now is what does this project focus on within smart homes? According to Meratnia (2015), “The human aspect of energy consumption is centrally studied by the Go-green project, in contrast to most research done at the University of Twente, focuses on the overall energy consumption of user devices or appliances. This is done using sophisticated sensing hardware and internal monitoring at which data can be used to read personal behaviour to adjust home utilities”. This is again in line with conceptions of smart home technologies. Some examples of this sensing hardware and internal monitoring according to Meratnia (2015), “looking into sound, by footstep monitoring, e.g. if you hear the footsteps of people you can easily tell who is coming. Or if you're looking into the sound of activities, so opening the door, turning on the coffee machine etc.” (N. Meratnia, personal communication, 2015).

The Go-green research project also yields new insight into technical concepts and models involved with the smart home. Go-green researchers Salomons, Teeuw, van Leeuwen & Havinga (2012), explain through their model, shown above, that the starting point of the smart home is making an assessment of current state, relevant parts of data have to be selected ordered and processed to create information. The second state describes the effort that is needed to reach the target
state. Thirdly the desired state is derived from system goals, at which there are global system goals e.g. sustainability and user preferences (Salomons et al., 2012: 356). This model helps us conceptualize how engineers and researchers approach a complex project such as the smart home, the question, what does this model mean for the Go-Green project? Salomons et al., (2012), argue that “for the Go-Green project the most important aspects are identification, localization and activity discovery” (Salomons et al., 2012: 356). Thus providing researchers with three main technical aspects to explore, in the table below these three main technical aspects are translated into technologies, and approaches to solve technical aspect of the smart home in relation to Go-Green. The table clarifies what research is involved with, also to put this in context with the Go-Green project Salomons et al., (2012) note that “For the Go-Green project, we want to make the solution attractive, easily installable for home owners, privacy-aware and cost-friendly. This has the consequence that we have to deal with less accurate sensors for identification, localization, activity discovery and mapping” (Salomons et al., 2012: 357). The problem of low accuracy as a result of approach choice in the Go-Green project is solved by “Instead of aiming to identify individuals, we introduce the concept of personas. A persona is a model of individuals that share (physical) traits and preferences” (Salomons et al., 2012: 357). One of the advantages they note is the introduction of personas increases privacy levels of the system, which will be assessed in a later article.

Now that the theoretical conception of a smart home as explained by Harper (2003) and Blumendorf (2013), is linked to a “practical” research application, it becomes clear that first of all the smart home differs significantly from the smart grid technologies in terms of focus. Smart home technologies have a propensity to focus on human activity within home dwellings; this human focus as compared to a more appliance focused view brings forth other alternatives in making private living more sustainable. The smart home anyhow needs to make use of some sort of central control system, even though this would be an automated AI system, people desire connectivity and communication, to fulfil both these wishes a central interface is needed. This central interface could be seen as a Smart Meter as the goal of both smart home technologies and smart grid technologies are to optimize energy flows and become more sustainable. As both technologies make use of this middleman technology smart meter, the next article will be explicating the design and controversy of the smart meter and its role in realizing both the smart grid and the smart home.

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<td>Localization</td>
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Sources
SMART METERS

The ethics of 'Smart' sustainable living

Up to this point some major ICT related technologies involved in sustainable private living have been discussed and explained in this magazine, this article will attempt to create a cohesive overview of the issues and challenges related to the various Smart technological developments in the energy sector. Through prior literature study it is shown that the technologies rely on customer feedback and acceptance; however when the Dutch government attempted to compulsory introduce the smart meter in 2008 heavy protest followed (Bakker, 2011:28). To further argue what reasons there are behind the protest against implementation, smart meters must be explained. Smart meters are a key component in the realization of smart grids and smart homes, at which smart meters serve as the intermediary of data communication. Smart meters are thus integrated in both the smart home and smart grid technologies, and therefore the most appropriate technology to study in context with the ethical problems of “smart “technologies. Smart meters are as said before the intermediary of the grid and the house, making it the technological component with most responsibility linked to it as the smart meter contains according to Bakker (2011), “Smart meter data contains a lot of information about whether or not people are at home, what their habits are, the Smart Meter can also be used as a gateway to the domestic devices and to determine the optimization potential” (Bakker, 2012:28, 45). Thus it can be said that both the ethical issues and the success of a “smart” grid/home depend on the acceptance of the smart meter.

The novel “smart technologies” in sustainable living have, as assumed through protest, its ethical setbacks and dilemmas. Molina-Markham et al., (2010) argue that “the widespread deployment of smart meters has serious privacy implications since they inadvertently leak detailed information about household activities. The information leaks directly correlate with the time granularity that a meter measures power consumption”. (Molina-Markham et al., 2010:61) Hereby information is collected through monitoring on home devices and in the case of Smart home technologies, the direct environment and habits of individuals. This combined with the fact that smart energy management technologies have imminent security issues, calls for ethical problematic situations. It is becoming evident that the problems related to smart energy management are closely related to one another, as all focus on the aspect of ICT and its integration into everyday energy practice. The issues arising from this integration of ICT have been noted by numerous academics, Kostyk and Herkert (2012),
argue that smart energy systems create large datasets which “If analyzed could reveal such information as home occupation patterns, the number of occupants, and the manufacturer and usage of individual devices—valuable to utility planners but additionally to marketing agencies, insurance companies (property, health, and life) and, potentially, criminals”. (Kostyk & Herkert, 2012:35). To secure these types of data they also address two points of focus for security within smart energy management structures “the physical security of power and ICT networks and equipment and the security of huge databases and computers that analyze the data. (Kostyk & Herkert, 2012:35). Heffner (2011) in line with this identifies three main issues regarding the ICT technologies discussed prior and states, “Customer privacy, data ownership and security issues are leading concerns of consumer and privacy advocates” (Heffner, 2011:9). Galdon-clavell (2013) argues there are several points on studying “the impact of surveillance-enabled (smart) technology namely; informed consent, privacy and data protection, dual use, non-discrimination and responsibility” (Galdon-clavell, 2013:720). To roughly summarize the authors cited, Security issues through hacking and data loss seem to be one of the first more obvious dilemmas, this leads to the issue of privacy of customer (data), all the prior mentioned ICT applications in the energy system seem to handle large amounts of personal data about inhabitants and/or devices. A third apparent issue is possible discrimination and responsibilities examples of this according to Kostyk & Herkert (2012) are “Internet access or computer skills, medical or cognitive impairments, or those who simply lack time, resources, or motivation to manage their usage patterns could be at a disadvantage” (Kostyk & Herkert, 2012:36). A last mostly overlooked problem is mostly related to the smart grid and its integration of sustainable energy generation, at which there could be “potential problems for equitable pricing and access to electric power service”. (Kostyk & Herkert, 2012:36).

With these obvious problems in Privacy of users and security of supply and data, one can now asses the integration of these issues into current ongoing projects regarding discussed technologies. Firstly it is widely accepted that, “any technology needs to adhere to the principle of data minimization and anonymization and ensure that the standard signs informing citizens of the data-gathering mechanisms in place are complemented with specific information on the treatment of the personal data taking place throughout the process” (Galdon-clavell, 2013:720). With this in the back of our minds, a next step can be made by looking the ethical considerations of the current go-green smart home and the Lochem and Meppel smart grid. Meratnia (2015), working on smart home technologies in the go-green project notes that there are two main aspects, monitoring and privacy, and security. Questions such as “How much data should we collect about users? What kind of data should we collect about users? From whom do we collect this data?” arise regarding monitoring and privacy. The second concern security raises issues according to Meratnia (2015) “So if you have a system which basically knows much about the inhabitants, then how should you make sure that this remains secure and nobody else has access and things like that. But it all relates to the data and the type of data that you're collecting” (N. Meratnia, personal communication, 2015). In this research application of the smart home problems are tackled by simplification, a functional structure using the least possible monitoring technologies has preference, through this minimizing security and privacy risk exposure. However as this is a research project problems are rather theoretical, to see applied problems encountered by professionals and academics working with these ICT energy management technologies our focus shifts towards the Lochem smart grid. Smit (2015) states that in the original smart grid “we were also after control, including appliances, but that really increases the threat of cyber-attack. So what we now only control is the connection outside
the house, so we don't want to control inside the house”. This compared with the issues faced by the Go-Green project it becomes clear that their focus on security and privacy is justified and relevant. Smit (2015) continues by elaborating that they “cannot really control any of the appliances. But in the information part, we might also work with profile-based control, which means we can ask people to provide their profile; profile means their energy use and availability in terms of appliances over time” (G. Smit, personal communication, 2015). With appliances one should think of the integration of sustainable generation technologies into homes, these profiles can then again be used to construct the grid. As Smit (2015) puts it himself, “we are trying to work out technical solutions to the concern of privacy”, at which profiles serve as a technical solution to the problem of privacy and security “controllers don't really know what users are doing with this energy, you cannot see which appliances or activities occur with this profile, only energy distributions become evident for controllers” (G. Smit, personal communication, 2015). These two projects shed light on how applied projects deal with these rather theoretical ethical issues mentioned in prior literature. It also becomes clear that the real ethical issues projects seem to be dealing with are related to information security and privacy.

A common way to assess information security and privacy problems is through computer ethics; “Computer ethics analyzes moral responsibilities of computer professionals and computer users and ethical issues in public policy for information technology development and use” (Brey, 2007:22). Brey (2007), explicates that these ethical analyses help us recognize and resolve moral dilemmas, in addition, it has been recognized that use of information systems requires moral reflection, but also their design, a system can be designed to protect privacy, but it can also be designed to give free access to personal information (Brey, 2007:34). These design considerations can be seen in the questions asked in the go-green project, and the issues stumbled upon by the smart grid project in Lochem. It has become evident that smart energy management technologies procreate ethical issues and dilemmas, encountered ethical issues in theory and practice seem to stand hand in hand with the problems faced by computer ethics developed in the 80’s. The fact that projects creating testing grounds for smart grids smart homes and smart meters encounter these issues in their testing, and the fact that both projects are well aware of these issues indicates movement in the application of ethics in the design process of the technologies. Ethical issues however still remain hard to solve and perhaps technological fixes and ethical consideration alone is not enough.

Sources
One of the most influential twentieth-century philosophers of technology is Martin Heidegger. Unlike the perspectives we have enumerated thus far, which are diverse but still generally supportive of the sustainability technology enterprise, Heidegger is profoundly wary of technology, even calling it “the greatest danger” (Heidegger, 1954/1977:28). To make sense of this warning, one must first perfunctorily understand Heidegger’s phenomenological framework. Although Heidegger’s philosophy is notoriously rhetorically cumbersome, especially in the English language, a few of his central concepts can be parred-down into a working framework through which to analyze sustainable energy production and management technologies.

Heidegger is not concerned with specific technologies, but rather “Technology-with-a-capital-T,” or modern technology as a whole, single concept. Heidegger resists the idea of technology as a neutral means for human use, and instead sees it as an inextricable participant in how humans understand the world. As Verbeek (2000) summarizes, “technology, according to Heidegger, is much more than only a means to an end, it must be understood as ‘a way of revealing’” (50). In-keeping with the tenets of phenomenology, revelation does not mean uncovering truth, it means entering a relationship with something previously concealed. This also indicates that these revelations are not to be mistaken for the “thing-in-itself” about which metaphysicians quibble, but rather as particular relationship with a particular(ized) thing. Verbeek (2000) clarifies, “only in the relationship humans have with entities do these entities become reality for them- - they ‘emerge out of concealment into un-concealment’” (50). The revelation is not objective, but relational. The “danger” of modern technology is in its particular mode of revelation, which differs from the modes of revelation for different eras. Heidegger posits that the modern era is dangerously dominated by the revelatory mode of modern technology.

He differentiates the ethos that comes from the ubiquitous application of modern technology from the dominant ethos of previous eras. He does so by essentializing modern technology, but also carefully resists essentializing it to a particular technological instantiation when he writes, “We say ‘technology’ and mean modern technology. One likes to characterize it as machine technology. This characterization hits upon something correct. But what is correct about it still
contains no truth... Modern technology is what it is not through the machine, but rather the machine is only what it is and how it is from the essence of technology” (Heidegger, ~1950/1994:32). He does not define technology by its artifacts, but rather by its function, which is the revelation of phenomena in a particular way. This revelation discloses the very field of possibility in which something like “the machine” can take place. He further clarifies, “the essence of technology is itself nothing technological. Every construction of every machine already moves within the essential space of technology. As technological construction, however, it is never capable of conceptualizing the essence of the machine. This is just as impossible an attempt as wishing to calculate the essence of the mathematical by mathematical means, or wishing to delineate the essence of history through historiological research” (Heidegger, ~1950/1994:33). He essentializes technology not to an instantiation, but to an overall function. He attempts to define this essential function when he writes “Positionality essences as the plundering drive that orders the constant orderability of the complete standing reserve. What we thereby think as positionality is the essence of technology” (Heidegger, ~1950/1994:31). While these terms might seem quite opaque upon a first reading, Heidegger thoroughly unpacks each one. “Positionality,” alternatively translated as “enframing” or “constellation” (Babich, 2012:158), is the role attributed to things through technological revelation. The essential quality of technology is its mode of revelation, by which it “enframes” or “positions” or “constellates” the entities it reveals in a highly specific and, according to Heidegger, problematic way.

The central problem to the way in which technology “enframes” or “positions” the things experienced through technology is that of revealing things as “standing reserve.” He writes “In positionality the presencing of all that presences becomes standing reserve. Positionality constantly draws what is orderable into the circuit of requisitioning, establishes it therein, and thus assigns it as something constant in the standing reserve” (Heidegger, ~1950/1994:31). What he means here is that technology reveals things as material for human use, and the world at large as a “standing reserve” of resources for human use. It does so by assigning things orderable constants from which to draw out some kind of “standing reserve.” As Babich (2012) clarifies, “modern technology, modern tools, power tools are different and everything turns on power and its dependencies: thus nature in the purview of modern technoscience becomes on Heidegger’s analysis something that it never was until modernity: a giant gas station, a source for the development of natural resources, meaning energy, meaning electricity” (161). The positioning of things as orderable in a system of standing-reserves is the problematic power-mongering dynamic essential to modern technology. What is particularly dangerous about this mode of revelation is the extent to which nothing can stand outside of it. The very use of technology for “deployment or utilization 'sets everything up in advance such that what is set up conduces to success ....But the resultant is arranged as success beforehand.' And for Heidegger the resultant schema cannot but be self-reinforcing, and what is defined as 'success,' as he goes on to elaborate this, 'is that kind of resultant that is itself allied to the production of further results. We call it ordering/requisitioning/comportment [das Be-Stellen]” (Excerpt Heidegger, 1994:26, Babich, 2012:167). So technoscience produces results which, in turn, support the enterprise of technoscientific application in the first place. These results circulate around “orderability” into “standing-reserve” which is produced by the technological revelation. The problem is that within the modern technological “enframing,” only such “orderable standing-reserves” can be revealed in the first place, and yet revelation of such relationships is treated as success. Heidegger posits that this supposed “success” is merely the necessary product of the modern application of technology, and
this confirmation-bias loop allows for the ubiquitous dominance of modern technological modes.

Heidegger also describes to the extent to which humans are made use of in this modern technological mode of revelation. He does not subscribe to an instrumentalist point of view in which humans utilize technology at their own will. Rather, “Men and women must place themselves in a work service. They are ordered. They are met by a positioning that places them, i.e., commandeers them. One places the other. He retains him. He positions him. He requires information and an accounting from him. He challenges him forth” (Heidegger, ~1950/1994:26). This process of collecting information and accordingly positioning is the “orderability” component of revealing things (including humans) as “standing-reserve.” He claims that humans necessarily participate either directly or indirectly in technological systems, and these systems necessary order them into parts “standing reserve.” He writes explicitly, “the human of this age, however, is positioned into positionality even when he does not stand immediately before machines or in the industry of a machinery” (Heidegger, ~1950/1994:36). Even when humans apply technology to other entities, they are themselves being positioned as “standing-reserve.” The perceiving human subject and the object are both part of the technological enframing. As Kisiel (2014) describes in a slightly updated context, “The planners themselves are no longer scientifically oriented toward a field of objects but now emerge in their true gestalt as technicians and even technocrats, i.e., humans who see beings a priori in the horizon of making-them-useful…. There is nothing other than reserve resources: warehoused stock, inventories of goods, stores of supplies, stockpiles of uranium, reserves of provisions, energy reserves, capital reserves, federal reserve funds, not to speak of the quasi-infinite store of information in the so-called memory banks of the internetted WorldWideWeb” (141). Humans themselves becoming the ordered material “standing-reserve” to the technological system when they deploy that system to superimpose the same orderability on the rest of their experienced phenomena.

Heidegger illustrates his ideas through a multitude of examples, some of which are particularly instructive in an application to energy production and management technologies. In an energy-specific example, Heidegger talks about changes in agricultural practices and the technological enframing of land as “standing-reserve” for energy extraction. He describes how the mechanization of agriculture and mining are prime indicators of technological enframing. He contrasts “Peasant activity does not challenge the farmland; rather it leaves the crops to the discretion of the growing forces; it protects them in their thriving. In the meantime, however, even the tending of the fields [die Feldbestellung] has gone over to the same requisitioning [Be-Stellen] that imposes upon the air for nitrogen, the soil for coal and ore, the ore for uranium, the uranium for atomic energy, and the latter for orderable destruction” (Heidegger, ~1950/1994:26-27). Industrialized agriculture and mining both prioritize the efficiency of extraction, and Heidegger links this approach to the technological enframing of things as “standing reserve.” Babich (2012) contextualizes Heidegger’s observations in the post-war context, wherein “the competing desire to use land for mining (raw materials) clashed with the need to use land for agriculture (foodstuffs), but the technization of both handicrafts, only meant that the one application namely mining or as we call it today: land use development, demanded vastly more land than ever before, and the second application, farming, also took more land in its mechanized variety than had been traditionally needed” (Babich, 2012:164). These practices extended the reach of technological applications, and also deepened them such that technology was now positioning land as material for “standing-reserve” and therefore manipulation and extraction. Hence, he makes the bold comparison, “Agriculture is now a mechanized food industry, in
essence the same as the production of corpses in the gas chambers and extermination camps, the same as the blockading and starving of countries, the same as the production of hydrogen bombs” (Heidegger, ~1950/1994:27). The efficiency-and-extraction ethos that underlies these practices is the same for Heidegger. Mechanized agriculture is the same thing as mechanized human extermination because both use technology to disclose things as material “standing-reserve” for use, extraction, manipulation, and ultimately, degradation. Babich (2012) justifies such an “offensive comparison” when she describes how “for him modern technology is all about such equations, such calculations, such reductions” (Babich, 2012:172). The connection of technologies to technologized industries which encompass larger tracts of humans and things is part of the domination process that Heidegger finds so dangerous. These technologized industries necessarily contain the same self-supporting loops as individual technological applications, by which these industries delimit possibilities then produce results within these possibilities. The mining industry, for example, already approaches land as “standing-reserve,” orders it as such, and any participant in this industry (which includes anyone who uses energy) supports this approach.

The most energy related example in Heidegger’s writing is that of the hydroelectric dam. This directly relates to both generative technology, which harvests resources for energy, and management technology, which transforms and distributes energy. He writes:

The hydroelectric plant is placed in the river. It imposes upon it for water pressure, which sets the turbines turning, the turning of which drives the machines, the gearing of which imposes upon the electrical current through which the long-distance power centers and their electrical grid are positioned or the conducting of electricity. The power station in the Rhine river, the dam, the turbines, the generators, the switchboards, the electrical grid—all this and more is there only insofar as it stands in place and at the ready, not in order to presence, but to be positioned, and indeed solely to impose upon others thereafter. (Heidegger, ~1950/1994:27)

This passage illustrates the extent to which energy production and management technologies fall under Heidegger’s skepticism. Even sustainability technologies loaded with moral clout, like renewable energy generation and smart energy control, are problematic to Heidegger. These technologies involve approaching every available resource, including water, air, sunlight, ambient heat, kinetic energy, and a number of other sources, as “standing-reserve” for extraction and use. In direct application to such technologies, Heidegger writes:

The revealing that rules throughout modern technology has the character of a setting-upon, in the sense of a challenging forth. That challenging happens in that the energy concealed in nature is unlocked, what is unlocked is transformed, what is transformed is stored up, what is stored up is, in turn, distributed, and what is distributed is switched about ever anew. Unlocking, transforming, storing, distributing, and switching about are ways of revealing. But the revealing never simply comes to an end. ...through regulating their course. This regulating itself is, for its part, everywhere secured. Regulating and securing even become the chief characteristics of the challenging revealing. (Heidegger, 1954/1977:16).

Heidegger links this mode of energy production and management to the perpetuation of the dominance of modern technology. From his perspective the purported “efficacy” of these technologies, framed in terms of efficiency, diversity, and breadth of extraction and distribution, is precisely the danger of technology. Projects like Weaving a Home and Aquion (see
“Generative Technologies on page 166) are problematic because they treat “the energy concealed in nature” as “standing-reserve” to be strategically harvested and stored (“ordered”) for human use. Perhaps even more problematic are the goals of smart energy management, like those of Lochem and Meppel, which seek to integrate these resources and introduce greater degrees of control and distribution, a further extension of “ordering” into “standing-reserve.” The smart home is, as exemplified in the GoGreen project, is perhaps the greatest threat to Heidegger because it so thoroughly integrates the human into the technological system. The technology and the human are co-dependent in this system, both “ordered” into “standing-reserve” for each others’ use.

This invites the conclusion that Heidegger would find modern incarnations of sustainability technologies highly problematic. While generative technologies are all about harvesting resources and therefore order and approach resources such that they are “standingreserve,” management technologies are even more problematic because they strive to increase integration into the energy industry as a whole. In general, the more high tech the approach, the more wary Heidegger is of it. As high tech systems generally strive to increase the diverse sources of available energy (like Aquion and Weaving a Home), control over this energy flow (like the smartgrids of Lochem and Meppel), and integration of humans to a higher degree (like the user-awareness of GoGreen), so Heidegger views humans as increasingly made service of by modern technology. Outfitting homes with solar panels approaches sunlight as “standing-reserve,” while using biogas approaches waste-water as “standing-reserve,” and wind turbines even necessitate air as “standing-reserve.” Smart management technologies further embed these extraction practices, extending their reach and the magnitude of their control, even to the extent of “ordering” individuals into the technological system. These technologies order these resources such that they are “standing-reserve” for human use, and also order humans such that they not only participate, but also themselves are transformed into entities ordered around use, extraction, manipulation, efficiency, and ultimately, depletion. Each of these technologies contain conception of wellbeing, and aim to promote this conception through their design. Heidegger brings a critical eye to such practices and offers a framework within which to conceptualize these practices as antithetical to wellbeing. Whether he is overly reductionist and incendiary towards modern technology is the counter-point taken up in the Postphenomenology article (page 187).

Sources


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The Device Paradigm

Influenced by Heidegger, the work of Albert Borgmann resolves around the question of the role of technology in shaping human existence and the definition of "the good life". Borgmann distinguishes three kinds of approaches in philosophy of technology and discusses each to come to his own theory of the device paradigm. As is later on shown, by means of this paradigm Borgmann strives to understand the way in which human beings engage the world and to illuminate how technology shapes human existence.

The first approach to technology that Borgmann distinguishes is substantivism. According to this approach, technology is an independent power that unfolds according to its own logic and that determines society and culture. An illustration of this can be found in the workings of a pioneer researcher into the structure of electricity. In the initial development of electricity related technologies, Benjamin Franklin was one of the first and part of his contribution was the development of the lightning rod. The results of his research were not really fruitful when considered their immediate practical application. It was only after his death that practical applicability of his findings ensued. The technology that Franklin developed took shape on its own and it was only later on that it changed society.

The second approach to technology is instrumentalism, which sees technology as a mere means for the realisation of human goals and thus as a neutral application. An example for this approach can be found in the conventional, fossil-fuel based energy generation technologies. After the initial development of the steam engine a wide variety of different heat and power generating technologies followed, all with different fuel or mechanics for different purposes or for better, faster, more cost-effective results and implications. Though none of them are sustainable and all have heavy and negative impact on the environment.

The third, pluralism, is an answer to the shortcomings of substantivism and instrumentalism, and sees technology as many faceted. According to this perspective, technologies are the outcomes of complex processes of evolution and interaction, with myriad forces playing a role and influencing which technologies ultimately arise and what forms they take. As is the case with energy generation technologies and energy storage and distribution technologies, the way of development can never be fully attributed to developments in technology and science alone. Whether it is economic factors, political developments, or societal and cultural influences,
there is an incredibly wide variety of aspects that influences the development and utilisation of a specific technology, with these aspects influencing each other and themselves in turn as well (see Green Housing Policies page 190). According to the pluralistic approach to technology no single technology develops in a linear fashion.

In his own vision Borgmann blends social analysis and philosophy, resulting in his device paradigm. He maintains that technology creates a controlling pattern in people’s lives and that the actions that technological artefacts promote help to shape the involvement of people with their environment. This influence of technology is discernible even in an indistinct action like turning on a stereo. Technological devices are the entities that fulfill the technological promise of liberation and enrichment by delivering instant availability and easy and safe utilisation. Through this availability, a technological artifact, or device, becomes a commodity – an entity that is ubiquitous and the workings of which is concealed as much as possible so people do not have to engage themselves with its workings or production. The availability of devices, the concealment of the device’s machinery and the commodisation of devices promote the consumption of these commodities without people having to engage with it. Consumption becomes effortless and thoughtless, cutting people’s existene off from its material and social contexts, thereby reducing people’s involvement with their environment. Borgmann describes the emergence of the consumptive lifestyle of human beings as the irony of technology; while trying to fulfill the promise of liberation and enrichment, technology delivers only impoverishment by distancing human beings from their environment.

Although Borgmann’s stance on technology is negative, he does not reject technology in full. He argues for a reform of technological consumerism that can be realised with his device paradigm. Since he argues that nontechnological things are present in an engaging way and technological artifacts in a nonengaging way, we need things and practices that draw human involvement and engage people in their own right. Borgmann calls these focal things and practices. They invite engagement with themselves and what they make possible, creating people’s dealing with the world as based on engagement instead of availability and disengaged consumption.

Borgmann’s claim that technology leads to an impoverished, consumptive existence implies for smart grid technology that developers must take care that consumers stay involved with energy production and their energy consumption, keeping the technology from a reducing from view and, instead, inviting attention and engagement. As with the Meppel and Lochem Energie projects (see the Case Profiles on page 152), energy is generated close by and, especially in Lochem, people are very much involved in the generation of energy and what it means for their consumption. Through the local generation of energy, the technology is more visible for the consumers. This different method of energy generation also requires more engagement from the people since behavioural change is necessary and desirable because of the workings of technology for energy generation. Additionally, the greater emphasis in the projects on renewability of the energy sources corresponds to a greater focus on the environmental impact of energy generation and consumption, creating more involvement of the people with their environment. However, the implementation of smart grids in the way of the GoGreen project (see the Case Profiles on page 151), energy consumption becomes automatic and does disappear from the people’s view. It will turn energy consumption into even more of a commodity than it already has become, leading to reduced engagement like Borgmann captures with his device paradigm and, instead, an increase in consumerism due to the peripheral role the technology plays. A role we have to avoid according to Borgmann for it is opposed to living the good life.

Sources
Responses to technological skepticism

Following Heidegger's analysis of the role of modern technology (see page 180), and Borgmann's warning about the “device paradigm” (see page 185), the reader might feel we have painted a rather grim picture of the influence of technology on the human. However, some contemporary philosophers of technology have extended this unilaterally damming view of technology into a more inclusive, dynamic, and variable framework. Postphenomenologists like Don Ihde and Peter-Paul Verbeek integrate philosophers like Heidegger and Borgmann with the most contemporary technological developments and a broader understanding of the interaction between technology and human development. They still rely on the phenomenological stance that humans and technologies are constituted and realized through relationships, as opposed to static and separate identities, but they extend the grim estimations of philosophers like Heidegger to a more multilateral estimation of the effects of technology on human perception, action, and ultimately wellbeing.

Postphenomenologists augment Heidegger's argument in several crucial ways. We cannot attempt here to summarize the contributions of every philosopher, so we hone in on Ihde and Verbeek, who directly situate themselves in response to Heidegger. The “phenomenology” part of this enterprise has to do with the shared recognition that “of necessity, any description of reality cannot avoid being a rationale, explanation, or constitution... Human beings never encounter a world in itself, only and always a world for them” (Verbeek, 2002:103). One of the defining characteristics of phenomenology is that humans experience the world relationally, as constituted through their perceptual, contextual, and technological apparatuses. Heidegger also falls under this phenomenological approach, wherein the world is revealed through modern technology as “standing-reserve,” indicating the relationality and particularity of perception. However, Heidegger essentializes technology to a singular function and ultimately cautions against it. Ihde's stance is in-keeping with Heidegger's approach in the sense that he is concerned with the role of technology in revelation and signification of experience. However, Ihde develops a vocabulary in which technology does not have a singular “essence” and therefore cannot be reduced to a single function (i.e. the function of reducing the world into “standing-reserve”). One author summarizes Ihde's endeavor as such: “what Ihde is doing... is to take Heidegger to task with the newer technologies that were not fully developed in his lifetime” (Hongladarom, 2013:270). In doing so, Ihde
identifies the essentialization and reductionism in Heidegger's approach. For example, he identifies the nostalgic romanticism of Heidegger's choices of exemplar technologies when he writes, “There is much in the Heideggerian choice of 'good' and 'bad' connotations... Heidegger 'likes' the tools of the workshop, the peasant shoes of the Van Gogh painting, the watermill on the stream, the windmill, and the old stone bridge with its arches. He does not like hydroelectric dams on the River Rhine, the atomic bomb, even the modern steel bridge which routes traffic to the same city square as the old stone bridge” (Ihde, 1995:105-106). This choice of 'good' and 'bad' technologies is highly contentious and seems tinted by Heidegger's context. In a life spanning from 1889-1976, Heidegger experienced both world wars and the onslaught of industrialization and mechanization. In keeping with the argument that people and technologies are co-constituent in their contexts, Heidegger's understanding of technology is, in turn, informed by his technological context. Ihde identifies how “the kinds of technology discussed by Heidegger are those from the older, industrial era; he was familiar with the technologies behind the hydroelectric dam, the typewriter, the television, and the nuclear bomb, but having died in 1976 he could scarcely have imagined the full bloom of the Internet and its social networking sites, for example” (Hongladarom, 2013:270). Philosophers like Heidegger and Borgmann wrote in contexts in which the particular technological developments supported the impression that technology yields industrialization and mechanization and these processes enable alienation and degradation. However, Verbeek (2002) argues, “Today, over half a century later, we see that humanity has not been entirely swallowed up inside the production apparatus, and is able to approach reality not exclusively as a storehouse of raw materials” (99). The project of Ihde and Verbeek is therefore to create a more inclusive framework through which to analyze modern technologies, one which does not assume a narrow set of technological preconditions, but rather looks at the variability of uses, contexts, and experiences of actual technological artifacts.

Together, Verbeek and Ihde offer an explanation of the hermeneutic dimension of technological mediation. "Hermeneutic" means they are concerned with the ways in which technology acts on perception (as opposed to an “existential” focus on how technology affects actions). Verbeek (2002) summarizes Ihde's stance as an analysis of “the human-world relation in terms of the way in which the world can present itself to human beings and become meaningful...” (Verbeek, 2002:111). A central term for understanding both of them is that of “mediation,” which originates from the phenomenological stance that technology co-constitutes the ways in which humans experience the world and themselves. This emphasis on the activeness of technology in human-world experience leads to the conclusion that “things, therefore, are not neutral ‘intermediaries’ between humans and the world, but mediators: they actively mediate this relation” (Verbeek, 2002, 114). Thinking from the stance that technology plays an active role in relating humans to their world, these philosophers decipher a number of ways this mediation takes place. They ultimately conclude that mediation is not a unilateral experience, in contrast with Heidegger's conclusion that technological enframing is singular and inescapable. Rather, technologies have what Ihde calls “technological intentionality.” Verbeek (2002) clarifies, “By this he means that technologies...have a certain directionality, an inclination or trajectory that shapes the ways in which they are used” (114). In Heidegger's thought, all technologies contain an intentionality which dictates that they are used in reduction of the world to “standing-reserve”. In a crucial break from Heidegger's thought, Ihde proposes that “these intentionalities are not fixed properties of artifacts, however. They get shape within the relationship humans have with these artifacts. Within different relationships, technologies can have a different identity” (Verbeek, 2006:365). Technologies, therefore, do not have a fixed “essence” which determines their effects. Rather, technology can be adapted to different contexts and therefore take on different meanings, enabling different relationships between humans and the world as experienced through these technologies. Ihde calls this “multistability” which essentially means a technology “allows multiple interpretations. What it 'really' is remains
undetermined. It is many things at once; it is ‘stable’ in multiple ways... They are only technologies in their concrete uses, and this means that one and the same artifact can have different identities in different contexts” (Verbeek, 2002:118). Technologics, therefore, can enable various relationships with the phenomena they mediate. While Heidegger and Borgmann assume the only relationships enabled by technology are those of reduction, “According to Ihde, the transformation of perception always has a structure of amplification and reduction. Mediating technologies amplify specific aspects of reality while reducing other aspects” (Verbeek, 2006:365). Technology does not unilaterally reduce, it also amplifies, and this amplification can yield new and interesting relationships with the revealed phenomena. This approach has significant ramifications in design ethics, wherein the design of technology is assumed to play an active role in the way it is used and the way the world is experienced through its use (i.e. Verbeek, 2006).

In application to energy production and management, this yields a more varied picture of the potential drawbacks and opportunities. Rather than wholesale rejection, as the Heideggerian approach entails, postphenomenology allows these technologies to yield multiple relations, some of which may be more productive than others (depending, of course, on the scales by which one designates “productivity”). While Heidegger and Borgmann are particularly wary of any high tech development, Verbeek and Ihde allow that even the most high tech artifacts have the manifold function of reduction and amplification. The example of the smart home as envisioned in the GoGreen project makes a good application of these ideas because it is so problematic by the estimations of Heidegger and Borgmann. By their perspectives, such a project might reduce the human to a part of a technological system (Heidegger’s stance), and might commodify the individual’s engagement with their environment (Borgmann’s stance). Yet, by Verbeek and Ihde’s stance, there are a number of amplifications it might also yield which promote a particular conception of wellbeing. Just one response to Heidegger from this stance might be that GoGreen’s goal of overall reduction of energy use can be viewed as an attempt to decrease the grip of centralized, fossil-fuel-based energy industries. By giving the individual home the capacity for self-sufficient functioning, this project might work against the integration of humans into ubiquitous technoscientific systems. A possible response to Borgmann is that the feedback coming from the smart home in the GoGreen project can be viewed as an increasing of engagement with one’s energy habits, critically changing the individual’s perception and behavior when it comes to energy. Verbeek and Ihde provide the framework to evaluate the use and design of technology as “multistable,” yielding amplifications and reductions which cohere with some conceptions of wellbeing and conflict with others. This shifts priorities from finding alternatives from Technology to finding alternatives within technologies. Technologists can design systems and artifacts which intentionally promote modes of wellbeing in how they are used and how they facilitate perception. A key step in optimizing this endeavor is clarifying the underlying conceptions of wellbeing and analyzing the way in which design features promote particular perceptions or invite particular actions which cohere with this overarching conception.

Sources
Many countries today consider renewable energy technologies as the crucial factor in the transition towards a clean energy future (Kalogirou, 2004). Energy resources like solar power, wind power, and biogas are valued highly for their massive energy potential and their renewability, contrasting many conventional energy resource systems. The pollutants many of these conventional systems produce create environmental problems like the greenhouse effect, ozone depletion, acid rain, and smog (Kalogirou, 2004). One of the benefits that arises from the installation and operation of renewable energy systems is a decrease of environmental pollution, besides energy saving and the generation of new working posts (Diakoulaki, Zervos, Sarafidis, & Mirasgedis, 2001). Renewable energy systems can, thus, have a beneficial impact on environmental, economical, and political issues of the world (Kalogirou, 2004). A lot of these issues revolve around the future level energy consumption and production. Determining factors for this level include technical aspects of the energy production and management technologies, but this level is also constructed by the demand and supply of the social context. As different factors like population growth, economic performance, consumer tastes, technological developments, world energy markets and governmental policies determine the future level of energy consumption and production, this article focuses on governmental policy making to lay out the importance and impact of policy making on the development of energy technologies.

Over the last two decades the attention for environmental considerations has greatly increased in energy industries as well as the public. Both industries and consumers know the interplay between environmental pollution and energy consumption and their responsibility in this matter, but the costs of environmental pollution have been largely accepted (Dincer, 1999). This article explores these issues, specifically the legislative and governmental issues, and how governmental organisations aim to tackle them.

In the late 19th century the technology for electricity generation was still in its infancy and seen as an opportunity for entrepreneurs to make money. The industry started out with small and privately owned companies and increased in the 20th century when the supremacy of electricity became obvious. The distribution of utilities like electricity, water, sewage and gas came to be seen as a public service and necessary for a modern civilisation. In many countries the distribution became publicly owned and in other
countries legalisation was introduced to govern distribution and supply. This governamental involvement came to be seen as uneconomic and unnecessary in the late 20th century. By the beginning of the 21st century it was a global phenomenon that distribution and supply of utilities became, again, privately owned, and legislation was relaxed to open up the markets to competition. Nowadays, most electricity supply systems are liberalised. But while state control of the electricity industry may be too overbearing and rigid, a liberalised industry may have too much freedom. Economic and political considerations must be weighed and since the former are usually predominant, implementation of government policy is difficult.

The introduction and legislation of renewable energy sources, for instance, relies heavily on calm and careful planning. This is, however, not the conventional way. An issue is often put on the political agenda because of a focusing event, like an oil embargo that forces a consideration of energy sources, in stead of a vast and contentious matter like global warming. A government that wants to increase the amount of electricity that is generated using renewable sources cannot simply pass an order down the line. A government can only use taxes and systems of allowances and penalties to direct people, institutions and companies in the desired direction. The involved parties will then weigh economic and political considerations and may choose to pay a penalty if that is the most attractive option, focussing on economic gain and disregarding government or dominant public opinion. However, this does not mean that governamental policy making should be abandoned.

At the core of international efforts to address the global problem of climate change are the United Nations’ United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto protocol established in 1997. This Convention set an overall framework for international effort to tackle the climate change. The Kyoto agreement was the result of a substantial extension to the Convention and derives its name from the place of its adoption, Kyoto, Japan (United Nations, n.d.). The agreement obligated industrialised countries to turn to non-polluting renewable energy sources to reduce CO2 and other gaseous emissions (Kalogirou, 2004). The Convention required all its Parties to implement national programmes and measures to adapt to the impacts of climate change, to promote and facilitate the transfer of environment friendly technologies, to try to stabilise greenhouse gas emissions, and to promote sustainable development (United Nations, n.d.).

As early as 2009 the European Commission established a directive that works as a framework for the promotion of renewable energy by setting mandatory targets for nations in the European Union. These nations are to achieve a 20% share of renewable energy in their final energy consumption and a 10% share of energy from renewable sources in transport by the year 2020 (European Commission, 2013). However, many Member States of the European Union have a hard time achieving these targets. The Netherlands, for instance, although reaching the indicative 2010 target for the share of renewable energy in the electricity mix, failed to achieve the indicative 2010 target of 5,75% in the transport sector. The Dutch government aims to see the growth of the supply of renewable energy to reach 14% of the total energy generation by the year 2020 and to use only renewable energy sources by the year 2050.

The main focus of the Dutch government is on wind energy, biomass energy, solar energy, and geothermal energy, exemplified in projects that deploy windmills on a large scale area on land or at sea. For these parks areas are chosen where a fierce wind blows and that only few people inhabit, such as harbours, industrial areas, the Northsea and Lake Ijssel. An example for energy generation using solar panels is the Lochem project. More on this project can be found in the Case Profile on page 152.

Projects for generating electricity from renewable energy, however, is only one step in an extensive process. It must be integrated into the market, and apart from economic considerations there are
infrastructural difficulties with renewable energy technologies. Some of the major renewable energy sources for the future have inherently different characteristics from conventional sources. They do not simply fit into existing structures. Adaptation and updating of the regular system of cost structure, dispatch ability and size, and electricity grid operations is therefore necessary to implement renewable energy sources.

However, there is another problem that is easily overlooked when considering and promoting renewable energy. It is one of the main issues addressed in the 2013 Energy Agreement of the Dutch government and of the Energy Watch Group. Even though the scenarios of the Energy Watch Group demonstrate that renewable shares in energy supply can be increased significantly, attention should also be pointed towards energy demand and the development of this demand in the future. In their study, the Energy Watch Group found that the contribution of non-renewable sources to final energy supply in 2030 is almost as high as the total final energy demand was in 2005. So even though the share of renewable energy in energy supply greatly increases, we still need to tackle the issue of energy consumption.

One way of doing this is by employing smart grids. The concept was developed by the European Technology Platform for Smart Grids in 2006. It concerns an electricity network that can integrate the actions of all users that are connected to it in an intelligent way. It greatly increases efficiency compared to a ‘regular’ power network since it integrates both generators of energy, consumers of energy, and those that do both. The objective of a smart grid is to efficiently deliver sustainable, economic, and secure electricity supplies by employing innovative products and services together with intelligent monitoring, control, and communication. The aims of smart grids according to this European Technology Platform are to better facilitate the connection and operation of generators; to significantly reduce the environmental impact of the whole electricity supply system; to maintain and improve the existing system in terms of its reliability, quality, efficiency, and security of supply; and the more general aim of fostering the development of an integrated European market.

After this first step the OPEN meter project was launched in Europe in 2009. This project developed a comprehensive set of open and public standards for smart metering and so removed the barriers for the wide scale adoption of smart metering and the building of the European Advanced Metering Infrastructure. In the same year, the European Commission issued a mandate to European standardisation organisations (ESOs). These ESOs had to establish European standards for the interoperability of smart utility meters for electricity, gas, water, and heat. The standardisation involved communication protocols and additional functionalities, such as assuring interoperability between systems to provide secure communication with consumer’s interfaces and improve the consumer's awareness to adapt its actual consumption.

The European Commission also issued other mandates, like in 2010, when ESOs were mandated to review existing standards and develop new standards so that a harmonised approach could be adopted across Europe for the interoperability of chargers for electric vehicles. This harmonisation will allow users to use the same charger for a range of electric vehicles and it will allow users to connect to those chargers throughout the European Union. In 2011, the Commission issued another mandate to develop standards that would facilitate the implementation of smart grid functionalities and services, all in order to ensure a smooth and fast process. The practicality and necessity of such standards are self-evident.

The Regulation of 2013 of the European Parliament and Council on the guidelines for trans-European energy infrastructure the need for international compatibility of energy systems was, again, addressed. In 2011 the European Council already underlined the need for modernisation and expansion of the energy infrastructure and interconnection of networks
throughout Europe. In the 2013 Regulation the need for solidarity among Member States was acknowledged in order to have no Member State isolated from the European networks after 2015. The regulation directed attention to the acceleration of refurbishment of the energy infrastructure currently in place because the deployment of an updated infrastructure was considered vital to achieve the objectives of the European Union’s energy and climate policy. The lack of sufficient interconnections between the energy networks of Member States retains a fragmentation of the energy market and a suboptimal use of the existing infrastructure. The vision of the European Union is that a Union-wide implementation of smart grids and integrated networks are vital for a competitive market, optimal utilisation of energy infrastructure, efficient energy consumption and integration of different sources of renewable energy.

The European 2020 strategy was developed to ensure growth through industrial innovation and technological leadership, while reducing emissions and energy import dependence, and improving access for electricity from renewable energy. Although the initial start under the Renewable Energy Directive was strong, the situation now is not as promising. The economic crisis affected the sector of renewable energy, as it has all sectors of the economy. But to compensate for market failures, Europe has a range of policy measures in place to advance renewable energy development, such as support schemes, standards and administrative rules. This may create just enough of an economic incentive for companies and individuals to make renewable energy profitable, feasible and preferable over conventional energy sources and to realise growth, employment and sustainable development. While business and consumers push the concept of sustainable energy to the background, it is gouvernamental policy making nudges and urges them into the other direction. The European 2020 strategy may, thus, show to be decisive in the transformation towards and realisation of a European market for sustainable energy.

Sources
An insight into the marketability of private sustainable living

To gain further insight into private sustainable living, the marketability of the technologies involved must be assessed. In this article various ‘sustainable’ marketing theories will be assessed in context with the definitions of sustainability, furthermore a comparison of prior discussed technologies with phases of generation and commercialization will be provided. This will be done to assess the development and implementation of sustainable private living in a more market oriented approach. A tendency towards a more market oriented approach in implementation is preferred as, “A market oriented approach will provide an increased stimulus for the renewable energy industry to continue the recent trend toward enhancing the ability to sell, finance and deliver solutions to customers with real world needs and preferences” (Nakarado, 1996:193). This market approach for assessing development is needed to see commercial applicability of technologies researched in the cases used in the magazine. Sustainable marketing can be roughly divided into four components and can be explained as “seeking a solution in which commercial goods can be marketed in a responsible way that does not adversely impact upon sustainability” (Gordon, Carrigan & Hastings, 2011: 147). Gordon, Carrigan & Hastings (2011) explicate that there are three major ways in which sustainable marketing is achieved. Namely green marketing, social marketing and critical marketing, with Green marketing being, “applying sustainable thinking holistically, from production to post-purchasing service, aiming to balance the company’s need for profit with the wider need to protect the environment” (Gordon, et al., 2011: 147). Social marketing including “the systematic application of marketing concepts and techniques, to achieve specific behavioural goals for a social or public good” (French and Blair-Stevens, 2006: 4), and lastly Critical marketing; “Analysing marketing using a critical theory based approach to guide regulation and control and stimulate innovation in markets with a focus on sustainability” (Gordon, et al., 2011: 146-147). The fourth element of sustainable marketing is Demarcating, “the practice of demand reduction, Demarcating uses the four Ps (product, price, place, and promotion) of marketing but in a reverse way thus marketing issues instead of solutions” (Kotler, 2011: 134). These four elements cover each level of stakeholder involved in any technology, these four elements of sustainable marketing show that the focus of industry and marketers lies not only in making the technology profitable and marketable but also address the shift towards customer engagement in Social marketing; a further focus is put on politics and
assessment of technology in Critical marketing. Demarcating serves a somewhat different purpose and is involved in reducing demand through campaign, to see whether these four elements fulfil sustainability as explained in the prior article on sustainability, we need to assess each form of sustainability and see if there is enough overlap between sustainable marketing practice and definitions of sustainability. Economic sustainability is and has been the historical prime focus in marketing, to preserve capital. More recent focuses on social sustainability have changed this picture for marketing practice, leading to more social input through customer engagement. This social input can be reflected in practice as not only has the increased role of the customer led to social marketing, but also included goals related to human welfare as opposed to organizational welfare. This shift in marketing practice also indicates that practice follows more general theory regarding the definitions of sustainability. One thing is becoming clear, social sustainability does not only yield a more diverse portfolio for marketing, but also seems to go more in depth into ways to actually impact society and human life.

To explicate the theories stated prior, one can use the smart grid projects and weaving a home project as two opposites. Obviously the smart grid aims for economic and ecological sustainability, and seems to use the four marketing theories mentioned prior, however when looking into social sustainability one might ask if the smart grid promotes human welfare. The Tents as proposed by the weaving a home project however seem to have a core in social sustainability, and seems to be somewhat reluctant on economic and ecological sustainability and seems not to use critical marketing as much as the smart grid. This explicates the one the one hand looseness of application of sustainable marketing theory, and on the other hand the difference in focus in sustainability. A perhaps peculiar fact is the focus of smart technologies on economic/ecological sustainability and a more social/ecological stimulus for generative projects. To get a clear picture of marketability, growth and implementation of the various cases studied in the magazine, an assessment of the technologies must be done in terms of commercialization. The cases studied in this magazine will be assessed using the phases of technology generation as presented by Balachandra, Nathan,

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<tr>
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<td>Applied research</td>
<td>Engineering and manufacturing</td>
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<td>Fully commercial</td>
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<td>Principal activity</td>
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<td>Business</td>
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<td>Economic feasibility</td>
<td>Business start-up</td>
<td>Business maturity</td>
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Reddy (2010) which can be found in Table 1 (from Balachandra et al., 2010: 1846).

When looking at the phases and cases studied it becomes evident that the Go-Green project is currently at a research phase at which feasibility of the ‘smart home’ and the market are assessed, the Lochem and Meppel energy projects are one step further at which they have two demonstration grounds for the technology ‘smart grid’, with a working/workable prototype. The weaving a home project also seems to be in a current demonstration phase, having a prototype but not a commercial production line. Lastly the Aquion energy project is the only of the mentioned technologies currently residing in a commercial phase. This in relation to commercialization of the technology leads to extraordinary conclusions for the feasibility and realization of a commercial product. Firstly the smart grid projects are both private and publicly funded, the smart home project’s financed through the public and the other two projects are private developments. This in relation to the phase the technology currently resides in gives enough input for deciding the marketability and commercialization of the technology. Balachandra et al., (2010) study the commercialization of generative technologies in India, at which they note that “government driven projects for one time demonstration have led to the bad commercial state of sustainable energy technology” (Balachandra et al., 2010: 1850). This is due to the fact that “these projects start with demonstration as objective, not commercialization, the finance and facilitation stops once the successful demonstration gets over” (Kimura, 2010:1846). The implications of this plus the phase of development lead to the conclusion that commercialization depends not only on the marketing practice, which should be in the framework of sustainable marketing, but also on the nature of the project, thus the aim of creating a product or a demonstration. In table two the cases studied are concluded in terms of commercialization and marketability.

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<th>Case</th>
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<td>Private</td>
<td>Product</td>
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<td>Lochem</td>
<td>Demonstration</td>
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<td>GoGreen</td>
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<td>Demonstration</td>
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Sources
The possibility of global application

The technologies and research into technologies for private smart and sustainable living rely greatly on a Western, modern, technology-oriented perspective. The implementation of such technologies for sustainable energy generation and management might not necessarily be limited to countries like the Netherlands or the United States. Supplanting fossil-fuel as the primary source of energy with renewable energy sources like solar energy and wind energy is not an objective to be reached by first world countries alone. The scarcity of fossil-fuels and the detrimental implications of its use for the environment concern not only Western countries, but extent to all corners of the world. The deployment of sustainable energy technologies is therefore not limited to the Western, first world economies, but can also extent to less developed countries so they too can enjoy the advantageous implications of sustainable energy technologies. Additionally, ensuring a more sustainable environment by changing energy consumption and generation in only a part of the world will not do much good when other countries take up their places. It is therefore necessary that measurements for a more sustainable energy industry are not limited to first world countries alone. The implementation of renewable energy technologies, for instance, should be possible in other, different countries as well. But the possibility and manner of deployment of sustainable energy production and management technologies in other economies, for instance in countries on the African continent, may not be the same as countries like the Netherlands.

It is clear that the inhabitants of a varied array of countries desire a connection to electricity, so they may use anything from lights, to heaters, to sound blasting systems. But although the citizens of developed countries today take electricity for granted, the people in underdeveloped regions and countries may yearn for it. However, one technology cannot be implemented in a whole different country without a shrug. The international diffusion of technology may result in a technology that is completely changed in the process due to necessary and desired adaptation to existing systems.

As Suzanne Voss lamber noted about the objectives of the Lochem Energie project, “overall what we want to achieve with technology is achievable everywhere”. Applied to the Lochem Energie project this means that it is achievable to make the transition to sustainable energy, not just by the use of solar panels, but also by balancing the demand and supply of energy, in whatever country. Meratnia Nirvana of the GoGreen
Building project explores the idea a bit further, saying about the applicability of her project that it is important to take the types of activities and habits of the people into account. "I can imagine if you want the same technologies, and monitoring, and controlling strategies in another country then you need to adapt because they have a different manner and they may have very different roles". The keyword for applicability of the technology is thus, according to Nirvana, the adaptability of the technology to the desires, needs, habits, manners, roles and existing systems in another country. The user requirements may be different in different countries, for instance, due to different expectations and desires when it comes to service and quality of the system. Other countries may be less concerned about the aspect of sustainability that concerns environmental impact or comfort, and instead focus more on the economical impact, namely saving money by cheaper energy or a reduction in energy use. Another difference may be the lack of an existing electrical grid. Gerard Smit poses a possible solution to this problem: "One of the projects we’re also involved in is about working off-grid energy management.”

Ultimately, it is clear that adaptability to the systems, however broad this concept may be defined, already in place is necessary for implementation of sustainable energy production and management system on a global scale. Countries vary in their geography, business practices, existing industry, developmental patterns, political arrangements, social customs, environmental concern, demographic factors, and religious orientations. These may all, in different degrees, have an effect on the applicability of renewable energy technologies in different regions and industries. However, when the development of a technological system is still in an early stage of development, and as such in a relatively malleable state, the option of transferring the technology from one country to another, very different, country is very much possible. It is like Seikaly tells us about the Weaving a Home project: "As a general idea, this can be applied anywhere in the world, however, one needs to always look at the project again and test/adjust it based on various cultural locations." (Seikaly, personal communication, 2015).

Case: global deployment of Aquion Energy saltwater batteries
Aquion Energy’s products have already been shipped and installed worldwide, for instance in North America, Europe, South-East Asia, and soon even on Antarctica. Aquion’s S-Line stack product, for instance, will be used as part of a solar powered demonstration in Australia. The batteries will be put inside a box that contains photo-voltaic panels and will provide base load power. For now, it is only part of a demonstration, but if successful one could envision these units being deployed worldwide. The power is generated by solar panels and Aquion’s saltwater batteries are used to provide that power all night long. Given the value proposition of the product when paired with solar panels, the people of Aquion Energy have no doubt that their products will deliver value to millions of people across the globe.

Sources
SOME CONCLUDING REMARKS

These articles have all been devoted to a comparative analysis of the diverse technical solutions to the problems of energy generation and management in private sustainable living. These link directly with the sustainability agenda for responding to energy scarcity and demand in such a way that the environment, economic continuity, and individual/collective wellbeing are all addressed. What we aimed to explicate here is not a solution or even a consolidated definition of these fundamental terms. Rather, we aimed to illustrate the interconnectedness and diversity of these ideas and how they co-shape technical research and development. We found the concepts of sustainability, wellbeing, and high tech implicit in our five case studies, but interestingly, none of these definitions were explicit. Even projects openly working on sustainability, promoting wellbeing, and using high tech solutions offered little insight into what they meant with these terms. The same pattern goes for much of the literature coming from scholars, policy-makers, and other related stakeholders. The point of recognizing this is not to devalue the technologists and researchers, because they realize these terms through operationalization and deployment rather than rhetorical clarification. This is where PSTS can offer some insight. Our goal is to explicate the underlying concepts that already exist in various practices. Essentially, the ideas were there, being deployed and operationalized into problem-solving and technical fixes, they just needed to be mined and refined. Clarifying whether one operates on an economic, environmental, or social concept of sustainability, or whether one endorses subjective or objective wellbeing, or whether one is operating in a high tech sector helps focus goals and provides supporting literature, concepts, and stakeholders. Researchers, developers, marketers, and policy-makers can all achieve greater cohesion with their goals if those goals are clarified to their most underlying concepts.

The role of PSTS here is to identify some of those central concepts and draw out the way these concepts influence research, development, and implementation. This is to assist in streamlining technical development from a general vision (i.e. environmentally sustainable renewable generation or subjectively satisfying system adaptability), to a set of goals (i.e. CHP or smart homes), to a set of technical solutions (too many to even begin). There are an indefinite number of technical approaches to sustainability, wellbeing, or even, as we saw, high tech, so invoking these general ideas does little to focus one’s vision, let alone operationalization. We wish to offer a correspondingly diverse set of conceptual foundations upon which to clarify and optimize the goals of these projects with greater cohesion between the initial vision and further development. For example, among technologists, conceptual clarification focuses technical problems, while for policy-makers, it distills priorities, and for marketers, it increases cohesion between promises and expectations. As the concepts and solutions within sustainability, wellbeing, and high tech become more diverse and specialized, so, as a whole, they become more widespread and adaptable. Although this necessitates that some technologies will overspecialize and never see implementation, if they belong to a clear set of goals and concepts, individual technical solutions can more easily be re-integrated into new and potentially more realizable developments. We find technical and conceptual allies and predict potential counter-views when we identify the kinds of sustainability, wellbeing, and technological classifications within which one works.