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The Need for Diffraction in STEM[1]-Fields: An Ethical Feminist Consideration of the Concept of Gender Scripting

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ABSTRACT

Gender scripting describes the process and all the associated factors of the development, manufacturing and marketing that ensure that technologies are given a targeted gender-specific imprint including all positive and negative consequences. Gender scripting leads, even if not always intended, to exclusions in user behaviour, so that certain groups of one gender, but also of other intersectional spheres, are not taken into account. The problem is very complex and particularly concerns the norms, rights and technical infrastructure in the areas of development, production and marketing, which disadvantage or exclude certain users who do not conform to prevailing patriarchal or societal norms of the use of technology by different genders. To prevent such misuses of societal ideas, norms and values Karen Barad introduced the concept of diffraction. Diffraction, originally a phenomenon from the field of physics, can point the way towards recognising and thus replacing the outdated and patriarchal structures in science and research and can contribute a model of inclusion of feminist imaginations and intersectional practice in research, development, manufacturing, and commercialisation. Diffraction is one way of implementing feminist techno imaginaries in STEM-fields and engineering. This article looks at these aspects and shows how diffraction can become reality.

Keywords: diffraction, discrimination, gender script, women's visions for STEM fields, sharing technology

INTRODUCTION

Science and research are structured and hierarchised by ontologies. Here 'ontology' refers to a collective term for the values and norms used in science and technology, which are applied as a systematics and guideline for subjective actions in science and research[2] (Richter, 2008: 430). This affects not only the humanities, but also the fields of science, technology, mathematics, engineering, and computer science (known as STEM). A concise example of the influences of ontologies in STEM fields is the gender script. The script is a developer's or engineer's interpretation of who uses a technology and how a technology[3] should be used. The gender script represents an extended specification and is aimed at scripting technologies for people of a particular gender. The gender script

[1] Science, Technology, Engineering and Mathematics. I use the term STEM to unite the mixture of scientific and technical fields discussed in the texts by van Oost, Bath, Ernst, etc. The term STEM seems to be the easiest to understand and therefore the most practicable solution, but it is nevertheless a very complex field that interferes with many other areas and is therefore not always clearly definable. van Oost, Ernst and Bath's works concentrate mostly on engineering, but are not limited to that field.

[2] I am referring here to an interpretation of the term ontology in the German standard dictionary used in Philosophy, Metzler's *Lexikon Philosophie* (Richter, 2008: 430).

[3] The term technology is used frequently in this article. Technology is a term that is used in many different ways and can cover several spectrums at the same time, e.g., a hygiene product, a related craft, computer programming, or as a collective term for things created by humans. Because the word technology is often used in a generalised way for a design process of a man-made artefact or technique, the term seems very vague. For the purposes of this article, I will use also the term technology to refer to designed objects that we humans interact with haptically on a daily basis, such as shavers, cars, electric stoves, etc. Technologies such as artificial intelligence or software, which are not haptically tangible, are not addressed here, but may also contain problematic influences from designers and engineers. Because the variance of terms, objects, practices, and artefacts that fit this description is very large, it is difficult to find an appropriate sub-concept for such a broad topic. Therefore, despite the concerns mentioned above, the very generalising term of technology has been used here.

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inherits the ideas of the designer, developer or engineer but can also contain elements of everyday socialisation that is oriented around the structural category of gender and that are implemented consciously or unconsciously. Through the concept of gender script, but also through various studies, it has been demonstrated that the STEM fields are primarily patriarchal in orientation and socialised accordingly (Horwath et al., 2012). That this is more than problematic for the development of technology can be seen in products of our daily use that have been developed with a gender script, as will be explained later. A major problem for feminist technology studies focusing on such patriarchal frameworks in technology is the use of ontologies, but also the lived and applied practice of science – both can have huge impacts and restrictions on our view on technology and how it should be used. In her article *Emancipatory Interferences with Machines* (2017), Waltraud Ernst referred to the efficacy of ontologies and to the principle of diffraction, first introduced by the US researcher and quantum physicist Karen Barad in her book *Meeting the Universe Halfway* (2007). Ernst's idea was to enable a more inclusive view of how we develop and design technology or artefacts and how we can open the field and infrastructure within engineering and technology development to all genders. To explain such a reformation of the interrelated fields of science, technology, industry and engineering, she used the concept of diffraction.

In my article, I want to explore the field of diffraction as an opening tool for technology itself, the process of engineering and industrial design, but also as a feminist techno imaginary. For me, the feminist techno imaginary is a way to show how feminist ideas and theories are connected to technology. I propose it also explains what is missing in the technical artefacts themselves, the used and submitted knowledge, the design techniques and procedures we use that directly affects women[4] but also other areas of intersectionality. And finally, how diffraction can be adapted so that women's ideas and theories are implemented to improve the technologies themselves, but also the framework within and behind the development. I want to do this in my article using the example of diffraction as an asset for the feminist techno-imaginary.

To do so, I will first explain what diffraction is, including its origins in physics, its transformation in the humanities, the various phenomena, problems, and benefits. This will be followed by the example of the gender script as a current problematic practice in science After that I will combine both aspects – the diffraction and the gender script – to demonstrate how diffraction acts as a reformer in technical science and to introduce the conclusion, which explains how diffraction can benefit feminist techno imaginaries. In the following, I will explain what diffraction is, where the concept comes from, and how it can be applied to technology design.

THE NEED FOR A MORE FEMINIST VISION AND IMAGINATION: THE CONCEPT OF DIFFRACTION

Diffraction is essentially an optical phenomenon studied in physics. Diffraction patterns show the entanglement of waves. That is, a diffraction pattern shows the diffraction of waves and the resulting entangled and superimposed waves. Karen Barad describes it as follows:

> Simply stated, diffraction has to do with the way waves combine when they overlap and the apparent bending and spreading of waves that occurs when waves encounter an obstruction. Diffraction can occur with any kind of wave: for example, water waves, sound waves, and light waves all exhibit diffraction under the right conditions. (Barad, 2007: 74)

Examples of such phenomena can be found in nature, for example, in the ocean when waves break on rocks or crevices and the waves colliding there interfere with each other. Or when drops fall into a puddle and the resulting wave motions of several drops collide and overlap. There are also diffraction patterns that are invisible to the naked eye, such as those of light waves. In her theories, Barad draws on her theoretical understanding as a quantum physicist and extends this natural phenomenon to theoretical considerations. Quantum physics deals with the motion and effects of particles and waves in time and space.

Diffraction in Quantum Physics – The Nils Bohr Double Slit Experiment

For a better understanding of the concept of diffraction as discussed by Barad, in what follows I relate it to quantum diffraction. However, in order not to exceed the scope of this article, this will only be sketched in the most necessary way. According to Barad, a distinction must first be made between particles and waves (Barad, 2007: 76). Particles are small entities that occupy a fixed place in space at a given time. This time of appearance cannot be changed or influenced by any event. Waves, on the other hand, are not fixed entities. They change and

[4] The selected references and research literature focus primarily on females, female users, or women, which is why this article presents women as the largely excluded users of technology. However, this does not mean that the areas of science, development in general and companies addressed in this article have not also excluded other groups of gender (e.g., transgender, non-binary, etc.). Therefore, in this article, I primarily refer to people who are female, female users, or women.

can take a different course when they meet fixed entities. As in examples of observable in everyday life, these waves can also overlap and form diffraction patterns (Barad, 2007: 76). This was demonstrated in the 1920s with a modified version of Niels Bohr's double-slit experiment. According to Barad, Niels Bohr continued the double-slit experiment developed by Thomas Young in 1802 for the refraction of light waves and developed a thought experiment for the division of quantum physical particles and waves (Barad, 2007: 80ff.). According to Barad, Bohr used this thought experiment to prove that particles occupy a fixed place at a given time, but waves can rearrange themselves and interfere with each other when they are refracted by an object. According to Barad, the entanglement of waves and the resulting effects are called superposition (Barad, 2007: 76). This brief outline of diffraction should be sufficient to allow us now to refer to the reshaping or reorganisation of a social ontology. First, however, it is necessary to explain how quantum physical experiments and theories are to be applied to theories of society in the social and political sciences and humanities. In physics according to Barad.

> It has now become routine to use diffraction experiments to determine different features of matter. Generally this works in one of two complementary ways: sometimes the goal of a diffraction experiment is to learn about the nature of the substance that is being passed through a diffraction grating, and sometimes it's to learn about the diffraction grating itself. (Barad, 2007: 83)

These two ways of looking at matter can also be related to theories and practices in the humanities. Either the object of research itself (i.e., matter itself) or the means or tool of research (here the diffraction grating) can be analysed. Barad contrasts two tools of observation and analysis that are elementary to science: reflexivity and diffraction (Barad, 2007: 87ff.). I will explain both phenomena in the following two subsections.

Reflexivity = The Current Method in Science

In the humanities and sciences, but also in the STEM fields, different methods are used to critically question existing theories and concepts. In her work on diffraction, Karen Barad refers to two possible methods: reflexivity and diffraction (Barad, 2007: 87ff.). Reflexivity is one of the most common methods of scientific analysis. Reflexivity serves to critically question theories, concepts, ideas, themselves. The knowledge produced is mentally reflected upon to allow for possible errors, approaches for improvement, or additions. Reflexivity is usually done by the researcher, but it can also be done by others. Here, a person can reflect on the knowledge produced on the basis of a body of knowledge and see to what extent this produced knowledge agrees with his or her findings or, if necessary, extends them (Barad, 2007: 88). According to Barad, reflexivity as a methodological tool has been criticised and its usefulness questioned by feminist researchers on several occasions, because the use of reflexivity raises two fundamental problems at the same time. On the one hand, the reflexivity of theories and assumptions, both in the humanities and in the Science and Technology Studies, takes place on the basis of an already established ambivalent dichotomy. As Barad writes:

> The irony is that while these scholars insist on the importance of tracking 'science-in-the-making' by attending to specific laboratory practices, for the most part they continue to treat social variables such as gender as preformed categories of the social. That is, they fail to attend to 'gender-in-the-making'—the production of gender and other social variables as constituted through technoscientific practices. (Barad, 2007: 87)

This means that science judges mostly by two different standards: In the natural sciences and in technoscientific research, results are obtained through observation and evaluation of observations in order to actually adhere to scientific objectivity and freedom. Of course, these standards can be critically influenced as Ellen van Oost and Corinna Bath outlined in their research on toxic technology development and infrastructure (Bath, 2017; van Oost, 2003). We will have a closer look on this later when analyse the gender script. On the other hand, social science aspects are judged according to a prefabricated standard, that follows dichotomous understandings of gender, and the results of the objective natural and technical sciences are analysed through a prefabricated methodological construct. Barad criticises this method because it reproduces a clear 'nature-culture dichotomy' that does not correspond to real conditions and does not allow for other concepts and methods, because these are two distinct issues, one does not follow from the other (Barad, 2007: 87). According to Barad, this dichotomy needs to be reconsidered and it also needs to be analysed for whom this dichotomy is valid and to which results it can be applied. Another problem of reflexivity is its representationalism (Barad, 2007: 87ff.).

> A second significant difficulty is the fact that reflexivity is founded on representationalism. Reflexivity takes for granted the idea that representations reflect (social or natural) reality. That is, reflexivity is based on the belief that practices of representing have no effect on the objects of investigation and that we have a kind of access to representations that we don't have to the objects themselves. Reflexivity, like reflection, still holds the world at a distance. (Barad, 2007: 87)

Barad's remarks show that reflexivity may not represent the true and real world but is only a representation of certain values and ideas that are lived and practiced in the research setting. This is critical for objective scientific research and analysis, for this is the case, it can only ever reflect a distorted picture of the findings. For technical science and feminist analysis, therefore, reflexivity is an inappropriate tool; and since, as Barad argues, technical science is embedded in patriarchal structures, the results are also a reflection of a patriarchal gender order. Therefore, this practice is not practicable for the emancipatory opening of technical science and industry to implement feminist and intersectional ideas and allow everybody to develop and use every technology, product or artefact. As an alternative Barad proposes the method of diffraction.

Diffraction – A New Tool for Science, Industry and Methodology?

For Barad, diffraction is an antithesis or a model that does not use the negative properties of reflexivity. Another important aspect, which should be mentioned in advance, is that diffraction does not rely on common homologous knowledge, as mostly reflexivity does, but deals with the entanglements of the objects under investigation (Barad, 2007: 88). By homologous knowledge, I mean knowledge that has been acquired, shaped, and constantly reflected upon by one person or like-minded group without taking into account other perspectives or elements of knowledge, either because they were deliberately ignored, were not known, or the relationship to them was not or could not be drawn. Thus, diffraction as a methodological practice can be clearly distinguished from reflexivity. The core idea of diffraction can be seen in the following quotation from Donna J. Haraway:

> (…) diffraction can be a metaphor for another kind of critical consciousness at the end of this rather painful Christian millennium, one committed to making a difference and not to repeating the Sacred Image of Same. … Diffraction is a narrative, graphic, psychological, spiritual, and political technology for making consequential meanings. (Haraway, 2018: 273)

I am using Haraway's quote to clarify the core meaning of diffraction in Barad's concept, to show that diffraction can function as a feminist critiques of technology. It is about distinguishing one type of knowledge from another one, showing differences, and examining how knowledge can be intertwined[5]. According to Barad, diffractive methodology serves to bring about 'a critical practice of engagement' (Barad, 2007: 91). It aims to recapitulate and represent scientific positions that have not yet been confirmed. Diffraction is based on the following core aspects, which clearly distinguish it from reflexivity:

Diffraction, as mentioned, forms what are called diffraction patterns. They show when there are differences or gaps in a knowledge construct and how these are distinguished from other constructs (Barad, 2007: 88). The search for distinctions or diffraction does not serve the repetitive representation of existing knowledge constructs, but rather the creation of 'performativities' that emerge through 'intra-actions' and thus become established (Barad, 2007: 89). For Barad, knowledge consists of an ontology with interrelated and interdependent terms. This ontology is a constantly evolving and changeable framework of knowledge that is affirmed, negated, and changed accordingly through constant confrontation and situational re-evaluation (Barad, 2007: 89ff.). Barad's theory also includes the issue of accountability. For her, it is important that developments arise from the scientific and social practices that are carried out in an accountable manner. Therefore, whoever uses these practices must also be willing to take responsibility for the consequences and to change them if necessary (Barad, 2007: 89). For this reason, Barad argues that the elementary philosophical fields of ethics, ontology, and epistemology should no longer be seen as separate fields of research and action, but rather as an inseparable unity that supports and conditions each other and should also be applied in fields that have not been directly included in the past, such as the STEM fields or the industry (Barad, 2007: 89ff.).

According to Barad, scientific papers and theories need to be read 'transdisciplinarily' in order to recognise the differences and boundaries that become apparent through the pattern of diffraction. Furthermore, she calls for 'respectful engagement that attends to each other's detailed patterns of thought' (Barad, 2007: 90). For Barad, diffraction is a practice that, at its core, is about 'accounting for how practices matter' (Barad, 2007: 90). Diffraction, or diffractive methodology, makes it possible to create a new perspective on science and make it more diverse. Knowledge is no longer examined in terms of a single discipline, but in terms of connections to all possible categories of knowledge and disciplines. Diffraction makes it possible to redefine natural and technical science and to free them from outdated patterns of thought, norms and values. This also applies to the gender dichotomy in engineering, design, industry and marketing which we will demonstrate and concretise in the next section of the

[5] In her research, Donna Haraway links the concept of diffraction with other innovative perspectives, such as the concept of situated knowledge (Haraway, 1988) or the concept of *sympoiesis* (Haraway, 2016), which advocates a general responsible coexistence in all aspects of life. Both concepts are not elaborated here, but can be read about in the respective works, see reference list.

article. We now turn to one area in which the problem of ontology and scientific practice is very clearly illustrated, and that is the gender script.

THE CONCEPT OF GENDER SCRIPTING – AN INTRODUCTION

Technology is an object created, developed and designed by human beings. Due to various historical circumstances, such as the segregation of the sexes, the long historical exclusion of women from the natural and technical sciences, sexist traditions and laws, technology became a field dominated by male figures and their ideas, visions, practices, techniques and infrastructures (Schatzberg, 2018; Ihsen, 2017). Since the second half of the 20th century, there have been developments to change this drastic imbalance of 33% women to 77% men in the system of technological development and design (Bello et al., 2021). Although women in most parts of the world now have the right and opportunity to create, develop and design technology or to become engineers or designers, the stereotypical tradition of this segregation is often still alive and in daily practice in science, industry and marketing. This lack of female knowledge, ideas and visions is very problematic and therefore an open vision of diverse technology engineering and design is more than necessary. To fulfil this change the use of technology by different users should be taken into account in the development and design of technical artefacts.

Technology is a very broad term and defines numerous analogue, digital, primitive or specialised technologies or artefacts in our society (see Footnote 3). Technology as discussed in this article is a combination of theorical objectives/ideas and physical technologies that are developed based on these theories and ideas. As Gilbert Simondon states, technology is a unity made of different technological parts that are created, produced and combined to function in a way that is thought by its engineers (Simondon, 2011: 421). We as users are reminded of this every day, and this duty of and the diligence to keep the different users and their different needs in mind, is expected of research, technology and industry. However, the development of these technologies, which accompany us in our daily lives, often shows certain shortcomings, which in turn can be traced back to the product development itself and the scientists and technicians responsible for it. When using these technological products and concepts and engaging in technologically prompted behaviour, it quickly becomes clear that the products, concepts and behaviours as designed are not functional or suitable for everyone. The cause of this lies in many different areas and functions, one of which, the gender script, will be examined in more detail below.

Gender scripting represents one of the most complex and human causes of the misdevelopment, misdesign and misproduction of technologies. Gender scripting is not a new practice; it was first addressed only in 2003 by the Dutch gender researcher Ellen van Oost. Her results were published in her article *Materialised Gender: How Shavers Configure the User's Femininity and Masculinity* (2003)[6] that focuses on technologies and products that are designed, developed and manufactured for our daily use in housework, hygiene, lifestyle or work by mostly economic orientated companies and industries. Her article provides an example that comprehensively explains the significance of gender scripting for industrial technology development and for female stereotyping, and shows why we need to rethink development and scientific practice themselves in order to make more room for women and imaginaries of femininity in the fields of research, design, development and industry, and in the STEM sector more broadly. This need for reformation has been discussed by various feminist thinkers like Judy Wajcman, Waltraud Ernst and Ruth E. Hagengruber who all demand an implementation of feminist values and visions for the patriarchally influenced and dominated fields of science, development, industry and marketing (Wajcman, 2004; Ernst, 2013, 2017; Hagengruber, 2016). This also opens the possibility of implementing diffraction as regular tool for engineering and how it can be used to deconstruct the gender script.

The Initial Problem: Product Development/Design and Matching to the End User = The Gender Script

In her article, Ellen van Oost explores gendered technology and its origins through the example of electric shavers and their product development over the years by the Dutch brand Philips. van Oost argues that technology reproduces an everyday relationship between gender, material design and development (van Oost, 2003: 193). Technologies are generally adapted to the end user and are in many cases gendered. This trend continues today and is reinforced by the growing concept of gender mainstreaming and the resulting market opportunities (gender marketing) (Hosny, 2018; Wagner, 2018). Gendered design may seem like a minor issue, but it has a significant impact on the end user's purchasing behaviour, handling of the product, usability and confidence in the technology itself. This is important for the design and development of technology because, for example, men perceive and develop technology specifically on the basis of their own needs and requirements and do not necessarily recognise

[6] In this article I have chosen van Oost's example because it is a very simple example to explain the complexity of gender scripts. Of course, this example is a more historical one for today's understanding, but the effects of gender scripts and the methods and situations described by van Oost and Bath are also current realities in science, industry and marketing.

differences in or to women's requirements so that these could be taken into account in the design. van Oost calls this process 'gender script' (van Oost, 2003: 195).

The gender script is the template by which technology is gendered. Today it is an important and also profit-oriented tool in the design and development of new products. Gendered operation and application are at the heart of design especially in technologies of our daily use (van Oost, 2003: 195). van Oost writes that in the development of technology, the I-perspective is at the centre of technological development. This means that the designer, developer or engineer[7] starts from personal conditions and prerequisites and therefore constructs and optimises the product according to her/his/their personal characteristics. However, this subjective approach to the development of technologies harbours risks and problems, especially when these technologies or products are ultimately introduced to the global market and thus to a large number of users with different requirements. In addition to the product design, the materials used and the technical construction, and specifically targeted marketing strategies using certain role models are also part of the gender script. The latter is therefore a formative technology for science, development and industry that has gained enormous relevance with the rise of gender marketing. In her article, van Oost uses the example of electronic shavers to illustrate the problematic nature of the gender script. This complex and discriminatory process is illustrated by the development of a series of electric shavers by the Dutch brand Philips. This example is also special because it is a well-documented case from research and industry that spanned several decades of the 20th century and illustrates what can happen when research, knowledge and industry are viewed in an overly one-dimensional way.

The Example of the Shaver as a Gender Scripted Technology

In the following segment, I present her study in an abbreviated form. The electric shaver is a good example of a gendered technology, as there are specific shaver models for both men and women. It is worth noting that the first electric shaver of the Philips brand[8], developed in the 1930s and launched worldwide in 1939, was a universal product, i.e., it was designed without specific gender connotations (van Oost, 2003: 197ff.). The shaver had a relatively neutral design – a black synthetic resin design with a leather case – and the focus was on shaving itself. The advertising strategy was based on print advertising or public presentation. The first Philips electronic shaver (nicknamed *The Cigar*) was aimed and advertised primarily at men, although women were not excluded *per se* (van Oost, 2003: 198). Like many products, the electronic shaver is a technological product that has been undergoing technical development for decades. The second Philips model, *The Egg*, was launched in 1948 and differed from its predecessor mainly in its more ergonomic design. It was not until the third model in 1951 that significant innovations were made with the addition of a double-headed shaving element (van Oost, 2003: 198ff.). The design was adapted to the new production material, which changed from resin to the then new and similar plastic. This design was in keeping with the spirit of the times and the market economy of the 1950s. Through targeted advertising strategies, the electronic shaver was specifically built and promoted as a product for men. This was achieved through masculine and cosmopolitan advertisements and slogans:

> Another marketing technique that proved effective was to provide airline company´s logo. In this way Philips not only linked its shavers with the modern symbol of speed (the airplane) but also saw to it that well-to-do male travellers became acquainted with them. (van Oost, 2003: 199)

Through such advertising strategies, the electronic shaver was linked to the ideals and images of masculinity that prevailed at the time, making this the first obvious gender script. From this model onwards, the electronic shaver can be read as a gendered technology. Philips shavers continued to adapt to role models. In 1957, the *Philishave* model, as the male-oriented product line was called, received additional elements, such as the ability to remove the shaving head at the push of a button. This was to enable the 'handyman' to take the shaver apart for maintenance or cleaning (van Oost, 2003: 199). In 1966, the double-headed shaver was replaced by the triple-headed shaver as the product standard for the men's range. The first electric shaver for women was developed in the 1950s. Women had been identified as potential shaver users as early as the 1920s, but until then they had only been a small part of the target audience and were not seen as a group with independent purchasing power. As cosmetic and hygiene standards increased, as did the number of potential marketable target groups, women also became a source of profit for manufacturers of electronic shavers. The *Beautiphil* was the first women's shaver

[7] The technology design process involves several players, including engineers and developers of the functionality of a product or technology. Aesthetics, haptic functionality, or sensor technology are considered by industrial designers. At a later stage, there are also designers or marketing specialists who also have a strong influence on the intended end users. However, it is very difficult to delineate this precisely in a peripheral analysis such as this one, because these transitions and responsibilities of these different experts in the process are different depending on the product (Paloian, 2019).

[8] In her study, van Oost gives details of the shavers based on the monograph by Sergio Derkes *Scheren: Van Klapmes tot Philishave* (1996). The details of several shavers mentioned in this article are taken from van Oost's study and refer to it accordingly. For further reading, also have a look at Derkes' monograph, see reference list.

developed, designed and sold by Philips in the mid-1950s and it established the *Ladyshave* range. This shaver was simply given a feminine casing and design to appeal specifically to women (van Oost, 2003: 199). In order to attract women as potential customers, Philips first used colours, fashion and fashion trends in its advertising campaigns in the 1950s and 1960s. These show the first primitive image of a gender script aimed at women as customers:

> The main design strategy used in the 1950s and the 1960s to tailor a shaver for female users was to give it recognisable female-coded features, such as pink housing or a round red storage case. Philips' competitor Braun followed a similar strategy, decorating its women´s shavers with little imitation diamonds. (van Oost, 2003: 201)

Philips' marketing strategies seem ambivalent in this regard. For men's shavers, for example, the focus seems to be primarily on the shaving technology, while for women's shavers it is primarily on feminine appearance, design and appealing advertising concepts. The underlying gender scripts here are that technology should be obvious to men and hidden from women. van Oost also describes this process as the 'masking of technology and shaving' (van Oost, 2003: 201). Women are supposed to associate the shaver with cosmetics, beauty, well-being, and femininity, and not develop an image of technology. This goes so far that even seemingly banal elements such as smells, e.g., the smell of motor oil that may leak from the device, are to be masked by perfumed pillows in order to avoid any possible association with technology (van Oost, 2003: 201ff.). The masking of embedded technology has also been applied to brand names. For example, one *Ladyshave* model bears the name 'Milady Decolletée' and thus evokes no association with technology, but with femininity, beauty, cleanliness, attractiveness, and well-being (van Oost, 2003: 202).

However, the separation of the products did not only apply to the development and marketing of the product itself, but also to the development and production of the shaver series. van Oosts showed that Philips separated the development and production of the shaver. Thus, the development and production of men's shaver remained at the main site in the Netherlands, while the development and production of women's shavers was outsourced to Switzerland. For van Oost, this circumstance means two things: on the one hand, this relocation and separation of development and production could be seen as an emancipation of the women's shaver, since development and marketing were also relocated. On the other hand, it is also possible that gender distinctions were cemented in this way. The men's shaver was seen as a technical electronic object and remained at the main site, while the women's shaver was downgraded to a cosmetic product and thus lost the symbolic value of technology and was deliberately 'outsourced' (van Oost, 2003: 202). This last assumption is particularly evident in the comparison of the two product lines and reinforces the image of the degradation of the women's product, as can be seen from the development history. While the *Philishave* series was further developed and redesigned with a metallic look, a plastic case, and a focus on office and management clientele, the *Ladyshave* series remained largely the same. The last remaining technical components, such as screws, were either completely covered or removed by a new connector housing (van Oost, 2003: 203ff.). The *Ladyshave* series thus became a cosmetic but untechnical product, equipped with outdated technology for a long time and not consistently improved like the *Philishave* series. It was not until 1980 that a new *Ladyshave* model was launched. This was the first wet-dry shaver that was waterproof. At the same time, the *Philishave* men's range underwent three further developments: First, the shaving head was improved to provide a better shave. Second, the wet-dry shaving technology was added to the *Philishave* and the first rechargeable battery version was incorporated to facilitate shaving in the shower. Third, the first microelectronics, such as small displays for information transfer, e.g., for a countdown function, were installed (van Oost, 2003: 205). These developments demonstrate and support earlier theories that the men's product line has a more thorough and advanced mechanisation and specified innovation performance than the women's line. Technology, according to van Oost, should be kept away from the female audience. This is also reflected in the fact that new technologies, such as the rechargeable battery function, were sometimes incorporated into women's shavers with a considerable delay. For example, the battery function was not integrated into the *Ladyshave* until 1990, 10 years later than in the men's models. The image of the woman as a cosmetics-loving but technology-phobic person produced here is almost elevated to an art form by the masking strategies. Women are virtually denied technical competence, and this is manifested in design decisions. How these decisions were made, whether simple ignorance or deliberate exclusion based on outdated or supposed economic, scientific or social values were decisive, cannot be clearly proven. But the example of Philips shavers clearly shows how technology can be targeted at or kept away from gender imaginaries, and which social expectations and images can be projected and manifested through technical products.

EFFECTS OF GENDER SCRIPTING = PROMOTING WOMEN INSTEAD OF EXCLUDING THEM

Ellen van Oost's study has shown that even pure design decisions can structure technologies in a gendered way and at the same time significantly influence and determine the market behaviour of women and men. At the heart of these effects is the gender script[9] described above as a driving element. It determines the basic structures of the technological production and products and, ultimately, by whom and how the product is to be used. The gender script does not necessarily have to be intentional, but it may well have been consciously initiated. Therefore, the practice of gender scripting is also problematic. All in all, gender scripting is a complex process with many aspects that need to be considered to improve technology development and production. Corinna Bath[10], a gender researcher and engineer, described the concept of (gender) scripting in 2012 as follows: The gender script concept is based on the concept of 'script' introduced by Madeleine Akrich (1992, 1995) and grounded in actor-network theory (cf. Latour, 2005). The approach aims to describe how technical objects 'participate in the construction of heterogeneous networks that bring together actors of all kinds and sizes, whether human or non-human'. (Akrich, 1992: 206)

The basic assumption here is that technology designers, in the course of the technology design process, always develop a multiplicity of visions of a product, which ultimately manifest themselves materially – discursively – in the artefacts (Akrich, 1995: 168; Bath et al., 2013: 89). The gender script, which is a significant cause of gendered technology, can be influenced by many factors. In her article 'De-Gendering Information Technological Artefacts' (2017)[11], Bath describes the process of gender scripting. Bath calls for the STEM field to go through a process of 'de-gendering' (Bath, 2017: 39). Technology development, according to Bath, has been created through decades of one-sided gendering processes. These development departments have been shaped primarily by men and now have inherent structures that prescribe a representation of gender and roles that is no longer in line with the consensus and with the political and legal zeitgeist. In order to give women and men equal participation in the gendering process, the field needs to be fundamentally reinvented. According to Bath, there are three steps to identifying these processes of gendering:

1. Conceptualise a 'systematic synopsis [...] of how informatics artefacts can be problematically gendered (racialized, etc.)' (Bath, 2017: 39).
2. Initiate and establish a culture of debate about the 'commonly identifiable problematics of the gendering of technology' (Bath, 2017: 39). This includes assessing which gendering processes are useful for the project and which should be avoided.
3. The first two steps mentioned here form the basis for a detailed analysis of design processes in technology development. The third step is to have these analyses accompanied by a team of gender researchers who will evaluate, assess and publish the results. This is to avoid possible misinterpretations and misunderstandings. Bath argues that these three steps must accompany the previous development and design process of technology in order to prevent previous problematic elements of gendering.

Moreover, these processes are compromised by other circumstances that urgently need to be rethought and reformed for neutral technology development: the I-methodology, our norms, stereotypical assumptions, and gendered infrastructure.[12] I discuss these below.

The I-Methodology

One of the best-known analysis and development methods in the design process is the so-called I-methodology. Here, technology is developed on the basis of personal self-understanding and personal preconditions, needs and habits (Bath, 2017: 40). In addition, the personal visions and ideas of the developers manifest themselves in terms of how the subsequent object or technology should look like, be structured, used and defined (Bath, 2012: 89). The I-methodology is one of the biggest problems, because technologies are developed only on the basis of the developer's own imagination and applicability. Consideration of other users is very difficult or even impossible. Other third-party innovations may not be considered at all. People with more specific needs, such as people with physical disabilities, are also not considered and thus excluded from use *per se* (Bath, 2017: 40). Technologies

[9] Every artefact conceived and produced by an engineer, developer, or designer follows a script. Thus, an artefact per se has influences and thought patterns of the creator behind it. The gender script is often another attribute assigned to the artefact. For further reading, see the attached reference list to the reference on script theory by Madeleine Akrich.

[10] The texts used here by Corinna Bath and Fleur Weibel are unfortunately only available in German. The quoted passages have been translated by the author.

[11] Original title in German: *De-Gendering informatischer Artefakte*, see reference list

[12] The information presented here still relates only to the issue of physical technologies for everyday use like shavers, as previously mentioned. Digital technologies are not included at first, but may also be affected in principle and in theory. This is not, however, examined in this article.

developed and produced using the I-Methodology must be extensively retrofitted and made widely available, which can be costly and resource-intensive for the producing manufacturers. The personal vision of the technology behind the I-Methodology can also be strongly influenced by dominant norms.

Norms

The design process of technology, like the whole of society and everyday life, is determined by norms. Since norms do not always produce and determine positive characteristics and behaviours, they can also entail massive restrictions and disadvantages for certain parts of society. According to Corinna Bath, it is therefore imperative to (re)examine established and emerging norms (Bath, 2017: 40). In everyday life, but also in the design process, norms can already be entrenched with negative gender ascriptions. Bath cites the long-neglected safety concepts in automobiles as an example:

> This is particularly evident in the example of standards that relate to people. In automotive engineering, for example, cars are designed to standard human bodies that serve an average person, but do not take into account very tall and very short people. In the early development of airbags, the assumption that such supposedly marginal groups were negligible led to small people and children being dangerously injured rather than protected. The history of crash-test dummies, which are also part of the field of automotive safety concepts, impressively demonstrates that the initial assumption was of a medium-size male standard body (US GI 1949: 170 cm, 70 kg), with women and children dummies being added later. (...) It took 40 years for the first manufacturers to come up with the idea of simulating a pregnant body. (Bath, 2017: 40ff.)

The example presented here drastically illustrates how dominant norms can influence a specific field and how long it takes for those very norms to be questioned and rethought. It is also a recurring pattern that shows how women are deliberately overlooked and disadvantaged in the gendering process. Reforming these norms is therefore of paramount importance, as we also quickly add to norms or allow them to become norms through stereotyping and prejudice. The correct use of norms, which means taking into account all peoples, not just men, is fundamental, especially with regard to possible legal opinions and the formation of laws. In addition, the application of norms in terms of economic or other purposeful intentions must be taken into account and universal norm formation must be established, including possible misuse or ignorance and reacting to them preventively.

Stereotypical Assumptions

In addition to norms and I-methodology, another serious problem is the assumption of stereotypical male and female behaviours. Stereotypical assumptions are reinforced by given norms and performative behaviours, leading to false assumptions that can be reflected in rights and laws. Bath therefore proposes the use of an alternative design concept. 'Human-centered design'[13] becomes the new standard through 'user-centered design' (Bath, 2017: 41). Here, newly developed technologies are re-evaluated by multiple users of different backgrounds, genders, and physical and psychological conditions. According to Bath, this results in a more universal picture of the user. This design strategy can help break down existing stereotypes and prevent new ones from breaking out (Bath, 2017: 41). Stereotypes and norms are formed through increasing reproduction and repetition, which in turn are manifested as part of a gendered infrastructure.

Gendered Infrastructure

The development and exploration of technology has been based on an infrastructure designed for this purpose, which has all the elements necessary to shape technology. When this infrastructure is preloaded with gendered content, such as norms or stereotypes, it is referred to as gendered infrastructure (Bath, 2017: 42). According to Bath:

> Gendering processes already begin at this level with abstraction, classification, and formalization that suggest objectivity, presuppose a neutral research object, and conceal prior decisions in the research and development process, while in practice, among other things, gendered classifications and dichotomies or hierarchies of knowledge are produced that reproduce the existing symbolic gender order. (Bath, 2017: 42)

The infrastructure of research and development can thus appear neutral and objective, even though it is already contaminated by assumptions, stereotypes, or norms and thus no longer value-neutral. Bath believes that this can

[13] Human Centred Design definition: '**Human-centered design** is a problem-solving technique that puts real people at the center of the development process, enabling you to create products and services that resonate and are tailored to your audience's needs.' (Landry, 2020)

be prevented through close collaboration between STEM research fields and the humanities and sciences. In this way, gendering processes could be identified and eliminated earlier, before the developed technology reaches the end user. This applies not only to the development of physical technology, but also to areas such as software engineering, as algorithms can also be programmed to serve certain norms or stereotypes and ultimately become a disadvantage for the user (Bath, 2017: 43).

Reuniting van Oost and Bath

Corinna Bath's remarks can be applied and thus extended to the example of Ellen van Oost's shaver study. The genesis of the shaver presented here has clearly shown that this technological development was carried out through gendered processes. This can be seen, for example, in the colour design of the devices, which assumes that every woman will find a shaver in pastel or pink shades attractive. It is also assumed that any reference to technical artefacts, however small, such as a screw, will lead to rejection of the product by the female user.

Similarly, it is assumed that women reject technology in general as can be viewed in the example of van Oost: The sometimes-late addition of modern technological elements to women's shaver lines suggests that developers applied double standards to the quality of the shave. Thus, men were generally presented with more modern shaving technology, while women were sometimes offered certain elements, such as a double-headed shaver or a battery mode, with a considerable delay of several years. This suggests that, on the one hand, men's shaving was given a higher priority by the designers and, on the other hand, a gendered evaluation was made, in which men were clearly given a more important position than women. In this way, the developers not only exploited certain stereotypes, but also made the predominance of men as the primary users of shavers the dominant norm. The resulting infrastructure of shaver development was thus able to develop product stereotypes over decades that are difficult to dispel today. After all, it is possible that not all consumers will be satisfied with the designer's product design. If it can be assumed that the developers were able to design the devices on the basis of their own preferences and experiences, the I-Methodology makes it more likely that users who differ from the designers in significant ways will be dissatisfied with the product design. Another consideration is whether the male or female consumer is satisfied with the design of the men's series at all. After all, it is possible that not every man is attracted by the design of the men's shaver as a technically modern object in black and screaming for power, masculinity and love for technology. The same goes for the design of women's shavers, but like already demonstrated, the connotations linked to female shavers are opposite to those liked to male shavers. Bath and van Oost's remarks show that it is important to link the development of technologies with the humanities, especially gender studies. This is the only way to prevent products and technologies that reproduce gender stereotypes, hierarchies and exclusions. At the same time, it can ensure that technological development benefits women and men equally. Women would thus be able to co-develop and design gendered technologies, such as an electric shaver, and act as technophile agitators. Bath and van Oost's theories can also be read as a call to give women equal access to the development, creation and marketing of design, and to dismantle outdated hierarchical structures that have so far denied women their right to actively co-design technology. To achieve this, it would also be a good approach, like van Oost argued to transfer features from men's shavers, such as the ability to unscrew and deconstruct, to women's shavers ranges (van Oost, 2003: 206). This would give women the opportunity to engage with technology. This research highlights the need to reform the structures in science, engineering, development, design, industry and marketing themselves. It is particularly important to embed women's imaginations in the process of designing technologies, but this also requires a redesign of the research and development process. Karen Barad's concept of diffraction can be used as a starting point.

DIFFRACTION AS A REFORMER OF (GENDERED) TECHNICAL SCIENCE

For Barad, it is clear that academic learning is not the only contribution to knowledge, because social structures and everyday experiences are equally important for the genesis of knowledge (Barad, 2007: 92). Her theory of diffraction can provide a solution to gender inequality in the engineering sciences, design and marketing and mitigate or eliminate the problems created by the gender script. By re-evaluating ontologies, and the ontology of gender in particular, there is an opportunity to re-evaluate gender altogether. It would be possible to redefine the gender hierarchy and place all genders on an equal footing, offering women, men and all other genders the same possibilities and rights with respect to the use, development, and research of technology. It would also be possible, however, to eliminate the component or category of gender from technological research altogether, and to seek and research only the benefits for human beings as universal beings. The practice of reflexivity is not helpful here, as it would only help to repeat outdated standards of knowledge, which in turn would mean repeating patriarchal patterns and thus halting progress in technoscience. Therefore, diffraction is a suitable tool to provide science in general but also specific fields like engineering, design or marketing with a new definition and orientation of knowledge. In addition, the diffractive methodology offers the possibility of critically confronting and eliminating

existing hierarchies and value communities that are historically based and considered outdated by today's standards and ideas of society. Therefore, through diffraction, a process of opening up technical science can certainly take place. Here, too, it is important to find people who are willing to take responsibility and rebuild the system from the ground up, subjecting it to ethical-ontological-epistemological scrutiny. These conclusions are also made clear by the analysis of Fleur Weibel, a Swiss researcher in the field of gender studies. In her article *Diffraction: A Phenomenon, a Practice, and a Potential of Feminist Critique* (2013),[14] Weibel argues for Karen Barad's concept of diffraction as an alternative scientific methodology. Diffractive methodology is a way of analysing and changing existing power structures based on gender and the performativity of gendered discourses (Weibel, 2013: 108). The analysis of effective connections of 'bodies, affects and technologies should be developed in order to find new possibilities for feminist critique' (Weibel, 2013: 109). Weibel believes that Barad's diffraction, and the theories and concepts presented there, is connected to Judith Butler's theory of recurrent speech acts and performativity. This, she argues, is still highly relevant in gender studies and therefore a good basis for all disciplines associated with gender studies to discover and reform recurring dichotomous patterns (Weibel, 2013: 109ff.). Weibel elaborates:

> In this optical phenomenon [of diffraction, author's note], which as an ambivalent diffraction pattern does not allow clear demarcations, 'the extraordinary liveliness of the world' is manifested, according to Barad, which not least goes beyond human thinking in dichotomous and binary categories. Barad specifies this independent liveliness with the example of the double-slit experiment, in which the quantum-theoretical 'wave-particle duality paradox' is revealed. (Weibel, 2013: 110; Barad, 2007: 83/91)

Her work demonstrates once again the possibility of a feminist analysis in the field of science and technology. In addition to Weibel, Corinna Bath has also studied diffraction. She sees a connection between diffraction and feminist scientific practice. According to her, interacting and interfering with each other is a fundamental part of human inter- and intra-acting. In this way, gender relations and entanglements to other fields of social cultural research are brought to light, and the patterns of action and performativities that emerge there in turn generate boundaries. According to Bath, these can be made visible through a diffractive methodology (Bath et al., 2013: 9ff.). Through diffraction, the system of gender can be questioned. 'Gender as a space of truth' is then consciously problematised and, according to Bath, no longer represents the only truth and norm in the fabric of technical science' (Bath et al., 2013: 17). When gender is seen as an interference, it is no longer a permanent entity, but a 'dynamic of 'referring to' (Bath et al., 2013: 21). Assume Bath and Weibel's remarks show that diffraction, as a new method of analysis and thinking, can redefine engineering.

This assumption is consistent with Bath's previous discussed ideas. Her four problematic spheres of I-methodology, norms, stereotypical assumptions and gendered infrastructure show a diffractive analysis of a critical scientific and industrial practice. By taking them into account and reforming the development process, this implementation can be seen as a diffractive view to improve the act of engineering and designing. Gender as a structuring category can be replaced by other, more universal categories that affect and challenge all people equally on an egalitarian level and from an egalitarian starting point. By implementing this multivisional rethinking, other spheres of daily socio-cultural action (e.g., aspects of care, health and physical needs, etc.) could also be mentioned. Barad's concept of diffraction can thus be seen as a still relevant alternative way of reading and analysing science, with the potential to address grievances and redress inequalities. Individual fields of research do not stand on their own; they also draw on and influence other fields of science, society, and everyday life. In a society and science as multidisciplinary as it is today, we need to take into account different types of action, needs and realities of life. Recurrent patterns of action and performativities that once created and manifested patriarchal structures can now by using diffraction be eliminated and replaced by new patterns of action and performativities that are intertwined and interdependent. In my opinion, the diffractive methodology offers a good alternative to counteract old structures (e.g., patriarchy), but also new structures that may arise in the long run and embody patterns of discrimination, and to make them more controllable and comprehensible for all people, especially in today's fast-moving time, which daily brings about various innovations and changes in society, science, but also in technology. The example of Karen Barad's diffraction has also shown how close the natural sciences and the humanities can be and how they can interact with each other.

CONCLUSION: DIFFRACTION AS AN ADVANTAGE FOR THE FEMINIST TECHNO-IMAGINARY

'The most dangerous phrase in the language is "We've always done it this way."' Dr Grace Brewster Murray Hopper, an American computer scientist, was quoted in a newspaper article in the weekly magazine *Computer World*

[14] Original title in German: *Diffraktion: Ein Phänomen, eine Praktik und ein Potential feministischer Kritik*, see reference list.

(Surden, 1976). Her quote points out what is wrong in science, business, industry, and society under patriarchal leadership. Recurring and unquestioned patterns and the missing of alternative views such as the feminist techno imaginaries often lead to recurring errors. An innovative, responsive and forward-looking rethinking is urgently needed. The reception, acceptance and *raison d'être* of feminist techno imaginaries in academia, society and everyday life is long overdue. This gives diffraction an advantage as a feminist perspective on the practice of science. The possibility of implementing feminist imaginaries and ideas can be strengthened and evoked both in the humanities and in the STEM fields, as well as in business and industry. Karen Barad's vision of a freer and more open science allows for the consideration of previously suppressed, unheard and unrecognised positions of women, but also of marginalised groups (people of colour, LGBTQIA+ people, disabled people, etc.), and thus for their influence and interpretive authority in science. The implementation of feminist techno-imaginaries, as illustrated here by diffraction, can further emphasise the need for such action. It also serves to democratise science by bringing in the positions, voices and ideas of marginalised, unheard or ignored people, theorists, activists and members of academic departments, industry and society who have not been heard or recognised. Concepts such as diffraction could thus be used as a tool that enables the applicability of technologies to everyone, regardless of origin, gender, physicality and other characteristics, thus making technologies universally applicable objects.

In the context of this article, the gender script was presented as a rather avoidable action that harbours great dangers for equal participation in technologies. Nevertheless, there are certain situations, such as medicine or technologies with a direct physiological connection, which make a gender script conditionally necessary. This could include technologies that require explicit situations that allow for a gender script, e.g., medical products or fashion for pregnant women and pregnant people, e.g., trans or non-binary people, but do not rely on stereotypical design choices. It must also allow for the design of a universally, perhaps even personalised, adaptable product that either appeals to everyone, can be applied or modified by them, or can be applied to them individually. In the case of the shaver, this could be a shaver version that is equally usable and physiologically adapted for all genders. It might also be designed in a fashion-neutral way, with colours and shapes that have no gender connotations and, last but not least, offer the possibility of dismantling the device itself in order to repair it, expand it with new developments or simply deconstruct it. This would not only counteract possible patterns of discrimination, but also make the product more sustainable and attractive to more customers. It would also take into account technologies that do not require a gender script and also allow the application of human-centred design through the diffractive perspective for every technology. Using this approach, feminist techno-imaginaries could also increasingly find their way into product design and development. Consideration should also be given to reviewing existing technologies and products that have an explicitly discriminatory gender script or similar discriminatory script or attribute, removing discriminatory attributes and reinterpreting the technology in a comprehensive way using a diffractive approach so that it can be used by all people.

Technologies could thus also become a space of realisation for all genders where this was not possible before. This is the case not only with the research and production spaces themselves, which could be made more heterogeneous through diffraction. It would also open up scientific and development practice itself to become a space of innovation for women, as Barad, Haraway, and Ernst have demanded (Barad, 2007; Ernst, 2013; Ernst and Cojocaru, 2014; Haraway, 2018).

Feminist techno-imaginaries, as has been shown, are no longer constructs that remain hidden in the minds of brilliant women scientists. They are already present and only need to be firmly implemented for performative application in research institutions, colleges, universities, and business and industry. Through political agitation and demands by women, this has already been initiated and is in full swing. It is only a question of time until feminist techno imaginaries become an instrument of everyday life and thus a lived practice in all areas of science, research and development. Only in this way will the desired form of equality, as demanded by progressive women and men, be reflected in the real world of life.

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