Searching for Methodology

Feminist Technology Design in Computer Science

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The objective of this article is to provide methods for technology design that avoid a perpetuation of the existing structural symbolic gender order. Moreover, by aiming for a systematic approach to conceptualizing and building computational artefacts, it seeks to identify a feminist methodology in the field of computer science. The core argument of the contribution is that methods for counteracting problematic gendering mechanisms need to be differentiated. Thus the main part of the article is arranged along an analysis of gendering processes.

Based on a review of existing science and technology studies (STS) research, four mechanisms are described that often lead to gendered computational artefacts: 1) the 'I methodology' that assumes technology to be neutral; 2) the inscription of implicit gender stereotypes and the gendered distribution of labor into computational artefacts; 3) the gendered technological concepts of human bodies and behaviors; and 4) decontextualization and disputable epistemological or ontological assumptions. For each of these mechanisms I will propose technology design methods adopted from the field of critical computing,[1] and outline in which way these methods can avoid problematic

1 | Critical computing refers to a field that can be characterized by the series of decennial conferences called critical computing (see Bertelsen et al., 2005), where researchers and designers from a variety of critical approaches to computing (e.g. participatory design, values in design or the German theory of computer science / 'Theorie der Informatik') meet.

ways of gendering. Finally, the potential and limitations of the methods and the methodology as such are discussed on the basis of feminist theory.

INTRODUCTION

During the last decades the corpus of knowledge about gender *in* technology has been growing continuously. Numerous case studies show in detail how gen der configures and is configured by the design of technology (see for example Archibald et al., 2005; Cockburn, 1986; Cockburn and Ormrod, 1993; MacK enzie and Wajcman, 1999; Oudshoorn and Pinch, 2003; Wajcman, 1991; Zorn et al., 2007). Though several comparative studies aimed at a critical review of the underlying theoretical concepts of gender in the gender technology lit erature, particularly in case studies (e.g. Faulkner, 2000; Gill and Grint, 1995; Wajcman, 2007) that have been conducted, there is still a lack of a thorough overview that focuses on the *processes* of gendering technology. A deeper un derstanding of the mechanisms that are at work when technological artefacts are gendered, however, is a crucial prerequisite for making suggestions for an alternative design that might be called feminist. In order to be able to change the design of artefacts and apply more appropriate design methods, designers of technologies need to know in which sense their artefacts might be problematic.

The gender category and, therefore, the gendering of technological arte facts is, however, a somewhat intricate subject. Some technology designers tend to ignore gender. For example, Anne Jorunne Berg (1999) pointed out that a designer of smart houses thought of the target consumers as 'everyone', while her study revealed that these artefacts were designed for the technically interested male user und not for supporting, for example, housework. Other technical designs such as lady shavers (Van Oost, 2003) or the Volvo concept car (Temm, 2008) explicitly take gender into account. This approach to de sign becomes problematic when gender stereotypes are built into technology, for instance when the design mirrors the assumption that women are techno logically incompetent,[2] while the assumption of gender neutral technology is

2 | For example, Van Oost (2003) shows in her historical study that Philips shavers were not only gendered by design (e.g. pink vs. black or metallic colors), but also by func tionalities. Whereas the Ladyshave can hardly be opened without destroying the device, men's Philishave has screws to open it and a display that conveys technical information to the user. Van Oost concludes that Philips shavers not only reflect the gendering of

particularly disputable, when it is assumed that the artefact addresses 'every one' without explicitly taking notice of gender and other differences. For the latter case it has been shown that gender is often an implicit element of the design process in the sense that certain user groups have to make a greater ef fort than others in order to access the technology or to make the use of artefacts meaningful for them (Oudshoorn et al., 2004).

These two forms of gendering were already well described by the concept of the gender script that distinguishes between explicit and implicit notions (see Van Oost, 2003; Rommes, 2002). Rommes, moreover, specified the mechanism behind implicit gender scripts. She pointed out that designers unconsciously base their design choices on their own preferences, interests, and competencies. Referring to Akrich's early use of the term, artefacts thus often become biased and one sided due to the so called "I methodology" (Akrich, 1995).

So far, the gender script concept and its related gendering mechanisms, stereotyping, and 'I methodology', seem to be a good starting point to un derstanding gendering processes in technology design. However, the existing 'gender in technology' literature provides insights also into other gendering mechanisms that defy explanation by the script concept. One gendered impact of technologies which the script concept can hardly describe are the substantial effects that some computational artefacts such as concepts of humanness in Artificial Intelligence (e.g. Suchman, 2007) or human like artificial characters (e.g. Weber and Bath, 2007) can have on the users' subjectivities. The gen deredness of these artefacts cannot be understood merely as a form of stereo types, i.e. an association of certain qualities and competencies with femininity or masculinity, since they tend to normalize gender and re establish the two sex system itself. Moreover, such effects are not necessarily related to the de signers' visions of use and users that are essential for the definition of the gen der script. By focusing on the designers' *user* representations, gender scripts can neither explain the gendering of human bodies and behavior, nor does it capture modelling methods such as object orientation, classifications schemes or dichotomies underlying technology designs. These artefacts, though, have been proven to have (gender) politics, too (see Bath, 2010; Bowker and Star, 1999; Crutzen and Gerissen, 2000). Hence, looking at computational artefacts, not in the narrow sense of technologies and products, but also including con

technological competence, they also construct and strengthen the prevailing gendering of technological competence. "In other words: Philips not only produces shavers but also genders" (Van Oost, 2003: 206).

cepts and material symbolic entities produced by those who work in com puting, raises the awareness for gender analysis in the field of technology. Extending the framework to gendered technological concepts and assumptions contributes productively to the search for a feminist design methodology, be cause counteracting the related gendering mechanisms might be even more effective and substantial than only avoiding gender scripts.

In the remainder of this paper I will discuss four categories of computation al artefacts (and their related gendering mechanisms) that have been introduced so far: alleged neutral technologies for 'everyone', technologies for the female user, representations of 'the human' in IT and abstract concepts/basic research. This distinction will be explored further in the next section which argues that there is a strong relationship between the categories of artefacts chosen, a cer tain gendering mechanism and a certain strategy of counteracting this gender ing mechanism. In the main part of the paper each of the four categories is discussed in detail: it starts with the gendering mechanism that is likely to occur and gives examples from feminist STS research that illustrate this process. As a next step, a feminist political epistemological strategy is suggested that might avoid such a gendering. Finally, possible technology design methods borrowed from critical computing are introduced that appear suitable to implement the chosen strategy in a concrete design process. Taken together, these four sections aim at a methodological framework that integrates systematic gender analysis based on STS research with technology design into computer science. How ever, such a pragmatic approach can only form a complete methodology if it is reflected upon on the basis of feminist theory and politics. The potential and limitations of the technology design procedure suggested will be evaluated in the last section. The concepts from feminist research that are needed to give the approach a theoretical foundation are introduced in the following section.

De-gendering Computational Artefacts: Theoretical Foundations for Counteracting Gendering Mechanisms

The methodology proposed in this article aims at avoiding the reproduction of the existing structural symbolic gender order and rupturing its further stabili zation by technology design. I call this objective 'de gendering computational artefacts'. This term does not imply that there can be a gender free zone or a gender neutral artefact. Speaking with Judith Butler, entities like bodies

cannot escape ongoing processes of gender signification and resignification (Butler, 1993). Judith Lorber argues that using more than two polarized cat egories of sex, sexuality and gender makes research more accurate. The term '*de* gendering' refers to her political goal of going beyond binaries (Lorber, 2000, 2005). In this context it is rather meant as an attempt to challenge those designers who assume that their artefacts were gender neutral, because it pos tulates that technological artefacts were already beforehand in some ways gen dered. The term is also chosen as a counterpoint to some recent initiatives that intend to 'gender' technological artefacts by considering women's interests or demands in the design and thus producing a new essentialism (see e.g. Bührer and Schraudner, 2006). 'De gendering computational artefacts' is therefore an intervention on several levels. As such it requires a theoretical foundation.

It has already been mentioned that the gender script concept, which is of ten used to capture the concrete processes of gendering technology, is not suf ficient to describe certain gendering processes of computational artefacts. For instance, it cannot be applied to concepts of human behavior or ontological and epistemological assumptions in technology design, because of its focus on user representation. To understand the gendering of artefacts on such a conceptual level, I propose applying Barad's concept of 'posthumanist per formativity' (Barad, 2003). Barad describes posthumanist performativity as a materialist and posthumanist reworking of Judith Butler's notion of perfor mativity (Butler, 1990, 1993). Butler developed this notion within the context of feminist theorizing of the body by stating that sex is a materialization of gender norms that is contested at all times. Barad agrees to the procedural character of gendering and the relevance of existing social norms that change during the process. However, she criticizes that Butler understands matter (i.e. the body) as a passive product of discursive practices rather than conceiving it as an active agent participating in the process of materialization. By contrast, posthumanist performativity, is "a robust account of the materialization of all bodies 'human' and 'non human' and the material discursive practices by which their differential constitutions are marked" (Barad, 2003: 810). On this basis the gendering of artefacts can be conceptualized as a co materialization of matter (or computational artefacts, respectively) and gender. This concept allows for a description of the gendering of software applications, information systems, and user interfaces, but also the gendering of concepts and assump tions in technology design, modelling methods, and basic research.

In her concern to de emphasize the discursive and linguistic aspects within feminism and within STS research, Barad stresses the relevance of "taking

matter seriously" (Barad, 2007: 132). Posthumanist performativity is framed by her "epistem onto logical" theory of "agential realism" (Barad, 1996a, b, 2007) that she developed by drawing on as well as fundamentally criticizing and further developing the actor network theory, particularly the version of the feminist technoscience researcher Donna Haraway. Along this line of thinking, Barad conceives the relationship between humans and non human artefacts as a complex and heterogeneous network or hybrid, without presuming essen tial differences between humans and artefacts. However, she stresses to keep in mind that this relation between human and non humans is always asymmet ric. "Agential realism acknowledges the agency of both subjects and objects without pretending that there is some utopian symmetrical wholesome dia logue, outside of human representation." (Barad, 1996b) This would not mean that authorship lies in the hand of humans only, on the contrary: "the world kicks back" (Barad, 1998: 112). Agential Realism therefore concentrates on "real consequences, interventions, creative possibilities, and responsibilities of interacting with the world" (Barad, 1996a: 8).

Lucy Suchman (2007) translates Barad's account from physics to compu tational artefacts. Against the background of Artificial Intelligence, a field that she studied thoroughly, she also calls for acknowledging the specific agency of humans in processes of mutual configuration of humans and technologies, without reiterating traditional humanist notions of autonomous human agency, which essentialized differences between human and machines. Moreover, she takes Barad's concern a step further by emphasizing this notion of account ability that also includes boundary making between humans and machines. "The accountability involved is not, however, a matter of authorship in any simple sense, but rather a problem of understanding the effects of particular assemblages and assessing distributions, for better and worse, that they per form." (Suchman, 2007: 271) In this instance she refers to Barad: "We are responsible for the world in which we live not because it is an arbitrary choos ing, but because it is sedimented out of particular practices that we have a role in shaping." (Barad, 1998: 102) Suchman argues that an asymmetrically distributed agency between humans and the non human implies understand ing responsibilities as also being asymmetrically distributed. "Agencies and associated responsibilities reside neither in us nor in our artefacts, but in our intra actions. The question, following Barad, is how to configure assemblages in such a way that we can intra act responsibly and generatively with and through them." (Suchman, 2007: 285)

'De gendering computational artefacts' is based on this broad theoretical account opened up by Barad and Suchman. It aims at taking agencies and re sponsibilities in socio material assemblages of humans and artefacts seriously. 'De gendering computational artefacts' is inspired by Suchman's (2007) sug gestion of making 'accountable cuts' as a strategy of analysis and intervention. Choosing four characteristically problematic gendering mechanisms and their related artefacts as a starting point here should be seen as a form of preparation for cutting a concrete network of humans and artefacts in a responsible way. However, every design process requires a thorough analysis of the gender ing at work. The approach that will be proposed in this paper also applies the second strategy that Suchman (2007) suggests: 'expanding the frames'. While she proposes to disenchant the effects by zooming out to a wider view and explicating the hidden labor and contingencies, 'de gendering computational artefacts' aims to move forward from gender analysis towards feminist design. It is argued there that each category of artefacts not only correlates with a certain gendering mechanism, but requires a certain political epistemological positioning towards gender. This means that designers have to decide what kind of change in the structural symbolic gender order they intend to address when aiming to counteract the identified gendering in their designs.

My suggestion for this part is mainly borrowed from feminist theory and politics, which distinguishes strategies such as achieving gender equality, ac knowledging differences or deconstructing gender (see for instance Gill and Grint, 1995; Maass et al., 2007; Wajcman, 2007). While these approaches gen erally conceptualize gender or the gender technology relationship, my idea is to translate such strategies into technology design and its gendering. For instance, feminist theory interprets the gender equality approach (liberalism) as aiming to get more women into computer science and engineering, whereas I suggest analyzing whether artefacts should produce gender equality by de sign. Hence, I propose to determine a goal as a first step of a feminist (design) process. This goal, the envisioned outcome, should be situated and chosen according to the computational artefact in question. Considering the four cat egories of computational artefacts discussed above, there are several options as to what counteracting the gendering of computational artefact can mean: in the case of alleged neutral technologies that ignore certain user perspectives the best counter strategy seems to be that designers acknowledge differences between users. This means that these artefacts call for a gender difference ap proach, in order to provide equal access and meaningfulness. In the second type of technologies intended for women, it can be suggested that artefacts

should support issues assigned to the female realm as much as those tradition ally considered as masculine. This means that these artefacts call for a gender equality approach, in order to overcome gender differences and hierarchies. The third category of artefacts that contribute to identity building or even more changing subjectivities indicates that technology should enable users to question and reflect on the existing binary sex and gender system. Thus, a deconstructionist approach seems to be a good choice here, in order to avoid a further normalization of existing gender patterns. Many gendered concepts of the fourth category require a re contextualisation before critical and interven tionist strategies can be applied. It depends on the context revealed whether the alternate design should rather aim at changes in epistemological or ontological assumptions or both, and if this refers to one of the goals mentioned above.

In the following four sections the four categories of artefacts introduced are described in detail. For each gendering mechanism I will propose technol ogy design methods from the field of critical computing.

ALLEGED NEUTRAL TECHNOLOGY AND THE 'I-METHODOLOGY'

Designers assume many technologies to be neutral, but a closer analysis re veals barriers in use. An example of these kinds of artefacts are early speech recognition systems in Artificial Intelligence that were said to not have been capable of recognizing female voices, since the designers did not think about the fact that adapting the technology to male voices could exclude female us ers. A more serious case study shows that even if designers explicitly aim to build technology 'for everyone', they are still in danger of excluding certain users by design. Els Rommes revealed the development of the Digital City Amsterdam as a design for hegemonic masculine interests (Oudshoorn et al., 2004; Rommes, 2002). She discovered that designers undermined their own agenda 'XS4all' (pronounced 'access for all') by using the 'I methodology' a form of implicit user representation. They unconsciously assumed that users would have the same technical equipment, knowledge and skills, the same preferences and interests, and thus, see themselves as representatives of the us ers. Since they often form a homosocial, predominantly masculine group, they actually inscribe this gendered background and knowledge, their concerns and attitudes into the technology.

The example of the early speech recognition systems refers to a (more or less) biological gender difference. It is argued that these artefacts could not be used by women, because of their higher pitched voice. Rommes, in contrast, draws on socio economic factors to demonstrate that the Digital City Amsterdam was gendered. Designers did not question essential, but gendered prerequisites, such as access to the latest generation of computers, a certain experience in the use of the Internet and the trial and error strategy. As Anne Jorunne Berg pointed out, such a structural exclusion of women and other 'others' from the use of certain technologies can already occur on the level of problem definitions that underlie technological solutions (Berg, 1999). Her study of smart houses illustrates that the designers were not aware of house work that is traditionally assigned to the female realm. The interviews revealed that they implicitly assume the customer to be a man interested in technology, not unlike the stereotype of the computer nerd.

All these examples illustrate the need for technology design method ologies that take into account a variety of users. Hence, the objective when facing alleged neutral technologies should be the inclusion of diverse users, equal access, and usability. The methodologies sought after should strive for the acknowledgement of differences, for example, physical and social gender differences, but also in terms of ethnicity, race, nation, class, age, and other categories.

Several subfields of computer science already have a long tradition of de veloping methods of technology design that aim to avoid the 'I methodology'. Ergonomics, socio technical systems design, and human computer interaction focus on getting to know the user, in order to build technologies for use and the real user instead of expecting that users will adapt to already existing tech nology (see for instance Dix et al., 1993; Nielsen, 1994). In the cases of the Digital City Amsterdam and the smart houses, designers could have conducted usability tests to realize that their products do not match the skills, interests, and preferences of the technology's envisioned target group (Oudshoorn et al., 2004). According to the field of human computer interaction, however, an alternative design should start with a thorough requirements analysis of the intended users not in the sense of allowing them only to test prototypes and end products, but involving them from the very start of the design process, which should to be understood as an evolutionary or cyclic user centred design (see for example Beyer and Holtzblatt, 1998; Preece et al., 2007). Although it has to be discussed which representatives of the users should be chosen, if the technology is meant to be used by everyone; particularly involving a diversity

of female users in the design process seems to be a way of preventing technologists from repeating the mistakes of the 'I methodology'.

TECHNOLOGIES FOR 'THE FEMALE USER', STEREOTYPES AND THE GENDERED DIVISION OF LABOR

A second class of technologies contains those which are built for specific users, e.g. women as customers, or to support women in their workplaces, but which in effect codify gender difference and reinforce the traditional gender hierarchy. Examples of this kind are the round dialogue box for font selection designed by the graphic designer Aaron Marcus for white American women, which is built upon the assumption that females would prefer curvilinear shapes (Marcus, 1993), or the early word processing software Jeanette Hofmann analyzed, which assumed secretaries to be permanent beginners and by design defined them as technically unskilled users (Hofmann, 1999). Other case studies, for instance in the fields of nursing and call centre service work, show the lack of knowledge on 'invisible work', since these software systems were modelled in a way that fails to adequately support the workflows by technological means (for example Maass and Rommes, 2007; Wagner, 1993). Since 'invisible work' is often done by women (Star, 1991), it is particularly their work that remains undervalued, since designers either ignore its importance for the organization as a whole or its complexity.

Design for women obviously risks celebrating stereotypes about 'women', their preferences, skills and work, which should be avoided. A de gendering methodology, therefore, has to aim at attributing equal competencies to female and male users and upgrading women's work. Hence, designers should strive to inscribe gender equality into technologies, if they are designed for female users, for instance at women's workplaces as opposed to the case of technologies for general use, where they should become aware of gender differences and the diversity of users. As already mentioned, in the latter category of technologies user tests seem to be a useful tool for recognizing that software and user interfaces do not fit the intended real user. In the example of the round dialog box it was demonstrated that, regardless of the gender, all test persons preferred a squared and axially symmetrical layout of the dialog box and strongly disliked the 'female' user interface (Teasley et al., 1994). Thus,

the gender stereotype that women like curvilinear features, while men prefer squared ones, was clearly disproven.

However, if we want to move from analysis to an alternative design for the cases mentioned above, it is not enough to remain at the level of aiming to map social realities of work, life, and use as best as possible as it is often assumed in computer science modelling, since such approaches tend to re produce the existing structural symbolic gender order. Hence, if technologies need to be designed for a predominantly female group of users it takes more than only applying user centred design methods and evaluating usability. For a de gendered design of such technologies, an explicit political positioning for those who are structurally discriminated against seems necessary. The most well known research to support workplace democracy and establish better working conditions for workers and employees through the use of technology is the Scandinavian tradition of participatory design (e.g. Bjerknes and Brat teteig, 1995). Following this approach, a variety of methods were developed and tested such as future workshops, design games, and prototypes (see for instance Greenbaum and Kyng, 1991). The aims and guidelines to 'design for skill' and 'design for technical empowerment' were already successfully applied in women's workplaces such as nursing, office work or call centre service work (see Maass and Rommes, 2007; Wagner, 1993). Since strategies against deskilling, degrading or learning to adapt and to program software in certain contexts work against the traditional gender hierarchy, these partici patory design approaches can be regarded as de gendering methodologies, if they are enhanced by a critical awareness of the gendered patterns in society and symbolism.

Representation of 'The Human' in IT and the Perpetuation of Gender Norms

A third category of gendered technological artefacts include those that rep resent certain abilities, characteristics or even the nature of 'the human', but actually normalize gender stereotypical behavior. Persuasive examples are human like machines that explicitly display human bodies and human behav ior such as anthropomorphic sociable robots or emotional software agents. The bodily appearance of these artefacts, but also their concepts of action/behavior and interaction/communication were exposed as intrinsically permeated by gender stereotypes (e.g. Draude, 2005; Weber and Bath, 2007).

Against a further consolidation of these genderings, a de gendering meth odology should aim to de construct the binary sex and gender system. This might be accomplished by artefacts that offer users and designers the possibility to gain an understanding of gender (and technology) as social constructions and instable, constantly performed and negotiated categories. A design philosophy that "allows users to engender themselves, to attribute to themselves a gen dered identity of any one of a number of sorts, to create or perform themselves through using technology" (Cassell, 2003: 204) is 'underdetermined design'. While Cassell's ideas were primarily directed at encouraging gender identity formation in computer games for children that transcend gender stereotypes, "technology as experience" (McCarthy and Wright, 2004) is an experimental account addressing 'felt life'. Rooted in phenomenology, this theoretical ap proach serves as a basis for some broader design methodologies. 'Design for experience' (Sengers, 2004; Sengers et al., 2004), as opposed to designing ex perience into an artefact, focuses not only on the subjective experiences (e.g. sensual, emotional, compositional, spatio temporal) of the users, but also opens up space for potentiality and meaningfulness, i.e. a plurality of processes that construct meaning and which should not be closed or specified by design. 'Re flective Design' goes one step further in stating that "reflection should be a core design outcome of HCI[3]" (Sengers et al., 2005: 49). Reflection, in this case, is to be understood as critical reflection that renders users aware of unconscious aspects of experience. The methodology consists of principles and strategies which combine the analysis of the ways technology reflects and perpetuates un conscious cultural assumptions (such as the politics of race, gender, and econ omy) with the design, building, and evaluation of computational artefacts that reflect alternative possibilities. It aims at providing support for self reflection. To my mind, this approach could be productively used to raise an awareness of gender stereotypes internalized by users, designers, and artefacts.

Formalisms, Abstract Concepts, and Basic Research: De-contextualization and Objectivism

A fourth category of computational artefacts includes algorithms, formal ob jects, and conceptual approaches in computer science that can be said to have

3 | HCI stands for Human Computer Interaction.

gender politics. Abstraction, formalization, and classification produce the im pression of objectivity and a neutral research subject. Here, it seems problem atic that these processes inevitably entangled with computer scientists' work disguise explicit and implicit decisions made in the process of technology de sign, while they in effect establish hierarchies of knowledge, gendered clas sifications or dichotomies. Striking examples of this kind of gendering mecha nism are the mathematical tools used to transform raw data from a computer tomograph into colored pictures of the brain. It has been shown (Kaiser et al., 2004) that depending on the algorithm and threshold chosen gender dif ferences of the brain appear or do not appear. Thus, formalization is not innocent. A field where this has also been demonstrated is the representation of knowledge. For instance, CYC, a knowledge based system, which received a huge amount of research funding over 10 years during the 1980s in the US, aimed to codify common sense knowledge. However, only declarative knowl edge has been taken into account, whereas procedural knowledge has been ignored. Alison Adam and Catherine Sherron complain that the knowledge, which is excluded from formal representation, corresponds with the knowl edge that is traditionally assigned to the female realm (Adam, 1998; Sher ron, 2000). Moreover, CYC assumes a universal subject of knowledge. Con trary to feminist insights into the situatedness of all knowledge (e.g Haraway, 1988), it is taken for granted that all knowers share the same reality, "be they a professor, waitress, a six year old child, or even a lawyer" (Lenat and Guha, 1990, according to Adam, 1998: 85). Recent formalization projects such as the Semantic Web or Linked Open Data encounter similar problems (see Bath, 2013). Another exemplification of the category of formalisms, abstract con cepts, and basic research are dichotomies that underlie computational concepts that might be symbolically gendered such as the dualisms of mind and body or rationality and emotionality. Attempts to overcome these dichotomies, e.g. in artificial intelligence, often consolidate a new, but also deeply gendered symbolic order (see for instance Bath, 2010).

A de gendering strategy for these formal objects presupposes a re con textualization in use and in structural as well as cultural effects. It requires questioning assumptions, ontologies and epistemologies of technology design, and a dissolution of dichotomies. Since such gendering processes do not nec essarily refer to users and use, alternative technology design methods should mainly involve designers.

'Mind Scripting' (Allhutter, 2012) is an approach to identify presumptions and gender scripts in the process of designing technology. The technique is

based on Frigga Haug's "memory work" that uses one page long texts writ ten by group members to deconstruct shared experiences and assumptions re flecting societal structures (Haug, 1999). "Mind Scripting" transfers this idea, which originated in the consciousness raising groups of the 1970s, to present groups of technology designers (Allhutter, 2012). "Value Sensitive Design" (Friedman and Kahn, 2003) is a method that aims to inscribe certain desired values such as equity, diversity, and inclusion into technological artefacts. It contains three levels of inquiry: empirical, technological and, most notably, conceptual studies that are based on moral philosophy and ethics. However, the method was already applied to computer game design by feminist schol ars (e.g. Flanagan et al., 2007). Particularly in order to undermine or resolve dichotomies that are gendered in western traditional thought and connected to technology design, "Critical Technical Practice" (Agre, 1997) can be a helpful tool. This method suggests analyzing designers' discourses, in order to iden tify key metaphors and then to invert these terms. It results in bringing in the margin to the center of technology design. For instance, Agre and Chap man (1987) developed a system, in which the model of abstract cognition that was dominant in Artificial Intelligence during the 1980s was replaced by a situated action approach that implemented Suchmans' theoretical account. An other technique to question and change concepts of basic research in computer science are interventionist laboratory studies. As a form of anthropological inquiry commonly used in science and technology studies (STS) laboratory studies are interventionist as such. However, applied to the context of basic research in computer science, this method can be explicitly guided by feminist goals in design such as the ontological and epistemological 'de gendering of computational artefacts'. This has been explored by own research in the field of anthropomorphic software agents (see for example Weber and Bath, 2007). Hence, there are already a few techniques that seem promising to use, in order to re contextualize formal objects and replace questionable ontological and epistemological assumptions in basic research in computer science.

Critical and Feminist Re-reading of the Methodological Framework

The approach that has been roughly presented in the last sections aims at a basic methodological framework for feminist technology design in computer science. It provides a broad spectrum of methods helpful for 'de gendering

computational artefacts'. The suggestions are based on a thorough and system atic analysis of gendering processes. It can, however, only become a method ology, if it is critically re read from the feminist theory perspective introduced at the beginning and evaluated in practice. This section discusses theoretical traps and possible empirical improvements of the four strands.

When technologies are created 'for everyone', designers often inscribe their own mental models into the technology. To avoid a gendering of the arte facts resulting from such an 'I methodology' it was proposed to apply methods from user centered design. Such a de gendering strategy is based on a gender equality argument and aims at the inclusion of users. Therefore, this strategy tends to essentialize alleged differences between women and men. In order to accomplish that, diversity and particularly gender differences have to be recognized. Involving diverse users and considering intersectional exclusions might support avoiding such traps. A second argument that needs to be taken into account when applying user centered design for de gendering purposes to this type of artefacts is that the method only has the potential to adjust the technology to users by empirical means. If the users involved, however, per form and perceive gender in a very traditional way, for instance, strictly binary or stereotyped, this method cannot bring critical, deconstructive impulses to technology design. Therefore, the participation of different users might extend design perspectives for products that better meet the expectations of certain users. However, these methods do not necessarily bring a gender critical ap proach to design.

Inscribing gendered images of use, users, and the division of labor into computational artefacts was identified as a second gendering mechanism that often occurs in the design of technologies intended for female users. To coun teract stereotypes and gendered hierarchical patterns in such processes, partic ipatory design methods were suggested. Especially approaches from the Scan dinavian tradition appear to be appropriate here, since they challenge existing societal structures of inequality and, thus, avoid reproducing the structural gender order by technological means. However, these approaches sometimes imply a rather simplistic view in how far emancipatory ideals can be built into technology. STS and media studies views can help to correct such narrow interpretations. It can moreover be put forward that applying these techniques often means to aim at making visible and revaluing women's work and com petencies. From a feminist perspective this means that the strategy tends to re essentialize gender. It is also problematic, since it aims to make aspects of work visible that should rather be hidden from a political perspective (see for

example Bowker and Star, 1999). Thus, the participatory design approach, too, needs a second reflection when adapted for de gendering purposes.

The third de gendering strategy addressed representations of 'the human' in IT, which tend to normalize gender stereotypes. In order to deconstruct not only such gendered assumptions inscribed into the artefacts, but also the un derlying binary sex and gender system, it was proposed to combine 'reflective design' and 'design for experience' with insights of current gender studies. Both of these design approaches are based on a constructivist epistemology. They furthermore combine technology design with critical social theory. These methods can therefore easily be connected with current feminist theory and deconstructivist approaches. However, they have so far not been applied as de gendering strategies. Beyond that, it is an open question whether 'reflec tive design' and 'design for experience' can be applied to a broader scope of technologies. Since the first two types of artefacts discussed in this paper tend to essentialize gender, deconstructivist approaches might also be promising methods to avoid the gendering of such technologies. It has to be explored whether there are more suitable techniques to deconstruct the binary sex and gender system by technology design in these cases.

The methods proposed to avoid the gendering of formal objects and ba sic research in computer science need further empirical evaluation. Most of these methods require either a practical implementation to explore, whether they can serve as a de gendering strategy, or whether they were originally de veloped for guiding software development and not for revealing problematic presumptions in technological concepts. It is the question whether they can be transferred to formalisms, abstract concepts, and basic research, and what they can contribute to re contextualising artefacts, counteracting disputable epistemological and ontological assumptions in the design process or resolv ing traditional dichotomies in basic technological concepts. Particularly in this area there is need for further research on de gendering methods.

In summary, this paper introduced a systematic approach to feminist technol ogy design. It presented a starting point for a general methodology to coun teract the gendering of computational artefacts that goes far beyond existing suggestions, which so far have been either restricted to software applications or to problematic guidelines. The proposed de gendering approach takes into account the complex gendering processes, which might occur in the field of computional artefact design. It clarifies for what cases well known design methods from the field of critical computing such as participatory design are

likely to support de gendering processes. 'De gendering computational arte facts' furthermore suggests design methods for those artefacts that have rarely been addressed, in order to avoid gendering by earlier methods. In critically reconnecting this approach with feminist theory we should be cautious not use it as a simple recipe. It has been argued that analyzing the gendering and aim ing at a 'de gendering of computational artefacts' needs a careful theoretical background, in order to avoid well known shortcomings such as essentializing gender or technology or falling into the trap of technological determinism.

Nevertheless, it requires further discussion whether the artefacts that have been developed according to the proposed methodology can, in the end, be 'better' or 'less gendered' than those developed outside of this framework. Why does design and particularly design for de gendering matter? Numerous STS case studies have stressed that designers' intentions do not necessarily re sult in a use that was intended. Users rather adopt technologies in their own way be it along designers' concepts and scripts or against them (see for instance Oudshoorn and Pinch, 2003). I would counter that these insights have already been included in the methodological framework theoretically, but also by the procedure: the concept of posthumanist performativity takes into consid eration that gender signification and re signification is complex, situated, and historically continuously changing. The actual gendering processes are neither predictable, nor controllable for the future use of an artefact. Gender is as fluid and unstable as artefacts are. However, design is not arbitrary. On the con trary, it has as Suchman (2007) and Barad (1996a, b, 1998) emphasize 'real consequences' (see also Van der Velden and Mörtberg, 2012). On this basis, 'de gendering computational artefacts' calls for a responsible handling of the design situation, where the use of the artefacts created is not foreseeable. Since the future use cannot be empirically researched, it takes into account those gen dering mechanisms that have already been identified in earlier STS studies and aims to avoid them in future designs. However, practically speaking, the ap proach proposed needs empirical examination. This evaluation might result in further refinement and enhancement of the methodology. Hence, the challenge is now to work with the methodological framework of 'de gendering computa tional artefacts' in order to gain more experience with it.

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