Diffraction Patterns?

Shifting Gender Norms in Biology and Technology*

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> "Not surprisingly, what is at stake in this dynamic conception of matter is an unsettling of nature's presumed fixity and hence an opening up of the possibilities for change."
> (Barad, 2007: 64)

Since the late twentieth century, feminist analysis of science and technology has been criticizing not only the absence of women as epistemic subjects and objects, but also their rather problematic presence as a stereotyped and devalued other. Studies show how prevalent gender norms impede people to develop technologies accessible to and profitable for all (Lerman et al., 2003; Sørensen et al., 2011). Studies also show how people find new ways to negotiate their gender identities within the materialized cultural space of normative assumptions about women and men (Kafai et al., 2008; Varma, 2007); and how people express gender in information and communication technologies beyond so-called natural or culturally desirable ways (Landström, 2007b; Wakeford, 2002). Therefore, feminist analysis of science and technology is in need of finding, first, innovative epistemic ways to empower those who are dis-empowered by gender hierarchies, racism, classism, homophobia, and other ideological conditions that classify persons in structural hierarchies. Second, feminist analysis can investigate the epistemic ground on which persons counteract those structural hierarchies. Third, I will argue that epistemological

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reasoning within feminist science and technology studies has to clarify the methodological and conceptual question of how to investigate gender in the life sciences and material sciences as well as in information- and communication technologies (ICT).

Feminist theories strive to understand how gender works. How does gender function as a social institution (Lorber, 2000) and as interactive iterative performativity (Butler, 1993)? How do narratives of identity acquisition interfere with a normative apparatus of gender (Kilian, 2004)? How do these narratives relate to gendered power relations (Castro Varela et al., 2011)? Finally, I will further elaborate the question of how can we practice gender studies within science and technology studies (STS) without reinforcing the binary of femininity and masculinity as the basis for gender hierarchies (Landström, 2007a). More precisely, I will explore what happens if we investigate gender, including sex and sexuality as diffraction patterns rather than as differences.

The chapter aims to contribute to a way of studying gender in technological processes and productions informed by a theory of gender that does not presuppose gender as a given binary or dichotomy. Drawing on the insights of Judith Butler's approach on performativity of gender (1993) and gender as an apparatus (2004), it will examine epistemic values for the discussion of gendered entanglements of scientific knowledge production. I will investigate whether – and if so, how – Butler's understanding of gender as an apparatus can be methodologically useful for feminist science and technology studies. A further point of discussion will be whether – and if so, how – Karen Barad's (2007) agential realist understanding of the apparatus as an epistemological concept can be applicable for gender studies beyond STS. With her understanding of matter as a dynamic intra-active becoming, Barad starts from the entanglement of matter and meaning to investigate innovative research methods for constructive interdisciplinary engagements between technosciences and humanities.

The paper will also debate the question whether this research perspective can be put to use for engineering design practices, as Lucy Suchman (2007) suggests. According to Suchman, the human-machine-interface is a dynamic process of materialization, in which meanings can change. This means that although newly developed technological objects need to be recognized in their envisioned cultural environment, they always carry the possibility of leading beyond the replication of established norms. From this follows that gendered subjects and objects can experience, in interaction, new practices and new meanings of themselves and the other, including their gendered meaning. In the area of biology, Anne Fausto-Sterling suggests an integrative, interdisci-

plinary and holistic model for the study of human sex, gender, and sexuality. This model includes questions about the cell, the organism, the psyche, person-to-person relationships, culture, and history on a larger scale (Fausto-Sterling, 2000). I will discuss whether her account on dynamic biocultural systems of reciprocally related processes can be put to use for the discussion of material and social aspects of gender, sex, and sexuality. In bringing these perspectives together, the paper claims that through the effort to counteract, to fit in or to perform along the norms produced by knowledge and ignorance of gender, sex, and sexuality, we all contribute to what counts as knowledge at any given moment. The paper argues for a relational epistemological framework and shows that not only our apparatuses and concepts shape the results, but that all involved "subjects, objects, humans and non-humans or inappropriate/d others" (Haraway, 1997) depend on each other, and thus mutually shape the understanding of each other and the world.

What is Diffraction? What is an Apparatus? What is Matter?

Diffraction is understood by Karen Barad in more than one way. The most important difference Barad makes is the one between diffraction and reflection. Reflection is problematized by Barad as an optical metaphor in representationalism, a widespread epistemological account in the philosophy of science. For Barad as well as for Haraway (1997), from whom Barad takes up the idea of diffraction as a useful concept for feminist epistemology, it is important to overcome reflection as an epistemological model as well as a means to understand difference – and thus as an ethical model – because it seems grounded in dichotomous thinking. In classical physics, diffraction points to an interesting picture:

> "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)

This means that diffraction can be an outcome of an experimental setting in the laboratory as well as a natural phenomenon: "The ocean waves are thus

diffracted as they pass through the barrier; the barrier serves as a diffraction apparatus for ocean waves." (Barad, 2007: 74) – Later, Barad uses the example of two stones dropped into a calm pond simultaneously to illustrate the meaning of interference or diffraction pattern: "The waves are said to interfere with each other, and the pattern created is called an interference or diffraction pattern." (Barad, 2007: 77)

A shift in gender studies from a framework of reflection to a framework of diffraction could be interesting for the following reasons. Understanding gender in the framework of reflection seems problematic, because it supports a binary system of thought which envisages the Other as an opposite in front of the self, in a dichotomous model which excludes similarities. In the case of gender, the Other has often been schematized as the one of 'the opposite sex'. To think of gender in opposites, in turn, suggests to think of gender in dichotomous binaries as either women or men. Yet, this idea has proved insufficient to 'reflect' empirical reality, in terms of material bodies as well as in terms of a culturally or socially lived and represented reality. But more than this, to envision gender as an exclusive binary construction reinforces the idea that what is feminine cannot be masculine and vice versa, a powerful thought that has resulted in gender-segregated fields of work and pleasure and a devaluation of those fields associated with femininity (Hausen, 2012). Therefore, overcoming the framework of reflection seems to be a promising way to promote conceptual shifts in gender studies. These conceptual shifts might suggest investigating gender, sex, and sexuality along with concepts of similarity and plurality instead of bipolarity and dichotomies.

Following Judith Butler, Barad stresses the intra-active performativity of matter concerning gender, sex, and sexuality. She elaborates on Butler's famous statement that gender is not the cultural interpretation of sex but "the very apparatus of production whereby the sexes themselves are established" (Barad, 2007: 61). In the following, I will take a closer look at the connection between Judith Butler and Karen Barad and first elaborate on Butler's account on gender as a performative norm and an apparatus.

Judith Butler has argued that sex is always already gender, just because we cannot relate to our bodies and other bodies without the cultural framework or mindset we live in. In her book *Bodies that matter* (1993) she stressed that this does not mean to say that there are no bodies or that bodies are not relevant. On the contrary, as the programmatic title of her book suggests, living is a bodily matter in an important way for Butler. I conclude from this that the way how we are told about or able to relate to our materiality or to the materiality of oth-

ers is a highly contested field, precisely because it is so relevant for existence. In her book *Undoing Gender* (2004) Butler elaborates her theory of performativity of gender and relates gender as a norm closely to its bodily enactment:

> "In fact, the norm only persists as a norm to the extent that it is acted out in social practice and reidealized and reinstituted in and through the daily social rituals of bodily life. […] [I]t is itself (re)produced through its embodiment, through the acts that strive to approximate it, through the idealizations reproduced in and by those acts." (Butler, 2004: 48)

This means that, according to Butler, gender is neither something one has or is, but rather a normative regulation to which persons shape or reshape their bodies – not necessarily along established binary-gendered norms but in relation to them. From this follows that to understand how sex is related to gender one has to understand not only how the so-called social is related to the so-called natural or how culture is related to matter or the body, but also how femininities and masculinities are produced through these relations.

To understand the contingency of this binary and its applications in feminist studies of science and technology, I will subsequently discuss Butler's concept of the apparatus of gender in more detail. In the chapter *'Gender Regulations'*, she uses the concept of apparatus to describe the production and normalization processes in which different concepts delineate more or less bodily, psychic or social aspects of human personalities: "Gender is the apparatus by which the production and normalization of masculine and feminine take place along with the interstitial forms of hormonal, chromosomal, psychic, and performative that gender assumes." (Butler, 2004: 42) Here, her concept of apparatus clearly encompasses much more than a 'lens' or 'construction'. It points to a complex and multifaceted interaction between social norms and material-semiotic states of humans as diverse as hormonal levels, chromosomal activations, psychic interferences – or diffractions in the performative display in which gender is produced and enforced. On the other hand, she points out that gender exceeds its definition as a normative binary of femininity and masculinity:

> "Gender is the mechanism by which notions of masculine and feminine are produced and naturalized, but gender might very well be the apparatus by which such terms are deconstructed and denaturalized. Indeed, it may be that the very apparatus that seeks to install the norm also works

> to undermine that very installation, that the installation is, as it were, definitionally incomplete." (Butler, 2004: 42)

She suggests conducting research on gender that studies existing transgendered subjects and phenomena such as gender blending as ways of living beyond the naturalized binary (see also Halberstam, 2011). If we understand the more overtly existing transgendered subjects and phenomena such as gender blending or gender bending as shifts in the performative display of gender, will it be possible to develop research questions that relate these shifts to historical and current shifts of gender norms in biology and technology? Can these performative material-semiotic shifts be understood as diffraction patterns in Karen Barad's sense? And, if yes, in which sense can gender be understood as the very apparatus which produces these (and other) diffraction patterns?

In her book *Meeting the universe halfway* (2007), Barad elaborates on various manifestations of matter on the conceptual level, as if her conceptual approach itself figures as a barrier or a breakwater in the ocean or as the slits in a screen of a two-slit-experiment. The way she discusses material aspects of human bodies, of brittlestar species and of single atoms being object (or subject?!) of nanotechnological transition (manipulation) evokes quite special diffraction patterns in itself. As a quantum physicist, she plays with the ambivalence of wave and particle on the most fundamental level of light and atom. She employs this ambivalence as if one could discuss it in a similar way when it comes to living organisms.

Barad gives an interesting example for this approach. In connection with the description of various ways of mating, reproducing or multiplying, Barad introduces the brittlestar. The brittlestar, living in a deep and dark ocean environment, is a nice 'example of nature' of queerness beyond human ways of living. It was not for its queerness though that the brittlestar became famous. It was in projects of biomimesis, Barad explains, where its technique of seeing attracted the attention of research. The author thinks that there is more to the brittlestar: She asks crucial questions about bonding, belonging, and boundaries of material organic bodies. Interestingly, when it comes to the brittlestar the relatedness of a (singled out) body to the 'environment' surrounding it becomes blurred:

> "The brittlestar species exhibit great diversity in sexual behavior and reproduction: some species use broadcast spawning, others exhibit sexual dimorphism, some are hermaphroditic and self-fertilize, and some

> reproduce asexually by regenerating or cloning themselves out of the fragmented body parts. When is a broken-off limb only a piece of the environment, and when is it an offspring?" (Barad, 2007: 377)

She asks even more to the point: "Is contiguity of body parts required in the specification of a single organism? Can we trust visual delineations to define bodily boundaries? Can we trust our eyes?" Barad concludes: "Connectivity does not require physical contiguity." The crucial question seems to concern the relatedness in connection with the generation of organisms: "Is the connection between an 'offspring' regenerated from a fragmented body part and the parent brittlestar the same as its connection to a dead limb or the rest of the environment?" (Barad, 2007: 377) With the brittlestar, Barad does not only give a telling example of variations on the multifaceted ways sex, gender, and sexuality is organized in natural environments, but also provides fundamental insights to the various research apparatuses turning to it. It is also the most convincing example for Barad's claim for the intra-active becoming of matter within the world, which indeed goes beyond Judith Butler's focus on human interaction in the world. Moreover, her discussion of the brittlestar exceeds an understanding of organisms which presupposes solid boundaries. Barad thereby enlarges our concept of the organism in an interesting way from an entity with clear boundaries to something related to the environment within much less distinct limits. Here, Barad's description delineates an apparatus of research as an intra-active scenario of discerning and understanding empirical findings 'in nature'. It creates a shift in the understanding of matter within living organisms. It shows a diffraction pattern not only concerning the object of research but also concerning the epistemological frame which consists of, and constitutes at the same time, the epistemic subject.

Karen Barad suggests her approach of 'agential realism' as a new feminist epistemology to understand matter, including the gendered body, as a dynamic intra-active becoming. With this account she claims to go beyond Judith Butler's approach of performativity of gender, because she also includes non-human organisms and non-organic matter in these intra-active processes of becoming. Moreover, Barad questions the clear-cut boundaries between organic matter and non-organic matter, as well as those between the organism and the 'environment'. With this understanding of humans as just one curious organic entity between an indefinite number of others, she opens our eyes for a big variety of natural systems of reproduction as well as interactive or intra-active relationality and attachment. In this way, the current binary gender system,

which still seems rigorously binding for humans, might become contested in its exemplary function for nature as a whole.

I am not sure whether Butler and Barad use the concept of the apparatus with the same intention. Nevertheless, reading the two authors together is helpful for two reasons: one, for making Butler's understanding of gender as an apparatus methodologically useful for feminist science and technology studies, and secondly, for making Barad's agential realist version of the apparatus applicable as an epistemological concept for gender studies beyond STS. I think Butler introduces the term 'apparatus' to point to the fact that a specific or current normative understanding of gender is more material than the term 'framework' or 'interpretation' would suggest: "If gender is a norm, it is a form of social power that produces the intelligible field of subjects, and an apparatus by which the gender binary is instituted." (Butler, 2004: 48) The term 'apparatus' seems helpful for understanding the imperative character of gender as a valid social mechanism. At the same time, it helps to imagine the possibility to change certain aspects – parts or tools – of this mechanism, or even exchanging it as a whole. Since an apparatus is a complex instrument which is built and installed to achieve a certain goal, the term may help to understand the historical contingency of a certain gender regime. On top of that, an apparatus, if understood in its functioning as a technological device, might be transformed by subjects in ways which are not intended by other subjects in the first place. In other words, if we understand gender as an apparatus by which subjects are produced as incorporating a certain femininity or masculinity in present time in dominant cultures, those who do not fit in might be comprehensible as subjects who not only point to the limits of the apparatus at work and the need to change it. On top of that, they already represent subjects and objects of diffraction patterns of gender.

Butler and Barad both seem to understand an apparatus as provoking a certain set of material-semiotic practices. However, Butler's focus is on the constitution of gendered subjects through performative iteration, while Barad focuses on the constitution of (gendered) research objects and phenomena through intra-active becoming: "Apparatuses are dynamically made and remade through different kinds of boundary-making practices." (Barad, 2007: 449) Here it is important to note that in both accounts the clear-cut differentiation between subject and object is contested. Since the establishment of phenomena through research apparatuses is understood as material-discursive practices, an empiricist understanding of empirical research, also of experimental empirical research, seems impossible. For Barad, the research question is already part of

the phenomenon produced in the epistemic process as the apparatus is installed. Her understanding of matter is not limited to the empirical data which are collected or measured within a certain established apparatus, nor to the interpretation of these data. Maybe in a comparable way, Butler's account shows gender as performed by human subjects within, but not consistent with, the existing binary apparatus of gender. Precisely because the performance (necessarily) fails to conform to the established idealized binary code, the apparatus of gender is, as Butler points out, an elaborated institution and reveals its naturalizing and normalizing function. In a similar way, material phenomena intra-acting within the epistemic process in Barad's account are never fully calculable in advance by the apparatus of research. The uncertainty relation, brought forward by quantum physics, leads beyond the calculable predictability of material processes in experimental as well as in natural circumstances (as held, for instance, by classical mechanics). In both Butler's and Barad's accounts, it seems that a better understanding of the world is achieved precisely through the transgression of the envisioned or installed order of things (see also De Lauretis, 1990).

But does this lead to a *new feminist materialism* – as a new paradigm for gender studies? Since the material conditions in Karen Barad's account clearly exceed empiricist as well as marxist accounts, I consider the term *material feminism* more suitable (see also Alaimo and Hekman, 2008). For the following reasons: By understanding the materiality of human bodies and non-human nature as informed by the feminist constructivist idea of performativity rather than as an essential authority of authenticity, this materiality can be acknowledged as an active aspect in the production of knowledge without essentializing it. Barad gives the example of shop floor machinery in order to illustrate the productive role of materiality in different forms: "The material conditions of the shop floor performatively produce relations of class and other forms of cultural identity in the intra-action of humans and machines." (Barad, 2007: 227) A little later, she relates the term of the apparatus to this material-discoursive practice: "Importantly, apparatuses are not external forces that operate on bodies from the outside; rather, apparatuses are material-discoursive practices that are inextricable from the bodies that are produced and through which power works its productive effects." (Barad, 2007: 230) Therefore, Karen Barad's insights seem to point more to the notion that diffraction patterns help to understand the overlaps and shifts in an attempt to make sense of the world, not only concerning the constantly shifting materializations and discourses of gender norms, but also concerning the production of knowledge in general. Barad suggests that with the diffraction patterns of waves produced

by the two-slit-experiment, quantum physics provided a promising framework of understanding scientific knowledge production. She also holds that with the capability to locate and at the same time shift a single atom of a certain material or texture with the help of the technological device called 'scanning tunneling microscope' (stm) the 'second quantum-physical revolution' took place – as the basis for nanotechnology and biomimesis. In her account, these new technoscientific apparatuses of nanotechnology and biomimesis need to be investigated within a broader socio-political and natural 'environment', as they create through material-semiotic practices new – maybe precarious – relations between humans, other organisms, and non-organic matter. Therefore, on the epistemological level, Barad goes beyond Bohr's account in that she shifts the framework of relativity of knowledge production in quantum physics to a framework of relationality. With this move she connects the 'second quantum revolution' to feminist epistemology. If we understand the production of knowledge as the establishment of an apparatus of research, we might be able to analyze this very apparatus in order to deconstruct or shift the normativity of (gender) patterns it might produce. When doing so it seems important to reflect the limited access to knowledge of the world provided through even the newest epistemological and technological devices (see Jasanoff, 2006). Barad's account of 'agential realism' transcends the idea, still held by many scholars in technosciences, of processes, materials, and phenomena as segregated or isolatable in the research process. It enables the notion that processes, materials, and phenomena are linked in a complex and never fully apprehensible relationality, in which processes become activated through specific research, in a way that goes beyond the intentionality of persons and the calculation by machines. In order to discuss the entanglement of matter and meaning as innovative methods for constructive interdisciplinary engagements between technosciences and humanities, it seems important to investigate the shifting intra-activity of human-machine-interfaces. It seems that the access to the world through our machinery, the technological devices of contemporary knowledge production, also shifts our understanding of knowledge production itself.

Material Interrelations: Machines and Humans?

What happens between humans and machines when they face each other or interact? Humans don't merely use machines to do something. The machine and

the activity leave traces on and in humans and vice versa. Traces could mean to signify abrasion, wear and tear or attrition, but also empowerment, enhancement or other enabling aspects of this interaction. Neither is it just an interface – a touch screen or a contact area, because it is humans who must initiate contact to the machinery to start a process. It makes little sense to speak of machinery or technological devices as initiating encounters (at least until now), since even the most 'intelligent' devices do not act in a comparably intentional way as humans do. Intentionality might not be a necessary difference between humans and machines, because human agency is not always intentional, and automatic devices sometimes seem to initiate a certain process of interference. But intentionality seems to be a sufficient criterion of difference, because technological devices only simulate intentional agency. These simulations actually involve humans interacting with other humans through machines, in other words: by way of technological interference. The term interference points to impact, influence and manipulation, to impairment, intervention and intrusion, but also to merging and mixing as well as to overlap, overlay and superposition, and to disturbance, disruption and disorder. In Barad's use of the term, all these dimensions are evoked, although she uses the term synonymously to diffraction, as we have seen above.

Consequently, the human-machine-interface is a dynamic process of materialization, in which meanings can change. This means that although newly developed technological objects need to be recognized in their envisioned cultural environment, they always carry the possibility of leading beyond the replication of validated norms. The dynamic of the human-machine-relation is also a central result in Lucy Suchman's study *Human-Machine-Reconfigurations* (2007). Here, machines are not understood as finite objects: "Rather than fixed objects that prescribe their use, artefacts – particularly computationally based devices – comprise a medium or starting place elaborated in use." (Suchman, 2007: 278) In the same way, persons who are involved in human-machine-relations should not be understood as autonomous subjects: "The person figured here is not an autonomous, rational actor but an unfolding, shifting biography of culturally and materially specific experiences, relations, and possibilities inflected by each next encounter – including the most normative and familiar – in uniquely particular ways." (Suchman, 2007: 281) This means that gendered subjects and objects can experience new practices and new meanings of themselves, including their gendered meaning, through their interaction.

As a result, the production of technology shapes our culture, which in turn is structured by a gendered social order. Therefore, the way in which tech-

nological developments take place and the way technology is designed and produced, including each person involved in the process, is open to change.

BEYOND THE 'RODENT'S TALE'

How can gender in human and non-human organisms be investigated as a critical site where the material and the social interact? The biologist Anne Fausto-Sterling questions a reductionist view of functional principles on human sexuality in her celebrated book *Sexing the Body. Gender Politics and the Construction of Sexuality* (2000). Here, she traces the 20th century history of biological theories on hormones, genes, chromosomes, and of experiments to study the chemical physiology of behavior. She exposes the continuously changing perspective on the behavior of laboratory rodents in connection with hormonal treatment, which leads to quite curious and ever changing 'facts' through analogy inference about human sexuality.

For instance: in the mid-1940s, Frank Ambrose Beach developed a detailed theory of animal sexuality, as he observed "striking individual differences within each sex, among laboratory strains of the same species, and among rodent species". He consequently argued that neurologically, "all animals have a bisexual potential" (Fausto-Sterling, 2000: 207). By contrast, in 1964, informed by "the cold war ideology that praised heterosexuality and ranted about the homosexual menace", William C. Young proposed that "pre- or perinatal hormones organized central nervous tissue so that at puberty hormones could activate specific behaviors" and "injected pregnant guinea pigs with testosterone" (Fausto-Sterling, 2000: 214). As a result, "male and female rodent behaviors, as well as those of humans, for whom they served as a model, emerged as more stereotyped than they had previously seemed, and as more rigidly determined by prenatal hormonal environments" in Young's observational frame (Fausto-Sterling, 2000: 217).

Fausto-Sterling sees this as problematic, since there has been evidence that hormones should be seen merely as one component in an interactive development, together with neural components, living conditions, social rearing, and adult behaviors. "Hormonal systems, after all, respond exquisitely to experience, be it in the form of nutrition, stress, or sexual activity (to name but a few possibilities). Thus not only does the distinction between organizational and activational effects blur, so too does the dividing line between so-called biologically and socially shaped behaviors." She concludes that current bio-

logical theories about human sexuality "derived from rodent experimentation are inadequate even for rodents" (Fausto-Sterling, 2000: 232).

Anne Fausto-Sterling's question is whether and how neuronal systems and behavior develop as parts of social systems. She asks how social experience could change the neurophysiology (= sex?) of gender. To clarify this, the author quotes a neurobiological study which investigated paternal behavior of male mice working with such an interactive framework (Ehret et al., 1993). Male mice, which never had contact with their newborn offspring, did not care later if the baby mice fell out of the nest. However, as soon as the paternal mice were brought in touch with the newborns just for a few hours a day, they cared and brought the baby mice back. So, on the level of social behavior, the result was that social and personal experience has consequences for the social behavior of adult mice. But there was an even more striking result. The research group measured the estrogen receptor binding and discovered that it increased significantly in several parts of the brain when the paternal behavior was intensified. Hence, the experience of paternity had changed not only the social behavior of male mice, but also the brain physiology of the paternal brains. Because of the evolutionary kinship structures between the hormonal physiology between mice and humans, Fausto-Sterling infers that there could be mechanisms through which gendered experience also changes the gendered human body on the hormonal level (Fausto-Sterling, 2000: 239–40).

As a consequence, Fausto-Sterling develops an integrative, interdisciplinary and holistic model for the study of human sex, gender, and sexuality. It connects questions about the cell, the organism, the psyche, the person to person relationships, the culture, and the history on a larger scale. She considers these components as a dynamic biocultural system of reciprocally related processes (Fausto-Sterling, 2000: 243). This makes clear that to understand the nature and culture of gender, sex, and sexuality these conceptual fields have to be studied within an interactive framework. This could enable us to overcome naturalized narratives of gender hierarchies, heteronormativity, and sex binarism. We can see here how so-called material, natural or physiological processes are closely tied to so-called social and cultural processes. We are able to install experimental settings in which brain physiology does not function as an ultimate cause for social behavior, but instead as a correlating factor in reciprocal processes of material semiotic actors. Understanding sex, gender, and sexuality as a biocultural system does not provide easy answers, and it does not only necessitate an interdisciplinary approach. It needs transdisciplinary thinking to correlate different methods to research cells, organisms,

individual psyches, social groups, national histories and transnational cultures to overcome the binary categories of sex, gender, and sexuality.

CONCLUSION

The above analysis shows that new epistemological ideas enable new ways to investigate sex, gender, and sexuality without reinforcing binary gender norms. Feminist analysis of science and technology provides innovative ways for research to empower those who are dis-empowered by gender hierarchies, racism, classism, homophobia, and other ideological frames to classify persons in structural hierarchies. The discussion in this chapter suggests that it is challenging but worth attempting to study phenomena that transcend the normative apparatus of gender. We have seen that through the apparatus of research diffraction patterns of gender can be generated. If we follow Barad and understand the apparatus of research as a part of the phenomenon we are studying, it seems interesting to investigate if scientific claims confirming the normative gender binary are related to stereotypical assumptions about women and men, or whether they rely on insufficient sets of data (see Jordan-Young in this volume). It seems promising to analyze and deconstruct the very apparatus of research which produces the results. To quantify sex or gender in order to understand how sex or gender is relevant at a specific location at a specific time in a specific relation to a research question, might not always be important or helpful. We have seen that the two-sex-model bears as many shortcomings and misunderstandings as other numerical models, for example the one-sex-model, as Thomas Laqueur has shown in his conceptual history of the gendered body (Laqueur, 1990). It seems that the most important insight of gender studies lies in the understanding that cultural, scholarly models of 'nature' are better not confused with manifold natural and cultural realities as such.

The surplus value of feminist theories for biology and technology then, is to help to develop research questions on how gender stereotypes or gender norms obstruct equal opportunities for all persons to develop and act along individual inspirations or aspirations. The goal is twofold: to foster democratic developments in biology and technology as well as to contribute to democratic developments through biology and technology. Therefore it seems necessary to connect those individual inspirations and aspirations with each other, and to enhance an ethical and political discourse on questions of justice and equal share which encompasses not only all human beings, but also non-human

organisms and non-organic matter. As Karen Barad puts it: "The attending ethico-onto-epistemological questions have to do with responsibility and accountability for the entanglements 'we' are willing to take on, including commitments to 'ourselves' and who 'we' may become." (Barad, 2007: 382)

Feminist technoscience studies, therefore, need to pursue a deconstructive as well as a constructive direction. This means, first, that epistemic entanglements of current or historical apparatuses of gender with scientific theories and technological products can be analyzed. Second, ideally through the very moment of analysis the apparatus of gender becomes visible as a specific arrangement or normative frame of gender. Third, this can be understood as deconstruction or de-naturalization which opens the way for new material-semiotic practices in which an established apparatus of research as well as an established apparatus of gender are (ex-)changed and a new understanding of gender gets established. In other words, gender relations become diffracted in a new way through epistemic negotiation. Or, to put it another way, a change in the apparatus of gender shows new diffraction patterns. In this view, the understanding of gender within the growing and fast developing (trans-)discipline of gender studies is itself subjected to changing diffraction patterns. Understanding this change and variation as diffraction of the very apparatus of gender within gender studies is helpful in order to avoid a reinforcement of stereotypes about gender differences through gender studies. Changing the focus of investigation from differences between women and men to diffraction patterns of gender, generated through the intra-action of natural and cultural processes seems to be a promising path for gender studies. The phenomena under investigation in this approach would be both: the diffraction pattern of gender relations throughout history and the diffractions in play in the comprehension of gender inside and outside of scholarly investigation.

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