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# Emancipatory interferences with machines?

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## ABSTRACT

Powerful entanglements and meanings of difference between machines and humans, designers and users, women and men become enacted in technical devices. Is there a potential for an emancipatory interference with industrial machines, their users and their designers? To answer this question, this paper develops a theoretical account from a feminist new materialist perspective on phenomena as political objects, machines as material agents, and gender as a material-discursive practice. To exemplify the theoretical claim, findings from an interdisciplinary research and development project are presented and discussed. Thereby, I argue for emancipatory interferences with machines on three levels. First, emancipatory interferences take place in the everyday "intra-action" between professional users and their machines with regard to the production of goods and thus gainful (self-) employment. Second, emancipatory interferences occur within collaborative research of these practices, and intervene in the apparatus of that research. Third, emancipatory interferences occur in the machine design process by enacting heterogeneous processes of experiencing and knowing that are diversely situated within both practices and practitioners in the workplace. I demonstrate how the project supported transformative becomings in the situated production of knowledge and items created with industrial machines.

## KEYWORDS

gender; emancipatory interference; material-discursive practice; industrial machine; engineering; material agents

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# Emancipatory interferences with machines?

## INTRODUCTION

> Agency is about changing possibilities of change entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices in the enactment of a causal structure. (Barad, 2007, p. 178)

Powerful entanglements and meanings of difference between machines and humans, designers and users, women and men, become enacted in technical devices. Is there a potential for an emancipatory interference with industrial machines, their users, and their designers? To answer this question, this paper develops a theoretical account from a feminist new materialist perspective on phenomena as political objects, machines as material agents, and gender as a material-discursive practice. To exemplify the theoretical claim, findings from an interdisciplinary research and development project are presented and discussed. The striking historical starting point is that women have worked with industrial machines for centuries. However, a persistent and widespread gender stereotype suggests that women in general—or by nature—lack technical competence. The flipside of this stereotype is that, in the same way, men have been credited with technical omnipotence. This stereotype operates powerfully on both material and discursive levels as if, in this socially significant realm, gender still functions as the most relevant causal structure for achievement or failure. This stereotype seems to draw on the even more widespread idea that the above mentioned differentiations between machines and humans, designers and users, or women and men are meaningful and have a stable, material, or even dichotomous character.

This paper aims to challenge this idea by revealing these differentiations as little more than rather powerful conventions that are reproduced again and again, and by demonstrating how they might be undone by changing the possibilities of agency. In doing so, it draws upon Karen Barad's (2007) conceptualization of "reconfiguring material-discursive apparatuses" (p. 178). Using this view as a starting point, the paper suggests how these apparatuses, including research apparatuses, embody the possibility of ongoing change in discursive practices and material outcomes—not only in feminist studies of science and technology, but also in machine design. It is also informed by Donna Haraway's (1991) notion of embodiment as "material-semiotic" when she establishes "[g]ender [as] a field of structured and structuring difference" (p. 195). This perspective grounds the understanding that matter does not come without meaning in contested fields of knowledge and power, especially in the establishment of potent gender differences. The idea is to develop and analyze situations in feminist science and technology studies and machine design that reveal the fluidity of gender identities in social encounters, the convergence of design, and use in machine development, as well as the entanglement of machines and humans in processes of production. Might these phenomena then be identified as emancipatory interferences with machines?[1]

There is a long tradition of feminist research concerning the variously shaped gendered human relationships with machines in patriarchal systems (Cockburn, 1985; Haraway, 1985; Wajcman, 1991). Since the early 1990s, researchers within the flourishing field of feminist technology studies have investigated the limited agency of professional women within the co-construction of gender and technology. These studies have analyzed the development of the microwave oven (Cockburn & Ormrod, 1993) and nursing information systems in hospitals (Wagner, 1993). Additionally, there has been further research on women as students and employees in the development of computer-based information systems and in office work (Mackinnon, Blomqvist & Vehvilainen, 1993) as well as projects including women as agents in call-centers and software development (Maass & Rommes, 2007). These investigations reveal the ways in which designers' disregard and devaluation of the knowledge held by professional women, as well as the stereotype of women's technical incompetence in general, impede the development of more suitable technologies.

Furthermore, technological devices designed either for "the general user" or specifically for women or men, often exhibit and reinforce gender stereotypes. This is demonstrated by research on electric shavers (van Oost, 2003), websites for women (Rommes, 2011), and "computational artefacts" (Bath, 2014). With the elaborated concept of the "gender script" (Rommes, van Oost & Oudshoorn, 1999) it has been shown how modes of use designed into technological objects often devalue femininity and actuate stereotypically gendered patterns of use. However, in her discerning analysis of feminist technology studies, Catharina Landström (2007) uncovered that these obstacles do not prevent all women from becoming more deeply involved in technology (p. 13). She proposes to study how technological discouragement of women is entangled with the "heterosexual matrix" (Butler, 1990) and how femininity and masculinity may provoke diverse ways of "wanting to belong" (Probyn, 1996). Therefore, Landström (2007) suggests to refigure "subjectivity as constituted in complex relationships with technology, placing the relationship as the crucial mechanism, not identity" (p. 17). This suggests that replacing gender as a deterministic binary within the apparatus of research with a more complex and fluid way of relating promises a more diversified investigation of "intra-action" (Barad, 2007) between humans and machines.

Much of this research has been undertaken in order to examine either technological product design for non-professional use, or the design of computational devices for professional and non-professional use (Sørensen, Faulkner & Rommes, 2011). The development of machines for industry has featured less prominently in the analysis of gendered relations, although there is a strong tradition of research investigating working practices in the industrial sector—especially where negotiations between employee autonomy and higher productivity are concerned (Karlsson, 2013). This paper attempts to contribute to the growing body of feminist technology studies and argues that research into industrial machine development and use offers insight in manifold—and possibly surprising—gendered positionings. However, this can occur only if the research is conducted "under the right conditions."[2] In this sense, industrial machines are powerful agents in material-semiotic networks of production. More than marketable goods, the differences between machines and

humans, designers and users, and women and men get produced, enacted and potentially transformed by emancipatory interferences. This term is used here to refer to liberating activities that interfere with normative machine design as well as norms of gender in a disruptive or intrusive way, eventually causing perturbations of these normative systems. Hence, political issues are negotiated with—and within—technological devices.

New materialism offers an innovative way to examine the entanglements of gender with design and machinery use more closely. What differences are made or "enacted" (Barad, 2007, p. 178) by design and use of machinery, as well as by research that examines it? How are questions of responsibility for justice and injustice encoded in technological innovation? Is it possible that emancipatory space is enacted in human-machine relations beyond outdated gender norms? My hypothesis is that methods of design practice, production, and research—including the people involved in these processes—are open to change their enactments of gender. In order to demonstrate this, I will "re-turn" (Barad, 2014, p. 168) to the process of research via a "re-turn" to the findings of a collaborative research project on the design and use of laser engraving and cutting machines. Barad shows that "re-turning" does not consist of a classical reflection of the past. Rather, it means ingesting and excreting soil like earthworms to make something useful out of it. This offers the potential of diffractive interferences, "opening it up and breathing new life into it" (Barad, 2014, p. 168). Therefore, I revisit predominantly unpublished research material, namely my analysis of the group discussions. However, this paper also includes the collaboratively published material of the three-year research and development project that focused upon the processes of development of industrial machines—specifically, their interfaces with humans (Cojocaru, Ernst, Hehenberger, Holl & Horwath, 2014; Ernst & Cojocaru, 2011; Hehenberger, Cojocaru & Ernst, 2012). I draw on Barad's (2007) "ethico-onto-epistemological" insights into the ongoing material entanglements of research apparatuses: "Discursive practices are boundary-making practices that have no finality in the ongoing dynamics of agential intra-activity" (p. 335). The goal is to show the potential for emancipatory interferences with machines that was made both visible and possible by this interdisciplinary project and its examination of laser cutting and engraving machines, their users, and their designers.

Emancipation, for a long time a goal of feminist research, has recently come back to the fore as a meaningful term beyond the modernist project (Allen, 2015; Coole, 2015). Amy Allen and Diana Coole relate the term "emancipation" back through the critical social theory of the Frankfurt School to the ancient Greek meaning of (legal) emancipation from slavery. They contrast to this tradition the Enlightenment discourse of Immanuel Kant on the topic, in which emancipation is said to be achievable through education. Both Allen and Coole engage with Michel Foucault's critique of emancipation as a modernist belief in the superiority of the European-Enlightenment values of autonomy and rationality. Drawing on Foucault's analysis, Allen (2015) develops an understanding of emancipation as representing spaces of critique "that enable us to transform states of domination into mobile and reversible fields of power relations, and practice freedom within those fields" (p. 524). Connecting Foucault's analysis with that of Simone de Beauvoir and Angela Davis,

Coole (2015) emphasizes the material aspects of an "emancipatory mode of being-in-the-world" (p. 543). She calls for a "threefold process of emancipation: one in which individual rights, practices of liberty, and collective socioeconomic equality are all at stake within an integrated but variegated totality" (Coole, 2015, pp. 543–544). This brings forward an understanding of emancipation as an ongoing process in relation to diverse material-discursive practices of power. Here, emancipation does not consist of a singular social achievement, for example, in the sense of formal freedom from slavery, nor of educational progress towards autonomy as personal duty, but rather as an ongoing practice of collaboration.

Thus, Allen and Coole's definition of emancipation is useful for understanding the phenomenon under scrutiny here. I argue for the usefulness of emancipatory interference as a category with which to describe the potential of spaces of experience in human-machine intra-relations for all genders. This means it is not just women, but also men, both in their versatile and various becomings, that may be part of such emancipatory interferences. Emancipation thus acquires the power to overcome the load of stereotypical (self-)ascriptions of gender norms for all persons involved in a collaborative network. This can happen by way of shifting understandings of their agency in their collaborative work processes with respect to machines. Hence, emancipatory interferences are understood as activities that are neither designed, intended, nor expected in normative systems of machinery or social normativity.

In this paper, I will argue for emancipatory interferences with machines on three levels. First, emancipatory interferences take place in the everyday "intra-action" between professional users and their machines with regard to the production of goods, and thus gainful (self-)employment. Second, emancipatory interferences occur within collaborative research of these practices and intervene in the apparatus of that research. Third, emancipatory interferences occur in the machine design process by enacting heterogeneous processes of experiencing and knowing that are diversely situated within both practices and practitioners in the workplace. The project resulted in a new generation of machines and a new self-consciousness amongst their users. As the paper develops, the concept of emancipatory interference is elaborated upon. Proceeding, phenomena as political objects, machines as material agents, and gender as material-discursive practices are discussed. Subsequently, the paper performs a "re-turn" to the empirical study on laser engravers, their users, and their designers. Thereby, the subject position of research expands towards the machine users and a methodological shift in the research apparatus is installed and reflected upon. In conclusion, the paper addresses the question of whether this research could serve as the realization of an emancipatory space of experience by shifting the injustices, prescriptions, and promises of the material-semiotic network.

## EMANCIPATORY INTERFERENCES

Women have been the operators of industrial machinery for centuries. However, as extensively analyzed by feminist research, as workers they have also been agents of change. For example, Maria Tamboukou (2016) analyzed the birth of the feminist

movement in Europe in the nineteenth century on the basis of the archival documents of seamstresses working in the garment manufacturing industry. It was a network of seamstresses that founded the first feminist newspaper in 1832, *La Femme Libre*, and later *La Tribune des Femmes*. In this way they produced, not only clothes, but also political writings, as well as letters and autobiographical texts. Most importantly, however, they struggled to unify women workers to fight for their rights and better material living conditions, both on the streets and within institutions. Tamboukou (2016) delineates the "assemblage of women workers' radical practices, which are inextricably entangled in the political, social and cultural formations of modernity" (p. 193) without ascribing to them any specific heroic or unified autonomous subjectivity. Instead, following Foucault, she describes their technologies of the self as proceeding "intra-actively" with changing technologies of both work and political struggle. She understands them as "narrative personae," as "conceptual figures, whose actions leave behind them storylines to be followed in the pursuit of meaning and understanding" (Tamboukou, 2016, p. 9). These storylines depict women as competent knowers, professionals in the garment industry, writers, and powerful political agents of—and beyond—their time. As a fluid collective political subject, the seamstresses serve as a networking example of emancipation from domination and ascribed gender norms. Their struggle can be understood as an emancipatory interference with material-discursive fields of profit and subordination—fields in which industrial machinery acted as a powerful and ambivalent material agent.

Emancipatory interferences were also enacted by Donna Haraway, when the poor material working conditions in the US American software industry inspired her to write her famous "Manifesto for Cyborgs" (1985) as a call for new entanglements of feminism with both socialism and machinery. Haraway (1991) grounds her analysis in the way women—predominantly women of color—were being exploited as preferred workers in the "integrated circuit" (p. 170) of the technoscience-based industries in Silicon Valley, California. This led Haraway to call for new alliances, as the social relations facilitated by the high-tech industry of the late twentieth century provoked "rearrangements of race, sex, and class" (Haraway, 1991, p. 165). Haraway further argues that feminists should gain knowledge and should be involved in new technologies, not just as users, but also as knowers and designers: "The cyborg is a kind of disassembled, post-modern collective and personal self. This is the self feminists must code" (Haraway, 1991, p. 163). She is convinced that in reconstructing collectively the boundaries of daily life, material and significant changes will become manifest. The machinery itself is not to blame for the "informatics of domination" (Haraway, 1991, p. 161). Rather, the question is how to use the machinery to which many are connected for material survival in order to change the system and to develop skills for survival with machines. This account suggests a new relationality between humans and machines, women and men, and design and use—one in which identity categories get blurred and mutual learning is encouraged.

In this way, Haraway sets the stage for new feminist materialisms that stem from both those that went before, and feminist theory—specifically as informed by women of color. She furthers this narrative by developing the concept of "embodied

objectivity," enabling an understanding of feminist embodiment as nodes in "material-semiotic fields of meaning" (Haraway, 1991, p. 194, p. 195) where boundaries are materialized in social interaction. Even more crucial, not only objects, but also subjects of knowledge are embodied in this account. This means that knowledge claims are related to the particular—material—positioning of those introducing them. This results in the inevitable partiality of any viewpoint and the necessity for an initiation of conversations with others in webs of connection.

However, the subjects in these relations or collaborations of "an ongoing 'becoming with'" do not precede their interaction (Haraway, 2008, pp. 16–17). Instead, the author relates here this practicing of relatedness to Barad's (2007) term of "intra-action," which happens at different scales of space-time. It signifies that bodies do not exist independently of their relations to other bodies in any given entangled environment, but rather come into being through practicing and eventually redefining these relations (Barad, 2007, p. 33). Haraway (2016) expands upon this theme, defining "become-with" through the mutual—though often asymmetrical—learning and training processes by rendering each other capable: "Ontologically heterogeneous partners become who and what they are in relational material-semiotic worlding. Natures, cultures, subjects, and objects do not pre-exist their intertwined worldings" (Haraway, 2016, pp. 12–13). For the analysis here, it is important to be aware of the subtle (and sometimes less subtle) patterns of difference and practices of relationality at work between humans and machines, which are often too sharply ordered simply as designers and users, or women and men. Within this conceptual framework I aim to understand how this powerful interplay of matter and meaning comes about through networking practices in an entangled field of investigation and production.

## PHENOMENA AS POLITICAL OBJECTS, MACHINES AS MATERIAL AGENTS, GENDER AS MATERIAL-DISCURSIVE PRACTICE

As queer, postcolonial, and other critical approaches within feminism show, privileges and injustices are constituted relationally and relatively (Butler, 1990; Sandoval, 1999). Neither privileges nor injustices simply adhere to specific genders and otherwise socially stratified persons, but are constantly made, remade, and undone (Butler, 2004; Fenstermaker & West, 2001). Scientific facts and technological products are constituted in exactly the same way (Akrich, 1992; Ernst, 1999; Longino, 1990). Taken together, they constitute a powerful set of phenomena that are available to humans and their ability to construct, dismantle, or change them (Barad, 2007, 2014). These phenomena are exposed to multifaceted politics, and therefore can be said to be political objects. Consequently, the human-machine interface is discussed here as a dynamic process of materialization in which meanings as well as materials can change. This means that, although newly developed technological objects need to be recognized in their envisioned cultural environment, they carry the possibility to move beyond the replication of accredited norms. The dynamic nature of the human-machine relation is a central result of Lucy Suchman's study "Human-Machine-Reconfigurations" (2007). Here, she takes up Judith Butler's theory of gender as a series of performative reiterations:

> Butler argues that "sex" is a dynamic materialization of always contested gender norms: similarly, we might understand "things" or objects as materializations of more or less contested, normative figurations of matter. . . . Technologies, like bodies, are both produced and destabilized in the course of these reiterations. (Suchman, 2007, p. 272)

Here, machines are not understood as finite objects in the sense that they are neither invented nor designed "once and for all." Consequently, I understand machines as materialized moments in ongoing processes of production. Similar to the notion of the "agential cut" as a way to describe the results of research in Barad's (2007) work, technological artefacts represent moments in an ongoing epistemic and social process: "Rather than fixed objects that prescribe their use, artefacts—particularly computationally based devices—comprise a medium or starting place elaborated in use" (Suchman, 2007, p. 278). In a similar way, persons who are involved in human-machine relations are not understood as autonomous subjects in this account:

> 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, p. 281)

Here, gender identities are not considered as given or fixed. Instead, persons can experience new practices and new meanings of themselves, including the meaning of their gender in relation to, but not necessarily constricted by, prevalent gender norms. Each person involved in these multifaceted material entanglements may be able to find new ways of self-positioning against even the forced adjustments to machines, e.g. in posture and pace. Through their "intra-action" within material-semiotic networks of "becoming-with" each other and their machines, they may also develop (self-)acknowledgements of solidarity, competence, and strength—e.g. in demanding better machine adjustments, or in experiencing joy through problem solving or successful production.

The following analysis offers a meaningful material-discursive apparatus in which "intra-action" between industrial machines and their professional users, designers, and researchers takes place. Machines are understood here as material agents. As such they carry injustices, prescriptions and promises. Although machines are in many ways powerful agents, they possess no inherent intention. Intention, as the capacity for more or less conscious wishes to act, differentiates human agency from the agency of machinery (Ernst, 2014, p. 157). Thus, there is no intention in machines to differentiate between the specificities (e.g. gender) of human collaborators. Machines "intra-act" with humans independently of their gender. In contrast, in human-to-human "intra-action" gender differentiating and the establishment of other social hierarchies is pervasive, as is signified by feminist scholarship through the concepts of "doing gender" (West & Zimmerman, 1991) and "doing difference" (Fenstermaker & West, 2001). It is important to understand

that the users in this research project were day-to-day workers with machines—professional users employed in small enterprises using laser engravers. Thus, the material-semiotic network under consideration here consists of human-machine relations that are also entangled with human-to-human relations.

## THE ENTANGLEMENT OF LASER ENGRAVERS, THEIR USERS, DESIGNERS, AND RESEARCHERS

In the beginning, the interdisciplinary research project Ge:MMaS: Gender Specific Requirements for the Development of New Machines Considering the Human-Machine-Interface had been designed to focus on the research of differences between women and men using industrial machines.[3] The aim of the project had been to isolate the specific requirements of women with regard to the development of industrial machines—to establish a profile of requirements. Part of the research consortium was a company specialized in the development of laser engraving and cutting machines, and selling to a global market. Laser engraving and cutting machines, which are used in the industrial sector, come in a variety of different sizes and are used to mark, engrave or cut a wide range of materials and items, such as ballpoint pens, rubber stamps, cardboard, plastics, wood, glass, and pieces of other machinery. The machines employ laser technology and connected computer software. The co-operating company connected us to its customers who, as outlined above, used the laser engravers for various different purposes, producing a range of products—some more specialized than others. The research application aimed at establishing a definitive woman-machine interface as its outcome.

However, this research path was not without risk, as it followed too closely established models of binary thinking—of women being generally different from men. This tradition of generalizing and homogenizing women (and men) can be attributed to dominant heteronormative conceptions of gender (Landström, 2007). Thus, such an endeavor risks unintentionally reinforcing gender stereotypes and norms, and thereby sustaining hegemonic masculinity. It was for this reason that I took up the challenge to re-direct the project by shifting this focus to an entangled and performative investigation of gender from the moment I joined the team at the initial meeting.[4]

Initially, the empirical research methods envisioned in the research application consisted of two questionnaires. Although the original research frame focused only on general gender differences, in the process of developing and refining the first questionnaire for the machine users we introduced more complex questions concerning the social positionings and preconditions of the workers (for example their age, education, language skills, migrant/non-migrant status, apprenticeship, training on the machine, computer use, and machine experience). This was a first step towards avoiding general comparisons between women and men as two homogeneous groups. The data analysis in relation to gender, age, apprenticeship, and machine and computer experience resulted in a differentiated picture of user requirements and machine performances (Cojocaru et al., 2014, pp. 160–162).

Within the research consortium, I convinced my colleagues to replace the planned second questionnaire with group discussions with the users. This was intended to provide deeper access to their knowledge and requirements, as well as to gain insights into the fluid processes of gender ascription and the "intra-action" between users and machines. This new approach was decided collectively on the basis of insights gleaned from the whole research team. We invited professional users from Austria, Germany and Switzerland who had taken part in the questionnaire to a workshop at the co-operating machine design company. In total twenty persons came, some travelling more than ten hours by car to take part. We allocated them into three parallel groups, each identified via color coding on the personal folders they received upon their registration. This was done to separate women from men, and managers from employees. The green group consisted of nine professional female machine users, two of whom had a leadership function.[5] The yellow group consisted of five professional male machine users. The white group consisted of six male decision-makers, most of whom were also users of the machines. The idea was to avoid the results being disturbed by potentially prevalent patriarchal communication patterns and other hierarchical features. We decided not to explicitly mention gender in order to avoid participants giving responses they felt were either desired or expected of them.

We asked just one question to initiate the discussion: "What are your experiences during your everyday work with the laser engraving machines of the cooperating company?" In order to analyze the transcribed protocols of the registered discussion, the documentary method was used (Bohnsack, 2010; Horwath, 2013).[6] The documentary method is a useful method by which to analyze group discussions because it represents a refinement of the inductive method developed in grounded theory (Glaser & Strauss, 1967). As a strategy for qualitative research it generates knowledge that is sensitive to the epistemic agency of the research participants. Moreover, it attempts to gain access to their tacit or practical knowledge (Bohnsack, 2010, p. 100). As a result of the analysis, the following patterns of orientation could be found: adjustments, exchange, operational procedures, perturbations, and emissions. As Sara Ahmed argues in "Orientations Matter" (2010), orientations are a useful tool with which to describe "how subjects and objects materialize or come to take shape in the way that they do" (p. 235). Orientation patterns thus delineate here how machine users relate to their material environment—the "intra-actions" between humans and technology that bring the worker and the machine into a collaborative process of production.

### *Adjustments: Approaching, testing, failing, saving*

One of the most central concerns of the users was to find the precise adjustments for the operation of the laser. Although there are suggested standard positions of the laser beam and the lens for each material according to thickness and other parameters, they have to be fine-tuned for each new job. The material to be engraved or cut requires adjustment to the focal point of the laser beam, which is dependent upon the installed lens. In the yellow group, a dialogue developed on this process of fine-tuning:

User one suggested: "As a user, I have bigger problems with the adjustments of the machine, [and with] the speed determination for every single material."[7]
User two replied: "The approximation."
User one: "Yes."
User two: "And the right adjustments."
Finally, user one concluded: "Much happens in accordance to feeling and testing and throwing away."

The proper adjustments determine the success of the work process. A participant of the green group said: "And then I have been sitting for half a night to adjust everything for myself and got everything just about working. After one and a half years he [the colleague] came back and readjusted everything. Now he is sick again, [so] now I am at the same point again…" As a consequence of this experience the user suggested installing the possibility to save the personal adjustments of multiple users on the same machine. A participant of the white group claimed boldly during the introduction round of the group discussion: "We laser everything which does not run away fast enough." Much later, the same person admitted: "Sometimes it is exasperating, if one does not find the right adjustments…!" These brief exchanges demonstrate early on that users of the yellow group consisting of men, as well as users of the green group consisting of women, struggle (and eventually succeed) to find the right adjustments for their work processes with the machine. Although it took the managers a little longer, gender norms or stereotypes did not hinder these machine users' ability to articulate their failings as well as their successes. They not only trusted each other by admitting their failures to a group consisting of complete strangers, but also related to each other through a shared challenge. They shared their orientation towards finding the right adjustments by way of approaching, testing, failing, and saving. In other words, they "intra-acted" in a sense of "becoming-with" each other and the machine.

### *Exchange: Knowledge, experience, machines, accessories*

The professional users of the laser engravers demonstrated an enormous desire and capacity to communicate and co-operate. In all three groups the conversation was lively and the need for more dialogue about experiences with the machines ("hints and tricks") as well as exchange on materials and accessories was articulated. The participants did not hesitate to discuss their problems with the machine within the group and also exchanged their knowledge concerning the use of specific functions and resources. A participant of the green group said:

> But I think, generally, it would be a good idea for [the co-operating company] to initiate an exchange of experiences among the users. . . . Because the problem [you mentioned] . . ., it exists certainly for many, I would bet on it. Considering the circumstances, it could also be a problem of the machine itself. And perhaps others have this problem too, and maybe there is some clever fox among them who has solved it.

Apparently, working with the machines commonly and necessarily results in questions regarding their use. If these questions can be answered by colleagues, it is possible to save resources (time and material), to avoid sub-optimal products, and to improve access to materials, machines and accessories. In the white group, the possibility for exchange was mentioned as the reason for the journey to the workshop. As one participant stated: "This is why I am here, today, to copy something from the others or to get information or so." The managers in the white group also considered it problematic if there was nobody from whom to seek advice: "Then you try and try and do not wangle something decent. Perhaps, it would be . . . nice if there would be access directly at [the co-operating company, to a consulting instrument]." The participants of the green group as well as those of the white group suggested installing an internet forum among the users of the machines on the website of the company that manufactures them. This shows that neither gender norms or stereotypes, nor any given user's own hierarchical position in their company prevented them (in the context of these group discussions) from requesting more opportunities for professional exchange and communication. This contrasts to what Heidi Schelhowe (2004) found in the male dominated setting of computer science students in Germany, namely that "the atmosphere can hardly be called positively disposed towards 'asking'" (p. 330). Furthermore, it relates to what Corinna Bath (2009) describes as the principle of "learning-by-doing-and-asking" practiced among women working with computer technology in Germany. She refers to this as a "de-gendering-strategy" (Bath, 2009, pp. 252–253) insofar as it helped these women to overcome gender stereotypes in computer science. In our study, it was not only women, but also their male colleagues who demonstrated what I term an orientation towards the exchange of knowledge, experience, machines and accessories.

### *Perturbations: Controlling, repairing, avoiding*

Another prominent topic in the group discussions was how perturbations can be discovered, controlled and—in an ideal scenario—prevented. The users further problematized how the machines cannot be operated without supervision because of the danger of fire. One participant in the green group admitted: "No, I left already for two hours when I knew it is busy for three hours." Another participant asked: "And [you] never had a bad feeling in doing so?" The first answered: "Well, for the first time. [Laughter of the group.] The second time not anymore." The participant who asked about having a bad feeling narrated:

> Because we are doing a lot of things, when the laser is running, we already thought whether it might be possible to install a camera somewhere into the corner, because we are afraid to leave it alone. Because with us, it is our apartment and if this flares, then we have a problem.

In the white group the possibility of camera surveillance of the laser engraver was also suggested. A participant suggested:

> With the [one version of the machine], sometimes one has to do something three meters away on the worktop, [so] it would be nice if one could see it on

> the screen. [It would be nice] to see what the machine is doing, because at the moment, I cannot look inside, what is happening, when I am sitting here. And because of that it would be nice if there would be a camera on which one could simply see generally if something is burning or something is happening.

This shows that questions concerning responsibility and "trust" between the agency of the machine and the users are also discussed independently of their gender and hierarchical position in their respective companies. The users are thus inclined to control, repair and avoid perturbations.

### *Emissions: Cleaning, filtering, vacuuming*

Methods and products that help to deal with the scrap and dirt after operating were also exchanged. In the green group responsibility for the cleaning and servicing of the machine was discussed at some length. The cleaning of the machine after operation (for example from pieces of rubber) was also a shared concern in the white group. Furthermore, both groups agreed that there was a problem with the aspiration of the machine. A participant of the green group explained how they arrived at a solution: "And now we installed air conditioning in the room and connected it to the laser, [and] took the carbon filter out." This means that the laser engraving machine is re-modelled by its users so long as there is the necessary knowledge in the company and the need is strong enough. In the white group the topic of aspiration also appeared, this time in their discussion of the adjustment and positioning of the aspirating device. The users improvised solutions where necessary. Although in the yellow group this topic did not appear, this shows that, independent of their gender and hierarchical position in their company, users do not consider the machine as something unchangeable or sacrosanct. On the contrary, the users exchange parts of the machine along with their needs and knowledge. There is an inclination towards improving cleaning, filtration and vacuuming emissions. This connects to both the previous discussion and Suchman's (2007) approach, in which objects become elaborated through use.

These analyzed patterns of orientation demonstrate that the machine's professional users consider themselves as experts with first-hand experience of problems, thus enabling them to both advise the designers and act as self-conscious agents with the machine itself. Not all processes of the machine are transparent or predictable, not even to experienced users and designers. In sum, the flexibility of adjustments, the compatibility of diverse computer graphics programs with the machinery, and the transparency and clear arrangement of the internal processes of the machine represent the superordinate requirements of the users over the machine. These requirements emerge from the patterns of orientation delineated above, framed as suggestions for improvement coming from the machine's experienced users addressed to its designers. Significantly, flexibility, compatibility, and transparency—neo-liberal requests for humans on the labor market—become the core requirements for the design of the laser engraving and cutting machine. To demand flexibility of machines instead of humans may already represent an emancipatory interference into neo-liberal policies of the human labor market.

### *Discussion*

The group discussions were analyzed in accordance with the documentary method. As researchers, we strived to gain "access to the structure of action and orientation, which exceeds the perspective of those under research" (Bohnsack, 2010, p. 101). This practical knowledge implied in using the machine might be pre-reflexive or represent a "knowledge of experience, which is so much taken for granted by the participants that it must not and often cannot be made explicit by themselves" (Bohnsack, 2010, p. 103). Epistemologically, the results do not lie in an envisioned causal explanation of user practices in the traditional realist sense of scientific inquiry, but rather in the explication thereof—in rendering explicit that which is implicit to both the users' practice and depictions thereof. In this way, the methodological strategy used in the second year of the research project had shifted from a traditional, social scientific realist approach to a methodological approach oriented towards Barad's (1998) concept of "agential realism." In an "agential realist" approach, reality—including epistemic reality—is constituted via manifold networks of "intra-activity". These can also be understood as processes of "becoming-with."

In line with the requirements of the documentary method we compared the three groups in the process of interpretation in order to isolate a framework of orientation. We asked if, and eventually how, the experiences, problems and requirements discussed in the groups differed from each other. We analyzed if and how gender differences became established within the discourse. In this way, a general framework of orientation—experienced and articulated in all three groups—was identified as the situated knowledge of these professional users of the laser engraving machines, namely the requirement to design the machines as flexible, transparent, and compatible systems to be adjusted in use by more than one user. Moreover, I want establish an explorative material-discursive space, a material-semiotic network of transformation. We discovered how various users—women, men, managers and workers—developed work practices and communication skills both with each other and with the machine. These skills transcend current pervasive stereotypes and gender norms, as well as dichotomous arrangements of the human and the machine, and those between its use and design. In order to produce products for sale and to fulfil the requests of their customers, the research participants not only operated the machine, but also re-modelled it as increasingly competent partners.

On a second level, the group discussions themselves constituted spaces of experience. This means that, by way of giving temporary space to material-discursive practices, those involved in the process could shift their positioning, for example, with regard to gender stereotypes. Hence, in installing the group discussions as a crucial part of the research apparatus, emancipatory interferences with machines amongst the users, researchers, and designers became possible. This stands in contrast to the image (still) prevalent in the industrial sector that men and masculinity are still widely normative, and thus androcentrism is hardly ever questioned (Faulkner, 2009). The group discussions provided and represented an emancipatory space of "intra-action" between humans (becoming colleagues in

and through connecting machine use, research, and design) as well as between humans and machines. Additionally, an emancipatory space of "intra-action" or "becoming-with" was constituted within the whole collaborative process of research, development, use, and re-development of the machines—or together with the machines. This shows how the design processes of technological items can be enacted as entangled networks of production.

## CONCLUSION: EMANCIPATORY SPACES OF EXPERIENCE?

The group discussions revealed that the orientation of all workers—not only women—to the machines they use allows them to relate to each other in solidarity as colleagues. They showed interest in each other's successes as well as failures, and shared and developed new ideas in order to "intra-act" in a more promising way with their machines. In a similar way, Maria Tamboukou (2016) suggests that the value of her analysis of the seamstresses' documents from the nineteenth century lies in their potential for further interaction and empowerment: "Moreover, it is through their stories that certain concepts, ideas and events can be expressed, rehearsed and dramatized so that their enactment can create a scene for dialogic exchanges, communication, understanding and action" (Tamboukou, 2016, p. 9). This strengthens the point that there is firm documentary value in the above analysis of the group discussions of laser engraver users towards inspiring further emancipatory interferences with machines. This is because the participants in this research showed extensive relational capacity towards their machines as well as each other.

Here, human and machine "intra-action" becomes a space of learning, of experimenting—of failing and success. It is also a space of experience in which the gender of those participating becomes less important. In these highly unpredictable interferences between the machines and their human co-workers a potential for emancipatory space becomes visible and can be enacted. This potential is based on the overcoming of ascriptions of technological incompetence to women and of technological omnipotence to men. In the process of working and becoming acquainted with machines, their creative potential and their limitations, and in the development of a certain proximity and intimacy in a shared working process, positionings to the machine inevitably shift. Thus, shifts in positionings to gender norms and stereotypes become visible. Human-machine "intra-actions" have the potential to become emancipatory spaces in which persons succeed in overcoming stereotypical ascriptions of gender. This approach to personhood also resonates with what Maria Tamboukou explains as technologies of the self:

> Instead of a unified and autonomous subject, there are instead technologies of the self, nomadic passages and subject positions that the *narrative personae* of my inquiries take up and move between, while writing personal and political stories. (Tamboukou, 2016, p. 9)

From this it follows that thinking subject positions in human-machine relations as nomadic passages does not mean forfeiting the capacity to act. Neither personal autonomy nor freedom in an absolute sense are at stake here. Rather, persons may

act as agents of change in an "intra-active" network of "becoming-with," as can machines.

Initially, the research plan contained a standardized social science research method—a questionnaire—to look for differences between women and men using the machine. Also, the prescriptions of the designers through the machine design had to be considered. In the final analysis, as a collective becoming within the research team, the research process, and machine design we were able to turn the notion of prescriptive agency around completely, defining prescriptions as suggestions of the professional users for re-designing the machine. Thus, these human-machine "intra-actions"—the "becoming-with" of the professional user and the laser engraver—serve as an example in which emancipatory interferences occur. The project supported transformative becomings in the situated production of knowledge and items created with laser engravers. As a research perspective, this approach was more sensitive to the real material conditions of machine use. In sum, when professional women working with machines to make a living are taken seriously as experts in machine development, outdated stereotypes that in many ways still govern prevalent patterns of femininity and masculinity, design and use, may be dismantled, shifted, and finally become obsolete.

## ENDNOTES

[1] Karen Barad (2007) uses the term "interference" as synonymous with the term "diffraction," since as phenomena in physics they "both result from the superposition of waves" (pp. 28–29, pp. 80–81). I follow Barad's inference in a more interdisciplinary and colloquial sense: on the surface of the water the superposition of waves constitutes interference under the condition that the surface is imagined as normally—or normatively—smooth or consisting of waves in only one direction. I also use the term "emancipatory interference" in a broader sense: to describe how liberating activities interfere with normative machine design as well as norms of gender in a disruptive or intrusive way, eventually causing perturbations of these normative systems.

[2] The wording "under the right conditions" is used in physics to qualify experimental data. I borrow this terminology to suggest that also in feminist science and technology studies data are produced through a specific research frame, or apparatus of meaning making, understood by Karen Barad (2007) as "material-discursive practices" (p. 146).

[3] Ge:MMaS: Genderspezifische Anforderungen für die Entwicklung neuer Maschinen unter Berücksichtigung der Mensch-Maschine Schnittstelle, September 1, 2010 – August 31, 2013. The project was funded by the Austrian Research Promotion Agency (FFG), FEMtech-research project no. 826182. Project leader was Eugenia Cojocaru, Linz Center of Mechatronics (LCM). Participating researchers were Waltraud Ernst, Peter Hehenberger, Helmut Holl, and Ilona Horwath from the Johannes Kepler University in Linz (JKU Linz), and Sabine Köszegi and Siegfried Sharma from the Vienna University of Technology (TU Wien).

[4] I was part of the research team from the start of the project, but had not been part of writing the research application. For related, although somewhat different experiences and reflections of "gender experts" in interdisciplinary projects, see Ratzer et al. (2014).

[5] Only during the group discussion, it became evident that among the women two had positions of leadership.

[6] Ilona Horwath inspired me to apply the method to this research project. She also commented on a preliminary version of my analysis of the group discussions.

[7] All group discussion material was translated by the author.

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