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On *Geschlecht*[1] in Brain Science Experiments

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Abstract
While in neuroscience *Geschlecht* (sex/gender) is a hard and rarely contested variable, in gender studies, *Geschlecht* is a social phenomenon; a result and a facet of human action and social structures – in short: a social construct. Since my dissertation is a `gap-work` between this epistemologically different disciplines, I would like to focus on some difficulties a gender studies-oriented scientist can encounter while operating experimentally with *Geschlecht*. Furthermore, I will pinpoint the experimental conditions, paradigms and variables of interest in the brain lab. How is the neuroscientific experiment implemented? Which items are measured in the experiment? What do the results show? Rather than attempting a deconstruction of *Geschlecht*, this paper is a hard-to-ask-question. For on the one hand, the paper is committed to scientific explanation, whilst on the other, it takes the post-butlerian era seriously.

Keywords
Brain, neuroscience, *Geschlecht* (sex/gender), scientific experiment

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[1] *Geschlecht* is a German word and means both, sex and gender. Looking for an alternative to simultaneously operate with the sex-gender phenomenon, I chose this term. The German word not only helps me to avoid a direct exposure to the sex-gender dissociation, but it also expresses an `intermediateness` between discourse and materiality.

Introduction

The most gendered body parts in the human body, the secondary sex characteristics, must be in their second crisis[2], I thought holding Volume 427 of *Nature*[3]. There, I was reading about our new sexual organ: the brain. As it is now *the* most important sexual organ, the brain may be able to disqualify any other sexual organ, for example the secondary sex characteristics, I assumed.

Fig. 1: From *Nature*, Vol. 427, p. 390. Reading the paper we realise that the `models` of this experiment are not humans, as suggested by this picture, but rodents and finches.

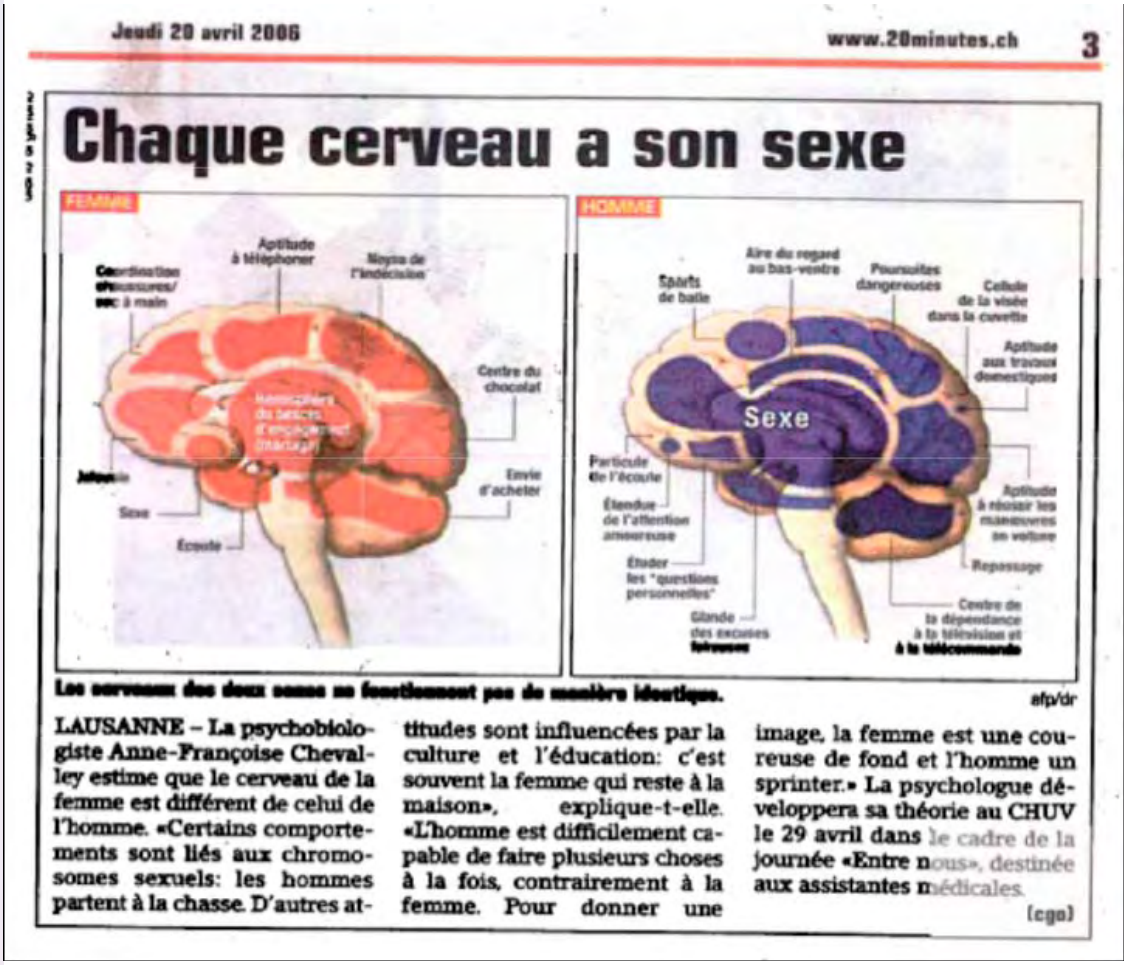
[2] They definitely must have gone through their first crisis just after the publication of Lacqueur's *Making sex: body and gender from the Greeks to Freud* (1990).
[3] Dennis, C. (2004). The most important sexual organ. *Nature*, Vol. 427: 390-392.

The brain has been connected for a long time with being a woman or behaving like a man. However it's labelling as the most important sexual organ in a high impact scientific journal such as *Nature* reveals a new dimension to the debate on sexuality, gender, and sex with human cortical materiality. Is the brain really the most important sexual organ, or is it a sexual organ at all? Are these statements justified conclusions in scientific publications and in popular science? What is the neuroscientific and empirical evidence?

I am mainly interested in the implicit notions and associations of *Geschlecht* in experimental brain science. These notions and associations become real, they take on materiality during experimentation, i.e. during the neuroscientific experiment itself. As my doctoral research is a `gap-work` between Neuroscience and Gender Studies, I'm always concerned with the starting points of analysis. Thus, the point of view of this paper will be from somewhere `outside` of neuroscience, but will still be committed to certain scientific explanations. I will switch at times, taking the perspective of Gender Studies, in which *Geschlecht* has already been ›deconstructed‹ for almost 15 years now (Butler 1990). However, the attempt to introduce a deconstructed *Geschlecht* into an analysis of brain imaging is a risky project and a bold venture. Nevertheless, within neuroscience, the question of `what is a women, what is a man?` still leads to confusion and evokes incomprehension – or even an all knowing insinuating smile.

There is no discussion or reflection on the materiality of *Geschlecht* in neuroscience. Unaware of their role in defining or creating *Geschlecht*, neuroscientists regularly keep on publishing *new* insights about the biological nature of `the most important sexual organ`. Popular journals contain clear and short messages about the interplay between female and male brain activity and female and male behaviour, which had clearly been extracted from scientific journals, but cannot be linked to serious science.

The image below shows, for instance, that `each (single) brain has its sex`. In this sense, women apparently have larger brain areas for skills such as buying or phoning, whereas men's most important brain regions are those related to cars, sex and ballsports.



Jeudi 20 avril 2006 www.20minutes.ch 3

Chaque cerveau a son sexe

FEMME

HOMME

Les cerveaux des deux sexes ne fonctionnent pas de manière identique. afp/dr

LAUSANNE – La psychobiologiste Anne-Françoise Chevalley estime que le cerveau de la femme est différent de celui de l'homme. «Certains comportements sont liés aux chromosomes sexuels: les hommes partent à la chasse. D'autres attitudes sont influencées par la culture et l'éducation: c'est souvent la femme qui reste à la maison», explique-t-elle. «L'homme est difficilement capable de faire plusieurs choses à la fois, contrairement à la femme. Pour donner une image, la femme est une coureuse de fond et l'homme un sprinter.» La psychologue développera sa théorie au CHUV le 29 avril dans le cadre de la journée «Entre nous», destinée aux assistantes médicales. (cgu)

Fig. 2: From the Swiss free daily newspaper *20 minutes* (April 26), p. 3. Examples of large areas in women's brains are: "aptitude à téléphoner" (ability to phone), "envie d'acheter" (desire of buying), "indécision" (indecisiveness); notice that sex appears to have a small brain field in women. In men, the large regions are "sexe" (sex), "sports de balle" (ballsports), "voitures" (cars), whereas "travail doméstique" (domestic work) seems to be correlated to a small brain area.

In this particular paper I will take a more focused look at how brain research implicitly and explicitly operates with *Geschlecht* in its experiments. How do the experimental implementations look? What are the variables measured in the experiment? By doing this analysis I hope to show what it means for empirically experimental science to engage with, or even to measure, *Geschlecht*.

My previous research leads me to the hypothesis that there are – apart from the usual women versus men comparison (see 4.) – four other groups of research topics (see 1. – 3.)[4] with specific measurable variables directly involved with determinations, presumptions and certain notions of *Geschlecht*.

These experimental research topics are grouped around a specific neuroscientific notion of *Geschlecht*. Through experimentation, these research topics reveal what *Geschlecht* in neuroscience is[5]. Furthermore, they provide an experimental situation, where *Geschlecht* can emerge.

I would like to emphasise that I will not present a tour through neuroscience showing deconstructively how a gender studies-oriented critique would analyse a hard science, neither am I claiming poststructural-oriented gender studies is disembodying material bodies. What this paper represents the attempt to pose a question that is hard to ask. It is an important question for `gap-workers` of the next generation who argue for more materiality without being essentialistic. It is an attempt to take the post-butlerian and queer era seriously without leaving science behind.

What are the research topics and the implemented variables around *Geschlecht*, around women and around men? Well, they can be found in an immense diversity of inventive experiments...

1. Sexuality

In brain imaging[6], one research topic measuring variables on *Geschlecht* is, sexuality. Neuroscientists do this by capturing the brain activation that arises during sexual involvement. Experiments on sexual arousal are numerous. However, all recent imaging studies show a similar experimental design pattern. Men are asked to have an orgasm – either with help of their

[4] To stay within length limits, though, I will not elaborate one of those research topics, namely the *sexual hormones* here.
[5] *Geschlecht* in neuroscience is difference-based. There is hardly any access to *Geschlecht* other than through differentiating women from men. A few times, though, studies do not find any difference (concerning the topic of language processing for instance, these are Weiss et al., 2003; Sommer et al., 2004; Plante et al., 2005), but still, the notion of dissimilarities between the sexes/genders dominates neuroscientific concepts.
[6] Body imaging, such as CT, MRI, PET, SPECT, is based on techniques that create images of internal body structures. In brain science, these are imaged reconstructions of the human brain and cerebral activation.

girlfriends or with the help of their own manual skills. Usually, additional stimuli in form of erotic images or short video clips are presented to guarantee a reliable success of the experiment. Examples of the titles of such studies are *Brain processing of visual sexual stimuli in healthy men: a functional magnetic resonance imaging study*, *Brain activation and sexual arousal in healthy, heterosexual males*, or *Men and women differ in amygdala response to visual sexual stimuli.*

Let us focus at *Brain Activation during Human Male Ejaculation* and have a look at the brain activations found here. Male ejaculation evokes in this study activation in the mesodiencephalic transition zone, which is said to play a crucial role in rewarding behaviours. Activation in these areas have been also observed during cocaine and heroine rush (Breiter et al., 1997), this leads to the implication that there is a link in addicts experiencing orgasmic pleasure with heroin usage. Furthermore, other subcortical brain areas are detected to be activated in this study:

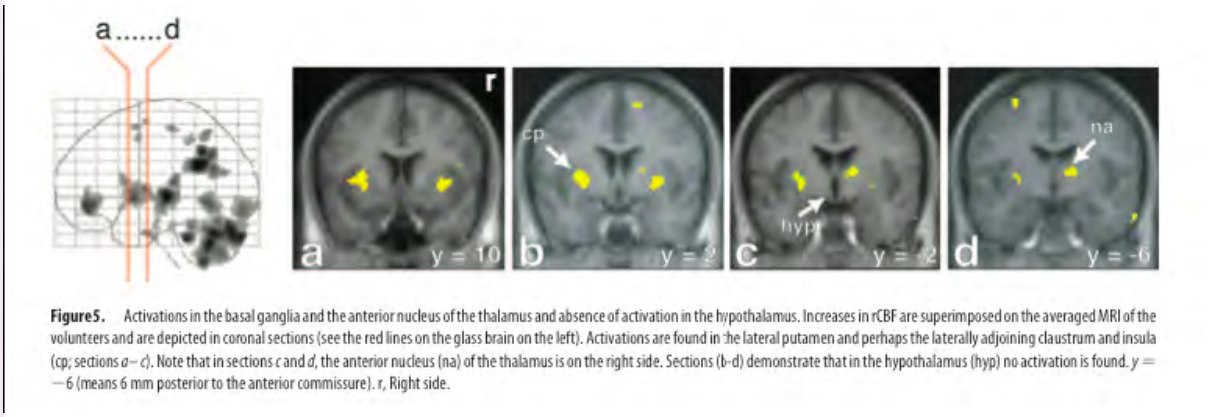


Figure 5. Activations in the basal ganglia and the anterior nucleus of the thalamus and absence of activation in the hypothalamus. Increases in rCBF are superimposed on the averaged MRI of the volunteers and are depicted in coronal sections (see the red lines on the glass brain on the left). Activations are found in the lateral putamen and perhaps the laterally adjoining claustrum and insula (cp; sections *a–c*). Note that in sections *c* and *d*, the anterior nucleus (na) of the thalamus is on the right side. Sections (b-d) demonstrate that in the hypothalamus (hyp) no activation is found. *y* = −6 (means 6 mm posterior to the anterior commissure). r, Right side.

Fig. 3: From Holstege et al. (2003), p. 9189. The images above demonstrate brain activation of certain regions in the `inside` of the brain, as highlighted by the red lines in the brain on the left.

Further activations were found in the basal ganglia (see pictures a to c) and the anterior nucleus of the thalamus (c and d; in d marked by an arrow) but no activation was found in the hypothalamus (see c; the arrow shows the lack of activation in the hypothalamus), which is a pity, as the hypothalamus is meant to be *the* location of *Geschlecht* in the brain.

By measuring sexuality, many implications, predictions, and determinations on what *Geschlecht* is are created as a by-product within a compulsory binary categorisation of women and men. Butler's conception that sex only comes to matter through heterosexual norms (Butler

1993: 10, 15, 23) shows evidence that most magnetoresonance imaging machines do not allow the researcher to leave the default box *sex* unchecked. If there is no insertion of an F for female or of an M for male the machine will not proceed to take a measurement due to hard wired technical configurations.

2. Sexual orientation

Another research topic is the measurement of sexual orientation. The main purpose of studies such as *Differential Brain Activation in Exclusively Homosexual and Heterosexual Men* is primarily to collect data on differences between gay and straight people – although these experiments are mostly concerned wit men. Again, the experiments vary widely in their implementations. However, I will pick one example to demonstrate how homosexuality becomes a neurological matter.

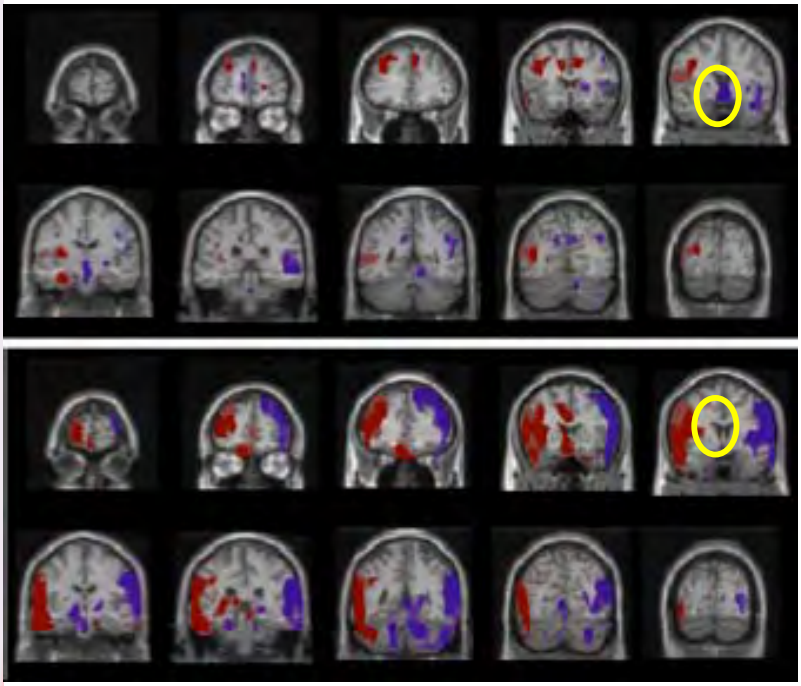


Fig. 4: From Kinnunen at al. (2004), p. 252. Homosexual (below), heterosexual (above)

These pictures show brain activation in homosexual men (below) and heterosexual men (above) after the injection of a pharmacological substance that influences the brain in a certain way. The authors focus on the difference between homosexual and heterosexual men in a specific area of the brain: the medial preoptic area of the anterior hypothalamus (mPOA). From animal experiments we know that the mPOA is `critical for the expression of sexual behaviour in male animals`[7] (Kinnuen et al. 2004: 251). Linking this specific area with a specific reaction of the transmitter system and with a specific sexual preference we risk drawing a deterministic conclusion in terms of `from the genes to behaviour`[8]. In this study, the authors detected – who wonders? – a difference in the hypothalamus (encircled); under these experimental conditions, gays showed more hypothalamic activation than heterosexual men. [9]

However, in this picture we see more than just a hypothalamic activation. Even an observer not used to contemplating brain images will discover other areas, for example in the frontal lobe, that could have been used as areas of differences or similarities. Why do we ignore them? Is it because the frontal cortex is related with thinking, executing and planning and not with drives as is the hypothalamus? Furthermore, we could have evidently emphasised some of the abundant similarities[10] in the activation patterns. After all, the coloured dispersion is almost the same, i.e. if there is a red activation in the gay group, there will be a red activation around

[7] Kinnuen et al. (2004), Differential brain activation in exclusively homosexual and heterosexual men, *Brain Res.* 1024(1-2), p. 251–254.

[8] Currently, in a large field of brain and biomedical research there is again the tendency to fix a deterministic perception of human behaviour as determined by our genes. This has been criticised by feminist science critique (Schmitz, 1999; Fausto-Sterling, 2000) and others. Some sociological experts on biomedicine and life sciences, though, explicitly avoid focusing deterministic interpretations but pinpoint regulative mechanisms and structures of biotechnology and biosciences (see Rose/Novas (2005), Rose (2006)). However, without taking *Geschlecht* into account.

[9] Excerpt: `differential effects were observed in the region including the hypothalamus, with the homosexual group exhibiting a significantly ($p \leq 0.01$) smaller reduction in hypothalamic glucose metabolism in response to fluoxetine than the heterosexual group (Fig.). Areas not known to play a role in sexual behaviour were activated differentially as well. The homosexual group exhibited significant increases in a portion of the prefrontal association cortex in which the heterosexual group exhibited no change, and in portions of the cingulate cortex in which the heterosexual group exhibited decreases. In contrast, the heterosexual group showed a significantly larger relative increase in lateral anterior cingulate, bilateral hippocampus/parahippocampal gyrus, and cuneate gyrus. The fact that the response of the homosexual group appears larger in spatial extent than that of the heterosexual group may be due to greater heterogeneity within the heterosexual group. This study is the first to report evidence of a sexual orientation-related metabolic difference produced by a pharmacologic challenge, possibly reflecting underlying between-groups differences in neurochemical activity.` (p. 253, Kinnunen et al. (2004))

[10] In Sexing the Body's fifth chapter, Anne Fausto-Sterling (2000) explains how differences are statistically built. It becomes evident that finding out, detecting and proving *similiarities* is generally not the aim in science.

this area in the heterosexual group, too. No red activation in a certain area in the gay group will be purple in the straight group.

Finally, even if there were a difference in the activation between gay and heterosexual men, that would not necessarily mean that this is the cause of a certain way of living and forming relationships; it could also be regarded as the result of it.

3. Transsexuality

Against the backdrop of sexual orientation, neuroscientists also pinpoint transsexuals. The research group around D. F. Swaab has been investigating post-mortem brains of transsexual people for more than 10 years at the *Netherlands Institute for Brain Research* in Amsterdam. Similar to the previous study, the subcortical nuclei become the focus of attention. These analyses werde based on postmortem brains.

In the article *Male-to-female transsexuals have female neuron numbers in a limbic nucleus*, the authors found out that a certain limbic nucleus[11] in male to female transsexuals correlates rather with the limbic nucleus of women and not of men. This result was put forward as further proof in regarding the brain of transsexuals as different compared to their genitals. Or, in other words, the sexual identity of their bodies was not congruent with the sexual identity of their brains. Furthermore, the results of this examination confirmed the neurological base of a malfunctioning gender identity. `The present findings [...] clearly support the paradigm that in transsexuals sexual differentiation of the brain and genitals may go into opposite directions and point to a neurobiological basis of gender identity disorder` [12] (Kruijver 2000: 2034). This quotation clearly shows that in neuroscience there are only evident women or evident men and that women are the opposite of men and vice versa. Furthermore, regarding the expression `the neurobiological basis of gender identity` we see how quickly conclusions on a naturalised gender identity are drawn.

[11] Limbic nuclei, such as amygdala, striatum, nucleus accumbens and septum, are areas of the limbic system.
[12] Kruijver, F. P., Zhou, J. N., Pool, C. W., Hofman, M. A., Gooren, L. J. G., and Swaab, D. F., (2000). Male-to-female transsexuals have female neuron numbers in a limbic nucleus. J Clin Endocrinol Metab 85(5), 2034-2041.

One year later, Kruijver and colleagues[13] focused on the hypothalamus in transsexuals (and others). They investigated the androgen receptors (AR) at a microstructural level throughout the mamillary body complex, which is known to be involved in aspects of cognition and sexual behaviour. The authors were interested in showing the relation between the endocrine status (presence of male hormones) and the intensity of the AR-staining.

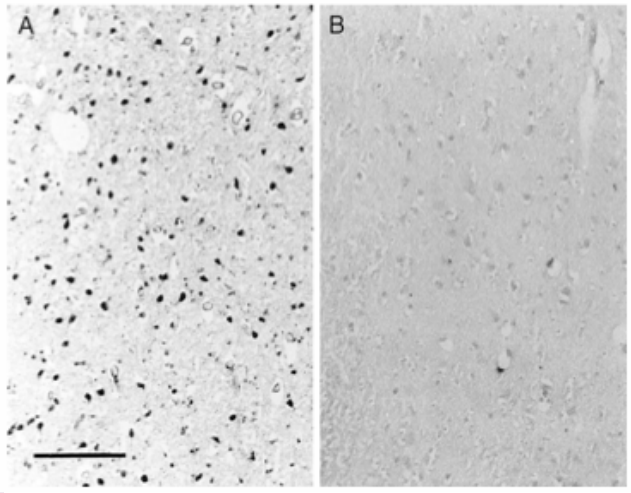


Fig. 5: Noncastrated 36-yr-old male-to-female transsexual (A) and a 26-yr-old castrated male-to-female transsexual (B). From Kruijver et al (2001), p. 821.

These two pictures showed the lack of staining in a 26-yr-old castrated male-to-female transsexual (right) compared with a noncastrated 36-yr-old male-to-female transsexual (left). The lack of staining implies a lack of androgen receptors, in other words, of male hormones.

This sudy was implemented to see whether the AR immunoreactivity, that is usually larger in men than in women in the hypothalamus, is related with sexual orientation or gender identity. To measure as much of the abundance of *Geschlecht* as possible, the authors examined a divers group of subjects, which were young heterosexual men, young homosexual men, older heterosexual castrated and noncastrated men, castrated and noncastrated transsexuals, young heterosexual women, and a young virilised woman. Notice that the virilised women was defined as `virilised` due to her `high circulating level of testosterone` (Kruijver, 2001: 823).

[13] Kruijver et al (2001). Sex differences in androgen receptors of the human mamillary bodies are related to endocrine status rather than to sexual orientation or transsexuality. *Clin Endocrinol Metab. 2001 Feb;86(2):*818-27.

4. Women versus men comparison in cognitive tasks

Finally, the most frequent way of doing the experimental *Geschlecht* is looking at the differentiations in cognitive tasks. In case we run out of further associations and variables by measuring *Geschlecht*, we can always go back to the good old women versus men comparison. Let us bear in mind that there is nothing that cannot be compared. As mentioned below, we can measure sexual arousal, hormones, illnesses and cognitive abilities, why not. Studies on human thinking skills investigate differences between women and men in numerous cognitive experiments, for example, in spatial cognition or language perception. Having said this, the question arises of why exactly these tasks were chosen, and not, for instance, memory tests. We may want to know if there is a neurological difference in women versus men especially in gender-related thinking, such as performing language. We may also want to detect a hard wired material reality beyond behaviour. Why do we need to see – in case there really are – different cortical patterns of women and men to be satisfied? Do we really know more after seeing cortical activation? What happens the moment we prove neuroscientifically differences in the brain?

Anyway, let us get back to the women versus men comparison in cognitive neuroscience.

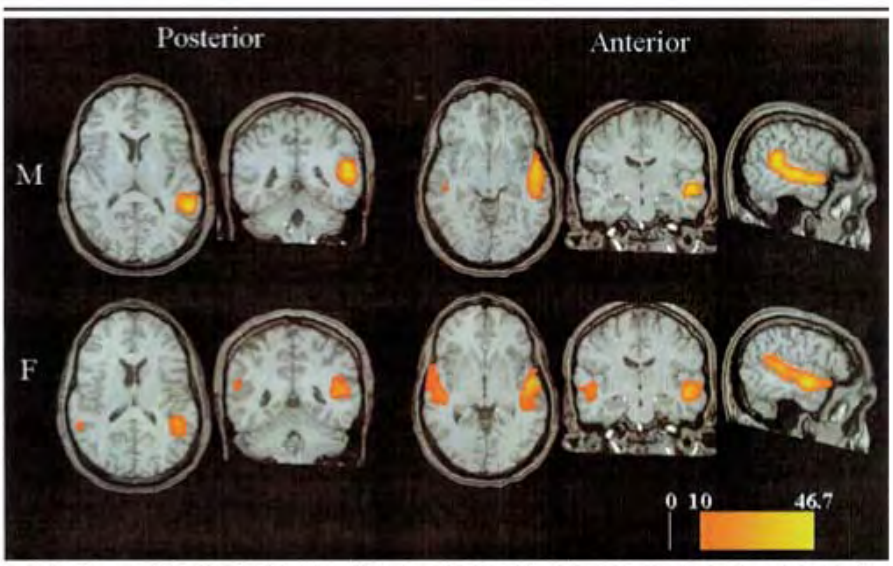


Figure 3. Combined subject activation data for 10 men (top row) and 10 women (bottom row) show both anterior and posterior temporal lobe activation at a threshold of 10^{-10} (see color bar, lower right). Men demonstrated markedly asymmetric activation, whereas women tended to show more symmetric temporal lobe activation.

Fig. 6: From Phillips et al. (2001), p. 220. Brain activation during language perception task, men above, women below.

This picture shows the brains of women (below) and of men (above) during a language task. The main criterion of difference in language fMRI-experiments is `bilaterality`, that means an activation on both sides of the brain in women, and `laterality` that means an activation only in the left side of the brain in men. Strikingly, our social notions of women as having `networking` characters, and men, as being `analytical`, acquire a neuroanatomical reality. In females networked and interconnected activation occurred in both hemispheres and a men focused activation only occurred in on one side. Having investigated all published studies on activational differences between women and men in language fMRI-experiments, I conclude that all of them reveal without any exception use `bilaterality` or `laterality` as *traits* of differentiation, i.e. as a characteristic to distinguish between female and male language activation in the brain.

In the context of differentiating one group of subjects from another there is a bias: some results are being published more frequently than others. Articles that significantly demonstrate differences between the genders are commonly published more often than those not showing any difference. This scientific fact depends on the politics and logics of detecting and proving differences in science.[14] Studies demonstrating similarities, or not demonstrating any differences, will get less scientific recognition.

[14] Dickersin, K. and Min, Y. I.. Publication bias: the problem that won't go away. Ann N Y Acad Sci 703 (1993), 135–46.

Finally, an example of my own research.

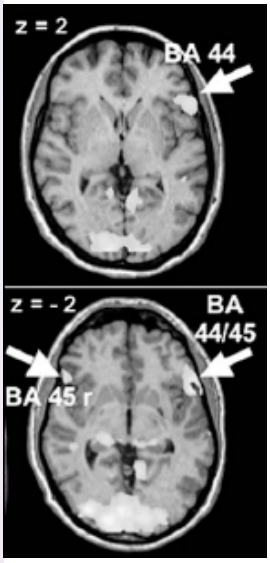


Fig. 7: From Kaiser et al. (2006; in print): Women's lateral and men's bilateral activation.

My study focuses on *Geschlecht* and language in fMRI research. We explore the question of similarities and differences in 22 men and 22 women, respectively, in a fluent narration task. In women, a left-lateralised activation concentrated was in BA 44 while in men activation was more frontal in BA 45 and more often bilateral. This result is the opposite of those shown so far. We argue that the *Geschlecht* differences in the brain should be regarded much more critically, due to numerous variables interacting and thus becoming confused with *Geschlecht*. Our study, too, cannot solve the controversy on the existence of *Geschlecht* similarities and differences in fMRI-language investigations. In this study I still operate with a binary *Geschlecht*, though showing a reverse *Geschlecht* pattern may relativise the bilateral and lateral fixation of fMRI-language studies. This remains of the work of feminist scientists who have been working within a scientific frame, always interested in desequilibrating expected *Geschlecht*-related expectations in the brain. For instance Ruth Bleier's study *Variations in Human Corpus Callosum Do Not Predict Gender: A Study Using Magnetic Resonance Imaging* from the year (1988).

Conclusions

Focusing on a few examples, I have shown how neuroscience explicitly and implicitly operates with *Geschlecht* in its experimentations. I have also tried to demonstrate the linkage between the neuroscientific notion of *Geschlecht* and the measured variables. In my view it is crucial to highlight the experiment as such, as it seems to be the moment when implicit presumptions on *Geschlecht* are transformed into a measurable and concrete research materiality.

The question of the materiality of *Geschlecht* is an old question (see, for instance Duden 1991, Butler 1993, Haraway 1995). However, this paper was meant to present a new version of this old problem. A version that shows how a `gap-worker` is trying to understand both, what is going on during an experiment inside the lab and what is going on outside during the deconstruction of *Geschlecht.* In order to finally take the deconstructed *Geschlecht* a step further into a `constructive` experiment. With this aim in mind, I am in the middle of one of the biggest debates between science and humanities, namely the debate on thinking and doing *materiality*. I know there is much to research in this epistemological gap where two antagonistic understandings of the material body come to clash: on one side a deconstructionist, ahistorical, and antiessentialist understanding situated at the symbolic level (as suggested by Foucault or Butler) and on the other an empirically constructing, contextualized and deterministic understanding at a materialistic level (as proposed by Fausto-Sterling).

The experiment itself could be the point of departure of a gender studies-oriented critique of gender biases and heteronormativ predictions and conclusions without making science ridiculous. It is not science itself, but the way of doing science that should be addressed by feminists and gender-concerned researchers.

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