Re-Conceptualizing "Sex" and "Gender" in the Human Brain

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Abstract. When is an observed dissimilarity between brains of females and males a "sex" difference and when is it a "gender" difference? The aim of this conceptual paper is to pinpoint the understandings of "sex" and "gender" within neuropsychological research, as these terms implicitly lead to overlapping and nonspecific associations when variables concerning female and male characteristics are operationalized. Also, it is argued, following a central approach within gender studies, that it is impossible for the variables of "sex" and "gender" to be categorized as solely biological or solely social components or to be measured or recorded as such, and for this reason, they should in fact be regarded as a unity and designated as *sex/gender*.

Keywords: sex, gender, neuropsychology, similarity, sex/gender

Although the question of a "sexed" brain has been a subject of study for over a century now, a comprehensive description of what constitutes the female and male brain remains elusive. So far, numerous "sex" and "gender"[1] (dis)similarities have been examined in neuropsychology (for reviews see Cahill, 2006; Hines, 2004; Kaiser, Haller, Schmitz, & Nitsch, 2009). However, little attention has been given to unbiased conceptualizations about what a female and what a male brain is. In this conceptual paper, I argue that although the sex-gender debate has left its marks in neuropsychology, neuroscientific terminology around "sex" and "gender" has yet not been clearly defined, which leads implicitly to overlapping and nonspecific associations when variables are operationalized and experimentally implemented. I also argue, following one of the central approaches within gender studies, that it is impossible for the variables of "sex" and "gender" to be categorized either completely into a solely biological or a solely social components or to be measured or recorded as such, and that for this reason they should in fact be regarded as an inseparable unity (Fausto-Sterling, 2000; Haraway, 1990) and named *sex/gender*. I will organize these arguments as follows. Firstly, I will briefly introduce the debate of "sex" and "gender," which is undoubtedly part of a broader debate between disciplines. Secondly, I will explain the implications of this debate for empirical neuropsychology. And thirdly, I will argue that in neuroscience, there is something approaching an unwritten convention by which "sex" differences are associated with reproductive areas and "gender" differences with cognitive functions of the brain. This implicit assumption, though, does not necessarily help us to clarify whether there are truly "biological determined" versus "socially acquired" brain patterns in women and men. It does not provide a reasoned account for where "sex" ends and "gender" begins in our cerebral organ. I will conclude the article by presenting current neuroscientific work on this domain and by suggesting the consistent use of the term *sex/gender* instead of "sex" or "gender."

The Sex-Gender Debate

The subject of "sex" and "gender" itself constitutes a debate, insofar as in numerous research fields throughout the disciplines, there is no firm consensus on whether "sex" or "gender" is being examined. Dissimilarities between women and men or in female and male behavior are sometimes stated as differences of "sex" and sometimes as differences of "gender." To give an example, we find studies obviously examining the same neuropsychological phenomena of structural differences in brains of women and men using the term "sex" (e.g., Gur et al., 2002) in one case and "gender" in another (e.g., Lüders, Narr, & Thompson, 2004). What might seem to be terminological indecision may reflect a deeper uncertainty about how the many observed differences between women and men originate. For instance, there is some disagreement whether a difference in behavior found in women and men should be attributed to "sexed" brain patterns, or conversely, the "sexed" brain should be explained by differences in behavior (Schmitz, 2011). In the context of this dispute and especially in the past, the notion of "the biological" as being

[1] The terms "sex" and "gender" are placed in quotation marks because – by the author of this paper – they are not seen as separable entities for the field of neuropsychology.

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something permanent was very common. In that view, "the biological" was understood as a deterministic matter of fact with little chance of convertibility. Today, bio-materiality is perceived as "in the doing" – we know that the brain can increase its neuronal response strength, can augment its synaptic density, and can expand its representation across cortical areas throughout life (Jäncke, Gaab, Wüstenberg, Scheich, & Heinze, 2001) – all of which are subsumed in the concept of *neuronal plasticity*. Researchers from biosciences operating with the biological matter always knew that brains are not the result of inborn, hardwired, or unchanging biological processes, but instead are responsive to ongoing external and social experiences, like those related to "gender." The brain is not only open to "gender" inscriptions; "sex" differences can also be regarded as mutable and attributable to changeable dissimilarities in cerebral organization (Jordan, Wüstenberg, Heinze, Peters, & Jäncke, 2002; Jordan-Young, 2010). It becomes obvious that the debate of "sex" versus "gender" still persists – and that it is undoubtedly part of a wider nature-versus-nurture discussion that has been so prominent in psychology ever since the 1970s (e.g., Bronfenbrenner & Ceci, 1994).

By definition, in many research contexts "sex" is set apart from "gender" – this conceptual separation can be ascribed to the work of gender scholars as early as de Beauvoir (1949). For many investigators, "sex" is clearly a product of genes and/or hormones, with biological manifestations that are dichotomous and permanent, whereas "gender" is a category that describes "gendered" behavior and social interactions, and is more flexible. Certainly, "gender" roles and "gendered" social behavior in human beings are now generally seen as being changeable and capable of being acted out in quite variable ways.

As for different disciplinary fields, "sex" is investigated (and thus also defined) in biomedical subject areas, while "gender" is a topic of study in the social sciences and humanities. Problems arise however, where these groups of disciplines meet and need to coexist – and this occurs most prominently in psychology, a discipline which is defined as belonging to both the sciences and the social sciences/humanities. However, we can find unclear use of terminology even within the clearly defined context of single subjects, for example in biology where we should expect the use of "sex" in research on animals. "Do mice have 'gender'?" one may ask when stumbling across this term in the literature about mice (e.g., Blumkin, Levav-Rabkin, Melamed, Galron, & Golan, 2011; He, Ma, Kim, Nakai, & Yu, 2008).[2] This can be seen in papers not specifically concerned with behavioral features of mice, in which the use of "gender" might be felt to make more sense. Similarly, it can be asked if "gender" is the right expression for sociologists to use when describing female or male physical/anatomical characteristics, even if they are defined as inscriptions of social circumstances such as individual experiences of "gendered" power relations in our society (Jaworski, 2002).

Theoretically, the sex-gender debate escalated in the 1990s when the "sex" versus "gender" dichotomy in gender studies was deconstructed, thereby abolishing the necessity to separate these categories (Butler, 1990, 1993; Maihofer, 1995). The new paradigm postulated that "gender" discourses and material "sex" were inseparable. "Sex" was said to be "gender," though this was not intended to mean "sex" (and "gender") do not *exist*, but rather that when investigating "sex," researchers always have knowledge about "gender" leaving traces on what is supposed to be a genderless and neutral biology (Fausto-Sterling, 2000; Haraway, 1990).

Implications for Empirical Neuropsychology

What does this all mean for the brain, though? Does it mean that differences found in the brains of women and men can also be social differences? Or does it mean that it does not matter which term we use, because this category cannot be separated into social and biological characteristics anyway and has thus to be regarded as unity? Or does it mean that a biological "sex" difference in the brain can never be purely biological, because no biological organism can originate, develop, and stay alive without an environment, so that biology is always intrinsically interactive? And finally, how does terminology influence what we describe as biological versus social?

The following two examples express the difficulty in trying to segregate what is, instead, inseparable. About 20 years ago, the research of LeVay (1991) compared homosexual and heterosexual men and showed that the INAH3 is almost three times larger in heterosexual men than homosexual men (where it can be completely absent). What is this about? It is undoubtedly about the plasticity of the brain, but does it concern "sex" or "gender"? What causes this difference, which at the time was considered characteristic of the two groups? Is it a genes-driven determinant or the result of a difference in life and love style? The other example of terminological and conceptual difficulty can be found in the neuropsychology of spatial cognition. Mental rotation is an example of a well-validated paradigm that shows robust differences not only in performance (e.g., Lippa, Collaer, & Peters, 2010)[3] but also in the brain between females and males (Roberts & Bell, 2000, 2003; Johnson, Mckenzie, & Hamm, 2002; Jordan et al., 2002; Weiss et al., 2003a, 2003b; Seurinck et al., 2004). Should these neurobiological variances be called "sex" or "gender" differences and how does this influence their treatment as biological and social phenomena? And: What implications does the choice of one or the other term have for the understanding of biological and social determinants in spatial orientation of men and women in neuroscience?

[2] Although this article does not focus specifically on this aspect, it would be interesting to find out more about the history of the use of the terms "gender" and "sex" in biological and medical texts, which should be accessible to corpus analysis.

[3] In opposite to these robust *sex/gender* differences in mental rotation, *sex/gender* differences in the field of spatial orientation, though, have been reported to be more variable (see Coluccia & Louse, 2004).

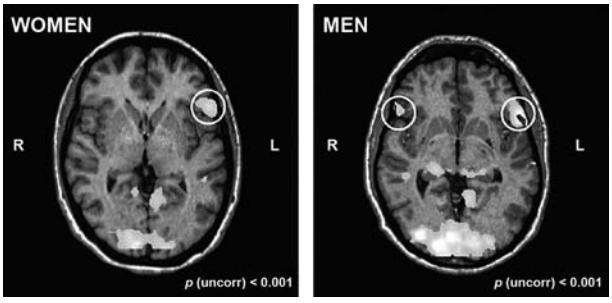

Figure 1. A simple question, a hard answer: Is this a "sex" difference or a "gender" difference? Image from Kaiser et al. (2009) depicting functional activation during an fMRI language production task in two different groups, females and males. Particularly in the case of language production, previous gendered language socialization as well as the social situation of experimentation could have led to (implementing) differences in the brain of females and males. Thus, this cerebrally materialized difference has to be considered as a unity of "sex" and "gender."

Figure 1 illustrates one critical aspect of these questions and the author's understanding of *sex/gender* as a unity. By asking whether a depicted dissimilarity between females and males is either a "gender" or a "sex" difference while framing this very question by a visualization of this "real" dissimilarity, the author not only intends to remind the reader that the "sex" versus "gender"-question is still unanswered. More than that, she aims to raise the reader's awareness of the fact that the brain image represents a biological fact but that it is not compulsory to choose "sex difference" as the correct term. If something has a biological materialization, this can be the result of social processes – and this is how unity can be understood – particularly for the described example of language processing in Figure 1. Also, a brain image is never the biological specimen itself but always a visualization of it: and in science we should always remember that we are *representing* biology rather than capturing it pure and untransformed (Fitsch, 2011; Nikoleyczik, 2004).

Some other aspects should be borne in mind. Why does the neurobiological approach to questions of "gender" always focus on *differences* when we are aware that, as shown, for instance, by Dickersin and Min (1993), Hyde (2005), and Fine (2010) and many others, it is misleading to place too much importance on differences instead of non-differences? In neuroscience, knowledge of "sex" and "gender" specificities is derived through the matrix of *difference*. Immediately after conducting the neuroscientific experiment itself, the registered "gendered" data are transformed into abstract information in the form of dichotomous classification as numerical matrices, from which groups of data classified as "F" (for female) or "M" (for male) are generated. These registrations and classifications, done here as a matter of course, determine the further evaluation of data analysis in particular. From this point on, "sex" or "gender," respectively, is merely a binary code (Imboden, Kaiser, & Ratmoko, 2007). Although approaches such as the *gender similarities hypothesis* definitely exist (Hyde, 2005), the emphasis on detecting differences still dominates the whole field.

When it comes to classifying women and men in neuropsychological empiricism, the variable describing female and male (neurobiological) characteristics is implicitly and automatically recorded as "sex": for its verification, only the name or physical appearance of the test subject is usually used (Imboden et al., 2007). Other aspects of information on biological "sex," much less social "gender" of participants, are not normally checked or recorded.

"Sex"- and "gender"-specific aspects have been debated many times with explicit reference to their neurobiological manifestations and with a direct reference to their factual existence in the brain. Although numerous studies on "sex" and "gender" do show "sex" and "gender" differences rather than non-differences (for a review see Kaiser et al., 2009), a tendency toward "sex" and "gender" similarities can be observed in the last years. Figure 2 illustrates – for the example of fMRI language studies – that differences have been constantly demonstrated throughout time whereas similarities were principally revealed in the last years. We find publications demonstrating differences between females and males in innumerable functional studies (for a review see Hines, 2004). An example of neurobiological correlates while experiencing selective satiety (of chocolate) demonstrates how female regional activation is found, among others, in the amygdala while most of the regional activation detected in men was revealed in fronto-cortical areas (Smeets et al., 2006). In language studies, female brains tend to exhibit "networking" characteristics, that is, activation occurs in language areas bilaterally in both hemispheres, while men have relatively "focused" or "analytical" activation, with left-lateralized patterns (Baxter et al., 2003; Kansaku, Yamaura, & Kitazawa, 2000; Phillips, Lowe, Lurito, Dzemidzic, & Mathews, 2001). Is it possible that these two examples reflect social "gender" stereotypes in the brain?

Implicit Assumptions on "Sex" and "Gender" Can Be Found in Neuropsychological Literature

So far we have seen that "sex" and "gender" are strongly entangled with each other, terminologically and conceptually. However, these terms are often implicitly separated and tacitly associated with different research fields as well as applied in distinctive thematic contexts. When this is the case, the choice of using "sex" and especially "gender" is based on general knowledge and not on theoretical gender studies about what women, men, and "gender" roles "are" or are supposed to be. This is how multiple associations and assumptions of the "biological sex" versus the "social gender" are superimposed on the brain. We will sketch two of these assumptions: (1) The understanding of "sex" as something highly linked to the neurobiological correlates of reproductive functions and "gender" as a notion usually found in the context of cognitive neuronal patterns. The gist of "sex" equals reproductive capacity and sexual functions and "gender" equals cognitive

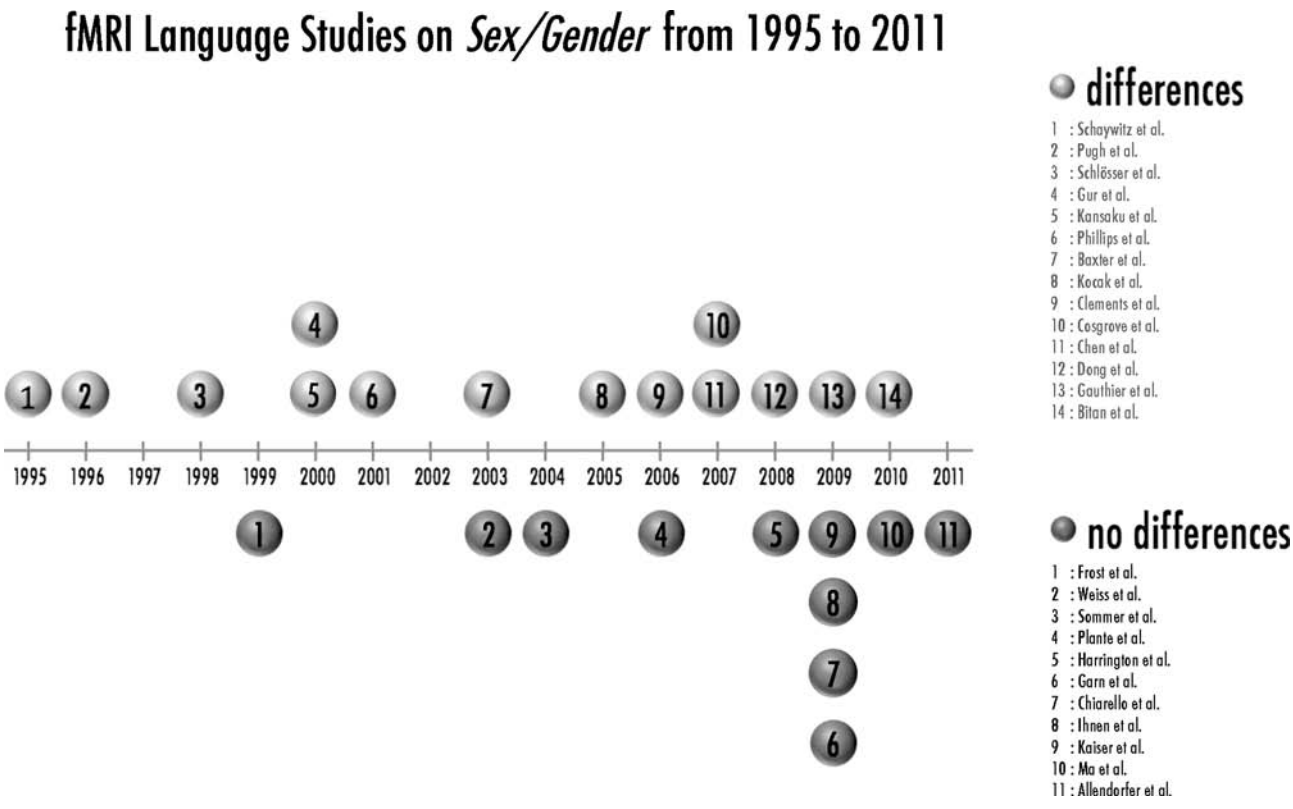

Figure 2. This figure lists the articles examining the variable of *sex/gender* in fMRI language research since the first study on that topic was published in 1995. Most (14) studies (light gray) demonstrate *sex/gender* differences (in terms of "bilaterality in women" and "laterality in men"), fewer (11) demonstrate no differences (dark gray) between females and males with regard to lateralization. However, a clear tendency toward similarities can be observed: While "difference-studies" have been published continuously from the beginning throughout time, the number of "similarities-studies" has grown in the last years. These data were compiled on the basis of a systematic PubMed search of key words, titles, and abstracts (keywords: "functional Magnetic Resonance" and "Language" and "Sex" plus "functional Magnetic Resonance" and "Language" and "Gender"). A paper-by-paper qualitative evaluation was performed to decide whether the question of *sex/gender* was examined based on a clear a priori hypothesis and not as a by-product (Kaiser et al., 2009). Clinical studies were excluded. The evaluations were done by the author of the present paper.

abilities reads: *There are some actual "sex," i.e. reproduction-linked, differences in the brain.*[4] *Cognitive performance is profoundly shaped by the environment and influenced by learning and socialisation. Therefore, the latter is a question of "gender."* Based on this distinction, it can be argued that (2) "sex" differences in the brain are quite uncontested – because reproductive capacities are clearly distinct between females and males – whereas "gender" differences in the brain are much more debatable. Because socialization may affect cognition rather than reproductive capability, biological "sex" differences seem to be clear and evident whereas "gender" differences are perceived as much more dependent on the environment.

To illustrate these points, I will quote an excerpt of a newspaper interview with a neuropsychologist (N). Of course, this is not meant to imply that this example reflects the thinking of all neuropsychologists. But the text does allow us to discursively describe a tendency in the understanding of "sex" and "gender" differences, and their relation to each other in neuropsychology. What the expert says in the interview is the following:

> N: "Everything else that becomes manifest on a cognitive level, like that women can't read maps and men don't listen[5] (...), these are all secondary, tertiary or even quaternary effects. They are biologically irrelevant. There is no biological background whatsoever that makes women slower in mentally rotating an object."

[4] The relation between reproduction-linked differences and cognitive performance is a matter of research (e.g., Andreano & Cahill, 2009; Hausmann et al., 2009).

[5] This is an allusion to a popular book by Allan und Barbara Pease entitled *Why Men Don't Listen and Women Can't Read Maps: How We're Different and What to Do About It* (2001).

I: (Then what?)
N: "It has to do with other interests or a lack of practice (...)"
I: "And the congenital emotional differences you acknowledged before, you attach no importance to those?"
N: "Yes, they are relevant mostly when selecting a partner (...)"
I: "Are these different reproductive strategies still relevant today?"
N: "Absolutely. All data indicates this. Women choose partners mostly for their status, that's why men are on average five years older than their wives and have a higher income. (...)"[6]

As we can see, an evolutionary-biological understanding still plays a predominant role in explaining partner selection, but apart from that we can understand that training obviously takes on a significant role in learning mental characteristics – in women as well as in everybody. Unlike subcortical "sexual" functioning – argued to be prenatally determined – it is easier to discuss cognitive differences between women and men as being influenced by social learning. And as the social environment plays a crucial role in cognitive performance, in my opinion, scientists often advance the separation of "sex" meaning different reproductive function and "gender" meaning similar cognitive performance between women and men, while hardly ever reflecting theoretically or conceptually on the implications that arise from this separation of "sex" and "gender" in the brain. Further tangible examples showing this tendency in the use of these terms can be found for "sex" in Allen, Hines, Shryne, and Gorski (1989), Giedd, Castellanos, Rajapakse, Vaituzis, and Rapoport (1997), Hofman (1998), Takahashi et al. (2006), and Savic and Lindström (2008) and for "gender" in Buckner, Raichle, and Petersen (1995), Klein et al. (2003), Lüders et al. (2004), and Feng, Spence, and Pratt (2007).

Conclusions

I have shown that there is a broad ambiguity in terminologically classifying and accurately defining "sex" and "gender" in neuropsychology, which reflects the effective problem of validly recording these variables as phenomena in between biological and social facts. There is a need to think clearly about what is meant to be regarded as female and male – and everything in between – when measuring "sex" and "gender" in neuropsychological experimental settings.

Others too have approached these issues. Most recently, Joel (2011) remarkably and systematically demonstrated why the categories of "female" and "male" require a theoretical, and consequently also an empirical revision in neuroscience: she explains how "sex" and "gender"-related factors interact in utero and throughout life in a highly complex way, resulting in a "multi-morphic," rather than a "dimorphic" brain with respect to the classification of female and male. Thus what we actually observe neurobiologically is a permanently changing heterogeneous mosaic of "sex" and "gender" characteristics on a continuum, rather than only one "female brain" or only one "male brain" (Joel, 2011). Similarly – though not as extensively – in a study on the morphology of the ventral frontal cortex, other neuroscientists demonstrated the importance of classifying femininity and masculinity on a spectrum (Wood, Murko, & Nopoulos, 2008). These authors were able to show correlations between cortical morphology, social perceptiveness, and the degree of femininity, not only in females but also in males. More precisely, Wood et al. showed that ventral frontal cortex morphology is not simply a function of "sex," but that there can be a "correlation between SG [straight gyrus] size (. . .) and quantification of femininity/masculinity in each gender individually" (p. 537). Taken together, the conclusions of these two studies are twofold. First, concepts of a discrete and permanent "femaleness" and "maleness" in the brain have to be revised. Secondly, as Wood et al. demonstrated, "sexed" patterns in the brain can be contrary to gender: female neurocortical biomarkers have been found in men.

It was the aim of this paper to fundamentally differentiate the very conceptualization and operationalization of what is usually denominated as distinctive, evident, permanent, and dichotomous: the factor "sex" and "gender." This article is surely just the beginning of further and long overdue work on this topic. Nevertheless, to express the difficulty in defining a clear-cut distinction between "sex" and "gender," terminologically as well as neurologically, I suggest using the double term *sex/gender* wherever applicable to express the impossibility of separating one term from the other (Bluhm, 2011; Dussauge & Kaiser, 2012; Kaiser et al., 2007, 2009). This suggestion is clearly in line with current knowledge of neural plasticity, which indicates that biological components of observed differences in brain functions and structures cannot be detached from social experience. Interestingly, a very similar neologism (*gender/sex*) made out of these terms has also been suggested by others. In their study on hormones, van Anders and Dunn (2009) argue that biological data can reflect innate as well as socialization-related influences and that adult measures of behavior cannot clearly differentiate between "gender" or "sex."

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