Sex and/or Gender?
Some Neuroscientific Approaches

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ABSTRACT

Traditionally, Gender Studies differentiates between the term "sex", indicating sex differences from the biological point of view, and the term "gender", indicating that sex differences are social and cultural constructions. In this paper I discuss some recent neuroscientific theses concerning sexual differences to sketch a path of inquiry that goes beyond the logic of the separation of biological and cultural studies.

I. Introduction: The Seduction of Neuroscientific Explanations

It can hardly pass unnoticed that today's TV-shows, magazines and book shops often direct our attention towards information that correlates classical philosophical problems – e.g. concerning ethics, aesthetics, economics or differences between the sexes – to the physiology of our brains. In a recent article entitled *The Seductive Allure of Neuroscience Explanations*, Skolnick Weisberg et al. have investigated the question of whether the non-expert public tends to take proposed explanations of psychological phenomena which make explicit reference to neural processes to be more credible than explanations which do not include such reference.[1] In order to answer this question, the Skolnick Weisberg research group has presented a sample of non-expert subjects with explanations of some specific psychological phenomena and patterns of human behaviour. The results of this study lend support to the hypothesis that adding pieces of neuroscientific information to an alleged explanation of a given psychological phenomenon tends to make that explanation more acceptable or credible to non-expert subjects – even

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[1] See Skolnick Weisberg, et. al, 2008.

when the neuroscientific information that is added is logically irrelevant to the explanation. In other words, the study conducted by Skolnick Weisberg et al. suggests that persons who have no or little neuroscientific training – i.e. the majority of us – tend to give greater credence to explanations of psychological phenomena when they include neuroscientific vocabulary,[2] and that there exists a tendency to attribute greater veridicality to neuro-biological explanations of psychological and behavioural phenomena. A similar point is stressed by Cordelia Fine in her book *Delusions of Gender*. In her words:

> There's something special about neuroscientific information. It sounds so unassailable, so very ... well, *scientific*, that we privilege it over boring, old-fashioned behavioural evidence. It brings a satisfying feel to empty scientific explanations. And it seems to tell us who we really are (Fine, 2010, p. 168).

The contemporary popularity of the neurosciences does not, of course, depend solely on their efficient presentation in the media. If one follows the history of philosophical thought one can notice that already in the first half of the 19th century there began to form a tendency that took the mind – today: the brain – to be the foremost object of philosophical thought. Today, more than ever before, scientific research produces results which seem to force us to reconsider wide areas of our traditional knowledge. Mental states, emotions, our perception of the artistically beautiful – phenomena which in the past have commonly been taken to resist complete scientific explanation – have become objects of scientific experimentation and theorizing. Moreover, the presentation of neuroscientific results is often accompanied by visual representations of the brain regions that react to specific stimuli, suggesting a strongly mechanistic image in which the entirety of our experience is traced back to specific brain regions which then appear to become the complete cause of a given function or psychological effect. The scope of neuroscientific research has grown considerably since the second half of the 20th century. Today it ranges over practically all areas of knowledge and it includes one of the most obvious, but at the same time most problematic, aspects of our everyday lives, namely that of sexual differences.

In this paper I will discuss some recent neuroscientific results concerning sex/gender differences in order to show how – once freed from certain misconceptions and stereotypes – they can help us redefine the meaning of the

[2] See Legrenzi & Umiltà, 2009.

term "sex/gender difference" and reconsider the thesis that sex and gender are two distinct and separate categories. Gender studies have traditionally distinguished between sex and gender, taking "sex" to be a biological term and "gender" to be a culture related term. By contrast, Feminist studies have preferred the term "gender" to emphasize that culture has an influence on the way we shape femininity and masculinity. In biological contexts, the term "sex" is mainly used to underscore the material and physical aspect of sex differences. In general, "gender" is used to describe the socially constructed aspects of sex-differences; "sex" is used to refer to the differences in terms of the physical and biological. Since I think that considering the terms "sex" and "gender" in a totally separate way is not advantageous for the understanding of sexual differences, in this essay I will use "sex/gender difference" not to assimilate the two terms, but rather to highlight their reciprocal interdependence.

II. Neuro-Gendering *versus* Neuro-Sexism

In what ways can the attention paid to neural processes and the attempt to provide scientific explanations of human behaviour influence or, perhaps, even add to the explication of sex and gender differences? The question that here comes into play is a venerable one. It regards the well worn but far from resolved dispute over the distinction between sex and gender or, more generally, between human nature and human culture.

The distinction between human nature and human culture has been the object of debates, which range back to the historical roots of western philosophy. The locus classicus is Aristotle's distinction, in the *Nicomachean Ethics*, between *zoé* and *bios*, i.e. between the life (*zoé*) that is common to all living beings and the life (*bios*) that is peculiar to human beings and which is constituted by the choices and practices of an individual or group of persons. Culture, according to Aristotle, is that which permits human beings to transcend the state of nature and to create a politically organized community, a *polis*. The term "human nature" is traditionally understood to refer to features of our lives which are simply given as invariable and beyond the range of what we can control or change according to the choices we make. The term "culture", by contrast, is often taken to denote those aspects of our lives which

are matters of locally variable conventions and which, as such, are in principle open to critique and change.[3]

In our context the distinction between what's natural and what's cultural translates into the following question: are sex/gender differences mainly the products of socialization and education within a particular social context with its specific cultural practices (constructivism) or do they rather derive from our biological make-up and are thus in some sense simply part of the "natural order" of how things are (biologism)? I will here not try to offer a solution to this dispute which, for its complexity, is difficult to reassume even in its main outlines.[4] In what follows, I will rather offer a brief sketch of the state of the current neuroscientific debate in order to then argue for the thesis that accepting either the constructivist or the biologist line of explaining sex/gender differences as correct and complete can lead to problematic and, in some cases, even dangerous ideological consequences for our social lives.

Arguably, if we considered both sex/gender differences as reducible to biological differences, any attempt to change institutionalised gender hierarchies would run 'against nature' and would therefore ultimately be doomed to failure. In this vein, Fine argues that «there is evidence that a stronger weighting of genetic influence on behaviour is associated with greater moral tolerance of the social status quo» (Fine, 2011, p. 8). Nevertheless, if we considered sex/gender differences as purely cultural constructs we would have to deny, implausibly, that biological research has anything interesting and relevant to say about the issue. I think that, for different reasons, both positions are unacceptable.

Relying upon techniques of brain imaging (fMRI), contemporary neuroscientific research provides evidence for the claim that it is, to say the least, inexact to maintain that the physiological make-up of our brains is fixed and not susceptible to change.[5] The new technologies, in fact, «have revealed the role of the environment in continually re-shaping our brain along our lifetimes as it goes through new experiences and acquires new knowledge» (Vidal 2011, p. 1). Even though it seems now indisputable that there is

[3] See MacCormack & Strathern (Eds.), 1980; Descola, 2003; Origgi, 2007.

[4] See Fausto-Sterling, 2000; Connell, 2002; Bourdieu, 1988; Vanni Rovighi, 1995; Tripodi, 2011, in particular pp. 36–52.

[5] The most important examples of these new techniques are Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (fMRI). Both techniques do not only provide images of the cerebral structure but also information regarding the functioning of our brains in that they allow us to identify, given different stimuli, which brain regions, show greater or lesser neural activity.

significant interplay between nature and culture and that the traditional dichotomy between the two cannot be upheld, one cannot help but agree with Lesley Rogers, when she observes that:

> In the recent past, people have tended to take up one or the other extreme position, some people believing that genes have a pre-eminent role, and others that social or environmental factors are overwhelmingly important (Rogers 2001, p. 2).

In the current debate, however, there are also authors who, as for example Catherine Vidal, argue for a theoretical reconciliation of the two positions. Beginning with *Cerveu, sexe et pouvoir* (2005), Vidal has pursued the aim of spreading knowledge of neuroscientific results concerning sex/gender differences and providing critical analyses of these results. Her goal is two-fold, as she wants to «provide evidence against archaic beliefs about the biological determinism of sex differences but also promote a positive image of scientific research» (Vidal, 2011, p. 9).

Since the discovery of brain plasticity lends considerable scientific support to the claim that the environment can have a modifying effect upon cerebral physiology and, therefore, that the brain's physiology is itself susceptible to change, one might ask whether it still makes sense to stick to the clear cut theoretical distinction between biological and cultural factors which lies at the basis of the dispute between constructivism and biologism. Rather, some of the results of neuroscientific research seem to call for a re-evaluation and revision of both approaches. This re-appraisal appears to be all the more urgent because – as Fine and Rogers have argued – theories that purport to show immutable sex differences within the make-up of the brain do not only tend to have an influence on how we perceive ourselves and others but also to consolidate prejudices and stereotypes concerning the sexes.[6]

A similar point applies to the theoretical interpretation of experimental results by science journalists, philosophers and, not least, by the scientists themselves. The interpretation of scientific experiments concerning biological differences between the sexes is a risky business because, under the guise of an alleged impartiality, there often linger prejudices and clichés whose contents are then "interpreted into" the experimental results and thus provided with a "scientific justification":

[6] See Rogers, 2001, p. 8; Fine, 2011, p. 3; Fine, 2010, p. 172.

> The idea that biology is a major determining factor for cognition and behavioural gender differentiation, is still very much alive. The media are far from being the only guilty party. Some scientific circles actively promote the idea of an innate origin of a gender difference in mental capacities. Experimental data from brain imaging, cognitive tests or genetics are often distorted to serve deterministic ideas. Such abuse of 'scientific discourses' have to be counteracted by effective communication of clear and unbiased information to the citizens (Vidal, 2011, p.1).

In order to avoid misunderstandings, I here want to stress that I neither intend to doubt the legitimacy of using neuroscientific methods in order to broaden our knowledge concerning the sexes nor to deny that there exist sex differences between the cerebral and functional structures of different individuals.[7]

Rather, my aim is to argue for a critical stance with regard to some neuroscientific explanations of sex differences which, in some respects, over-interpret, misinterpret or even manipulate the experimental results which they rely upon.[8] For this purpose, I here suggest a brief reconsideration of some relatively recent studies which investigate the neuro-biological bases of sex differences. In particular, I will consider three well known areas in which neuroscientific explanations have been proposed: 1) language skills; 2) spatial cognition and 3) the influence of hormones on the brain.

III. Language, Spatial Cognition and Hormones: What Makes the Difference?

1. Although it may seem problematic and controversial, the view that there are sex-related differences in the faculty of linguistic communication is widely held by many neuroscientists. «There is some evidence, for instance, that language may be processed in different parts of the brain in women and men,» and it seems that women elaborate certain aspects of language use in both brain hemispheres, whereas in men there exists a «bias to the left hemisphere» (Rogers, 2001, p. 18). Since the late eighties several studies have suggested that women, in comparison with men, on average have more pronounced communicative skills, while men seem to possess greater skills in the resolution of complex mathematical problems and a stronger sense of direction. The idea that women are more communicative and empathic than

[7] See Jordan-Young & Rumiati, 2011; Cahill, 2006.
[8] Similar points are made in Fine, 2010 and 2011; Vidal, 2011; Rogers, 2001.

men, and that men are more "rational" and "mathematical" than women is so ancient and rooted in our western culture, that it can count as a paradigmatic stereotype concerning sex and gender differences. As Fine points out, sex/gender stereotypes can be problematic because they are apt to «influence social perception in ways that are apparently unintended and unnoticed» (Fine, 2011, p. 3).

Evolutionary explanations of sex differences, on the other hand, suppose «that males and females have evolved different behavioural strategies to optimize their chances of successful mating» (Cahill, 2006, p. 480). Since Charles Darwin, in fact, it has been assumed that women generally possess more pronounced empathic and communicative capacities than men. This assumption – which has been extensively discussed by gender theorists – has also been put to the test in neuroscientific experiments. Baron-Cohen, for example, relying upon results obtained by means of fMRI, hypothesizes that «the female brain is predominantly hard-wired for empathy» and the «male brain is predominantly hard-wired for understanding and building systems» (Baron-Cohen 2003, p.1). Baron-Cohen's point is, of course, a statistical one: while it is possible for men to have a "female" brain and possible for women to have a "male" brain, on average more men than women have a "male" brain and more women than men have a "female" brain. Still, by interpreting his fMRI results with the help of the metaphor of "hard-wiring", he purports to lend scientific support to a stereotypical claim about sex/gender differences.[9]

This stereotypical claim – criticized strongly by Fine (2011) – can also be found in Helen Fisher's book *Anatomy of Love*. Fisher holds that women's presumed greater empathic and communicative skills are due to the particular physiology of the female brain, in which, or so Fisher claims, the nerve fibres which connect the two brain hemispheres (*corpus callosum*) are thicker and more interconnected than in the male brain. According to Fisher, by invoking the physiological structure of the "female" brain one can explain not only women's presumed greater capacity to understand the points of view of others but, at the same time, women's presumed propensity to apprehend new languages more easily than men (Fisher, 1992). It is, however, important to clarify immediately that Fisher's explanatory claims are laden with problems. In an analysis and critical review of 49 pertinent studies conducted in the eighties, Bishop and Wahlstein show that those studies provide no evidence for

[9] See Chizzola & Veronesi, 2011.

the thesis that there obtain a positive correlations between the volume of the *corpus callosum* and the number of nerve fibres or the intensity of brain activity.[10]

Arguably, the new technologies which are at the disposal of today's brain scientists make recent investigations of sex related functional and anatomical differences of the brain more reliable than the volumetric analyses of the past. A recent experimental study which *does* actually speak in favour of the thesis that there are sex related physiological differences between the brains of women and men has been published by a group of researchers based at the University Milano-Bicocca in the 2008 volume of the journal BMC Neuroscience (Proverbio, Zani, Adorni, 2008). In their experiment the group observed, again by means of fMRI, the brain activity of 24 men and 24 women while they were looking at images depicting persons and landscapes. The research group comes to the conclusion that, with regard to the case at hand, there are significant differences in the activation of brain regions in women and men. More precisely, the results of the study suggest that women react more quickly to pictures displaying social situations and that, in comparison with men, women are physiologically predisposed to take greater interest in other persons.

It must be stressed, however, that the advanced techniques which have been used in this study do not by themselves guarantee the epistemic legitimacy of generalizing its results in any significant way. After all, these results have been obtained with regard to a rather small sample of roughly 50 individuals. As Vidal reminds us, it is often the case that «when a large sample of subjects is analyzed the sex differences disappear» (Vidal, 2011, p. 4).

At this point, furthermore, it merits emphasis that even though the claims which have been brought forward in favour of the thesis that women possess more pronounced linguistic, communicative and empathic capacities than men or in favour of the claim that men possess more pronounced mathematical, analytical and constructive capacities than women are based – in one way or another – on empirical evidence. Actually, most of these claims have by now been contested on the basis of equally strong empirical evidence and therefore are the objects of ongoing controversial debates. The proposed refutations, however, usually do not excite the same amount of (scientific) media attention as their respective target claims. Presumably, this is the case because curiosity

[10] See Bishop & Wahlstein, 1997.

tends to prefer claims to novel knowledge over admissions of ongoing ignorance.

However this may be, the more important consequence of these observations concerns, I think, the fact that instead of pondering statistical averages we should direct our attention towards individual differences and peculiarities. With respect to language processing capabilities, for example, it seems not just more plausible, but more interesting as well, to pursue the hypothesis that

> the location of language zones [in the brain] varies considerably from one individual to the next. The differences between individuals of one and the same gender are so great that they outweigh any differences between the sexes. It appears that each individual has his own way of performing a language task (Vidal, 2011, p. 10).

2. Another very active area of research concerning neuronal differences between the sexes is the investigation of presumed sex related divergence with regard to spatial cognition. A recent study, conducted by Tim Koscik et al., about the performances of men and women in the task of mentally rotating three dimensional objects suggests that men often perform better than women in this exercise.[11] The study seems to lend support to the hypothesis that the sexual dimorphism in the cerebral structure lies at the basis of the more pronounced capacity in men with respect to the specific spatial cognition task of mental rotation. At the same time, however, Koscik et al. highlight in their paper that there is no reason to generalize from the better performance of men in this *specific* spatial-cognition task to an attribution, to men, of greater spatial cognition capacities in general. Despite the fact that Koscik et al. are very clear on this point, the results of their study have been misrepresented und misused by the media in order to offer bogus justifications for certain well known stereotypes concerning women's alleged incapacity to park cars or to read maps.

What Koscik *et* al.'s study *does* show is that women's performance *in the mental rotation test* tends to be weaker than men's and that men, on average, have more pronounced capacities with respect to the cognitive tasks involved in that specific test. As Koscik et al. make clear, however, this finding does not exclude the possibility that in other areas of spatial cognition women have greater capacities than men. There is empirical evidence, for instance, that

[11] Cf. Koscik, 2009.

women, on average, excel in remembering the precise position of objects in space. Furthermore, Koscik et al. lay emphasis on the point that their study should not be taken to lend evidential support to the claim that observable cognitive specialization in women and men is entirely innate, since socialization, training and traditional role allocations can have a significant effect as well.

Considering the results of studies concerning mental rotation capabilities in men and women, Vidal maintains that «[s]tereotype threats have a strong impact on performance»:

> [I]f before carrying out the 3D rotation test in a classroom, pupils are told that this is a geometry exercise, the boys will generally get better results. But if the same group is told that this is a drawing test, the girls will perform as well as the boys. These findings clearly show that self-esteem and internalization of gender stereotypes, and not biology, play a decisive role in spatial performance (Vidal, 2011, p. 4).

Neural structures and cognitive performances are not static but susceptible to change in correlation to various environmental parameters. There are studies, for example, which lend support to the hypothesis that specific forms of training as well as variations in situational context can enhance women's performance in the mental rotation test up to the point of reaching the same level as that of men's performance.[12] Individual experiences, social context, internalized stereotypes and training can have modifying effects on our neural circuits, and in this way they can contribute to the emergence of differences between individuals with respect to their competences and capacities in varying practical and cognitive contexts.[13]

3. The last example of neuroscientific research that I here want to consider concerns the questions of how hormones influence the brain and how this influence, in turn, can result in various sex-typed attitudes and behaviours.[14] These questions are not just interesting in themselves but gain further relevance by the fact that many "pseudoscientific" stereotypes about human

[12] Moè & Pazzaglia, 2006.
[13] Cf. Massa, Mayer, Bohn, 2005.
[14] A detailed explanation of how sex hormones influence the anatomic differences between men and women can be found in Cellerino, 2002, pp. 70–98. On this topic see also Rogers, 2001, who in the chapter "Hormones, sex and gender" questions the theories about the influence of hormones on sex-type behaviour, pp. 75–101.

behaviour are based on the issue of hormones, and also because hormones develop their influence in an intermediate area, on the boundary between nature and culture. Indeed, as Rogers puts it:

> On the one hand the X and Y chromosomes determine how the gonads will develop (into either ovaries or testes) and influence which hormones they will secrete (testosterone, oestrogen or progesterone) both before and after puberty. On the other hand the secretion of these hormones is influenced by factors from the outside environment. Certain experiences can change hormone levels (Rogers, 2001, p. 75).

The gonads begin to function at a very early stage of the ontogenesis and produce female and male hormones that are released in the blood. In the same way the hormones enter the brain and influence the formation of neuronal circuits that later on will be involved in reproductive functions: the female brain, for example, is characterized by particular circuits that are activated in order to enable ovulation.

In the course of her studies since the 1980s, Doreen Kimura – a well-known scholar of the cognitive differences between men and women – has come to the conclusion that there are structural differences between the female and the male brain and that these differences can be explained by divergent concentrations and functions of sex hormones in women and men respectively.[15] Inspired by Kimura's investigations, numerous recent studies have found the main cause for the behavioural differences between men and women in the presence of a high percentage of testosterone in men.[16] Vidal holds, on the other hand, that the juxtaposition of the activity of testosterone with that of estrogen leads to a simplistic view which in no way corresponds to biological reality (Vidal, 2005, p. 49), because there is reliable evidence that both hormones are produced in human beings irrespectively of their sex and that sex-related differences pertain only to the level of the concentration in which these hormones are present in the organism.

The question is rather complex in its details. However, it is certainly safe to claim that the brain plays a decisive role in controlling and regulating the levels of sex hormones secreted and released in the blood. The brain is able to "modify" these levels. Sometimes these modifications can be quite radical, as for example in situations of stress or suffering which are regularly

[15] Kimura, 1992.

[16] Cf. e.g. Bos, Terburg, Honk, 2010; Baron-Cohen , Lutchmaya, Knickmeyer, 2004.

characterised by increased levels of sex-hormones in the organism. In situations of calmness, on the contrary, the presence of sex hormones is much more limited.[17] The brain perceives and recognizes events that happen in the outside environment and it responds in different ways. Sometimes it «allows the level of sex hormones in the blood to change fairly markedly, as in the case of stress» (Rogers, 2001, p. 79). Taking into account this reciprocal exchange between brain and environment is fundamental because, as Rogers plausibly maintains, it can prevent misrepresentations and misconceptions of causal chains. While many studies of sex differences and hormones indeed take for granted that hormones are biological entities capable of modifying behaviour, relatively few take into consideration that «the causal chain may work in reverse, from behaviour to hormones to genes» (*ibidem*).

It's worth mentioning here, however, that the scientific data regarding the influence of sex hormones on the differences in male and female behaviour are rather limited. Kimura's experiments on rats have shown considerable behavioural differences depending on the presence or not of a high percentage of testosterone, but the same type of experiment done on primates has yielded inconclusive results. By now it has been shown that, while hormones can "interfere" with certain behaviours, they cannot be their constitutive cause. It seems rather that, in the course of evolution, the brains of the more advanced species have developed the capacity to withdraw – to some extent at least – from the "rule of hormones" and to regulate and "guide" sex-typed behaviours on an individual level.

The studies on hormones and neuronal receptors (proteins that have the task to recognize and absorb the respective hormones) indicate that, while hormone concentrations sometimes do have an influence on behaviour, it can also be the case that, vice-versa, behaviour affects hormone levels. This point should certainly be taken as highlighting the theoretical difficulties in any attempt to establish and fix certain sex-typed behaviours based on different hormone levels.[18] Moreover, it seems legitimate to ask whether the line of research just sketched, while certainly conducive to expanding our knowledge about human embodiment, is also apt to lend support to the claim that there are

[17] Cf. Rogers, 2001, p. 109.

[18] The problem of how to conduct reliable experiments on hormones is clearly illustrated in: Jordan-Young, 2010; on recent experiments on sex-type behaviour and hormones see also Vidal, 2011, pp. 4–6.

behavioural differences between the sexes which can be causally reduced to physiological differences. As one can see from the three areas of neuroscientific research which I have here briefly considered (language and communication abilities, spatial cognition and hormones), it sometimes may appear tempting to move from the claim that there is an observable correlation between differences in neuronal processes and differences in human behaviours to the assertion that behavioural differences are generally "caused" or "generated" or "produced" by neuronal differences. The inferential passage from the identification of brain areas that are activated in a particular experience or behaviour to the claim that this experience or behaviour can be explained by the activation of specific brain regions should be viewed with some suspicion – at least at the current state of research.

Furthermore, one has to be aware of the fact that the images of the brain that we see so far are instantaneous representations of brain functions which, as such, make it tempting to think that our mental states, our emotions, behavioural patterns and values *etc.* occupy precise and fixed locations in our brains. However, knowing which areas of the brain are activated during the experience of, say, tasting chocolate does not yet amount to knowing what tasting chocolate is like. To use a well known and somewhat disturbing image introduced by Thomas Nagel, even if a scientist that has never eaten chocolate in her life were to try and observe the experience of tasting chocolate by licking the brain of a chocolate-eating person (at the "right spot" as it were), she would thereby not succeed in getting to know, let alone in explaining, the phenomenal experience of tasting chocolate (see Nagel 1987, p. 30). What goes for licking might go for functional magnetic resonance imaging as well. And still, the power of the fMRI-images is such that we find it tempting to identify brain circuits with thought or cognition itself, to view the brain as the only valid «metaphor of thinking about what it is to be human» (Vidal, 2011, p. 2), and to think about behavioural and intellectual attitudes as fixed, crystalline and localizable in specific brain areas.

It is, however, important to stress that these temptations primarily concern the *interpretation* of the data provided by neuroscientific research and that, as with interpretations in general, there is room for variation. Taking a closer look at these data, they themselves can be seen as casting doubt on the idea that behavioural and cognitive sex differences can be traced back to cerebral difference.

IV. Gender and/or Sex? Plasticity Crossing the Dualism

When neuroscientists talk of the brain's plasticity, i.e. of the intrinsic propensity of the brain to modify itself in relation to external stimuli, they do not exclusively refer to cerebral structures in children but to those of adults as well. They use the term "plasticity" to denote a characteristic that live human brains possess independently of their respective age. While it is true that learning abilities are particularly pronounced during childhood years, there does not seem to be any biological obstacle to an adult person's having similar abilities. In this regard, a study conducted on London taxi drivers by means of fMRI has shown that the development of brain areas correlated to the sense of direction grows in proportion to the number of years that taxi drivers have been in service.[19] Furthermore, this study has shown that when regular training is interrupted the pertinent areas of the cerebral cortex slowly regress. Cerebral plasticity, therefore, is involved not only in the augmentation and increase of the neuronal networks which get activated by specific and regularly encountered stimuli but also in the regression of the respective neural connections when the activating stimuli are no longer present.

In the adult brain neuronal connections are subject to a continuous reorganization and modification, «the processes of formation and elimination of synapses are constantly at work,» and this continuous "autopoietic" activity of the brain would suffice by itself to lend strong support to the claim that «theories which postulate the existence of *innate* structural differences between the male and the female brain are unfounded.» (Vidal, 2005, p. 41, my translation) Learning a language, a musical instrument, or a particular profession etc. involve continuous changes in neural circuits. Bearing in mind that changes in the brain can result from experience and environmental inputs, it should not come as a surprise to find cerebral differences between male and female individuals – just as it is not surprising to find brain differences between persons of the same sex.

These last considerations might be taken to suggest that the discovery of brain plasticity is apt to lend strong support to constructivist theories which focus exclusively on culture and socialization while tending to neglect the biological basis of human life. The issue, however, is much more complex than radically constructivist theories would have us believe. Certainly one of the

[19] See Maguire, Gadian, et al., 2000.

positive aspects of the spread of neuroscience consists in its having increased the awareness of the possibility that the thesis «everything is socially constructed» might be too simple and thus might stand in need of criticism. Neuroscientific studies on the functioning of our brains suggest that much, but "not everything", depends on our education. By paying more attention to that "not everything", it might be possible to achieve considerable theoretical and explanatory progress with regard the issue of sex/gender differences.[20]

It is the very structures of our brains which show us that the two points of view, constructivism and biologism, need to be theoretically reconciled. While it is no longer acceptable to view the individual as a *tabula rasa* which, in the course of its life, gets engraved by experience, the idea that every peculiarity of our being is a consequence of innate physiological differences seems equally unfounded. The development of our brains is affected by both aspects. On the one hand, the environment is able to effect changes upon the brain, but on the other hand the brain does not undergo these changes in a completely passive manner, since its structures guide the "implementation" and "translation" of environmental stimuli. The relationship between the physiological structure of our brain and the environment in which we live is essential, and it seems plausible to assume with W.J. Freeman that the shape and dynamics of our brains have evolved and adapted through communication and social interaction.[21]

The results of current research on brain structure provided by neuroscience suggest that one key to understanding whether or not there are brain differences between men and women consists in paying more attention to individual differences. If one considers the complexity and the unique potential of each person doubt is cast on research projects which aim at tracing social, ethnic or sex related differences back to brain structure, i.e. to a structure which is different in each individual. I think, therefore, that when we encounter stereotypes or vague generalizations of neuroscientific results, we must not forget, just like an "alarm bell", the fact that each brain is unique and unrepeatable because of individual differences which penetrate even to the minutest neural networks.

[20] See Cahill, 2006.
[21] See Freeman, 2001.

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