



Experimenting with Gender: How Science Constructs Difference

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ABSTRACT

Gender/sex plays a significant role in discussions around education and science for policy makers, educators and heads of institutions of higher learning working towards increasing the number of women in Science, Technology, Engineering and Mathematics (STEM) subjects. In recent times, evidence-based educational reforms have been championed by education psychologists. Neuroscience and gender studies are two disciplines heavily engaged in this discussion, each attempting to explain whether and/or why males outnumber females in higher-level research and business. While neuroscience approaches the problem from biology to behaviour, gender studies exposes the various ways in which power relations create difference. This paper sheds some light on what happens in a neuroscience laboratory when experimenting on gender/sex difference, elucidating the process through which experimental systems enable the appearance of gender difference and validate it within the hetero-normative norm. Taking the standpoint that gender/sex differences in cognitive performance result from a process that carefully assigns meaning to abstractions based on laboratory tools and components, this paper explores the constructedness of gender/sex differences by integrating perspectives from three disciplines namely neuroscience, science studies and gender studies. The article concludes with an analysis of the implications of these practices.

KEYWORDS

Education; neuroscience; policy; gender



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INTRODUCTION

Feminists introduced the gender/sex distinction in the 1970s assigning sex to the biological sciences and gender to the social sciences (Oudshoorn, 2001). This distinction, as notes the author, has resulted in the 'naturalization of femininity'. Reproduction of gender/sex differences¹ within neuroscience research as obvious and naturally existing, has flourished because of "blackboxing". Blackboxing (Latour, 1999) refers to the veiling-up or closure of the processes that hypotheses go through in order to become accepted and integrated into the 'thought collective' (Fleck, 1981) of the scientific community. This is not an automatic process. It involves experimenting, evaluating, organizing and cataloguing of information and data collected within expected paradigmatic parameters. Through these processes an evolution ensues, and once the dust settles, the outcomes defined solidify and are no longer open for scrutiny or debate; hence the blackbox. *Experimental systems* are the structures that enable this process; they make the activities around validating a concept become invisible including the scientist's active engagement in introducing implicit selectiveness to the experimental system. The objective of this work is to demonstrate that there is a lot that goes into locating gender/sex differences in a psychological task, and that finding difference is neither obvious nor automatic in a manner that is easily derivable from observation. The generation of difference is a technical collaborative process that involves organized activities, tools, closed terminologies and technologies. This paper opens up the blackbox to expose the elementary fragments involved in camouflaging the constructive process of knowledge production. This is done by evaluating a kinematic experiment designed by neuroscientists to evaluate the influence of gender/sex on social contexts.

A BRIEF INTRODUCTION INTO THE RATIONALE OF THE NEUROSCIENCE EXPERIMENT

It is a norm to examine gender/sex differences in behavioural and cognitive performance of tasks in psychology and neuroscience. However, evaluating the effects of socially constructed categories like gender/sex and race on psychological performance seems to be a difficult process in the neurosciences. It has to date required researchers to first name/affirm stereotypes in order to expose the psychological patterns that enable the performance of these categories through¹priming. Stereotype threat is the name attributed to this phenomenon; 'the phenomenon whereby individuals perform more poorly on a task when a relevant stereotype or stigmatized social identity is made salient in the performance situation' (Schmader & Johns, 2003, p. 440). It seems that stereotype threat shapes psychological performance by shifting power relations, resulting in behaviour that fulfils the activated stereotype. These subliminal influences of power

relations have also been exposed through the Implicit Association Test (IAT, Greenwald et al., 1998)

Following this model, various other researchers have been able to show similar effects of stereotype threat on academic performance for female students, especially with regard to subjects like mathematics and engineering. Reports indicate for instance that female students perform worse in mathematics as a function of the number of male students in the room (Inzlicht & Ben-Zeev, 2000; Murphy, Steele & Gross, 2007). The kinematic task evaluated here is a paradigm that exhibits the influence of social contexts on psychological behaviour without overtly priming for stereotype threat. This is the aspect of the experimental paradigm that makes it especially interesting for our purposes as it presents us with gender/sex effects even in the absence of overt stimulation, thereby elucidating the strong influence and integratedness of power relations in our everyday lives. This kinematic task was designed and run at a laboratory in Italy. The outcomes were unpublished because the authors were reluctant to implement the use of stereotype priming to emphasize the role of gender/sex in shaping performance as was later suggested by the reviewers examining the experiment. Rejecting the reviewers' request to deliberately activate stereotypes in the task implied a disapproval of the canon. Consequently, the article was not accepted for publication in a neuroscience journal. This exclusion might suggest to us that neuroscientists are cautious when entering this volatile gender/sex debate, and that they are careful to follow their protocols before making gender/sex difference attributions. The 'safety' of the thought collective is a construction that will be explained later.

A second reason for examining this experiment is that it is based upon a well established paradigmatic framework in neuroscience research. The study of motor action has a long successful history in the field of neuroscience and kinematic tasks relating to reaching and grasping have been extensively studied, are well understood, and have been utilized to provide useful illustrations of other important principles of brain functioning. It is also a principle methodology used in the field of social neuroscience. Recent evidence suggests that social intentions translate into specific motor patterns that reflect the actor's intentions. Georgiou et al., (2007) reported that persons interacting with a competitive attitude towards each other presented distinct kinematic patterns of hand motion compared to persons within a cooperative context. Tubaldi, et al. (2008) discuss how odour shapes hand motion, and Castiello, et al., (2010b) show that sound shapes motor patterns. Sartori, et al., (2009) conclude by discussing how expectations shape kinematic hand motion. Following these findings and new ones that suggest that social action is hard-wired (based on the kinematic profiles of movements in five pairs of twin foetuses, Castiello, et al., 2010a), researchers in the experiment described here considered the influence of gender/sex interactions on kinematic patterns.

TESTING THE INFLUENCE OF GENDER ON KINEMATIC PATTERNS

A key question for psychologists studying behaviour concerns mechanisms that allow for skilful social interaction. Although numerous advances in the understanding of the links between the mind, brain and behaviour have been made in the past decades, these have largely been based on studies where individual

performance was investigated as a strictly isolated unit. Social neuroscience takes into consideration that individuals live within a social world where humans continually interact with each other; indeed the fabric of society is socially and culturally defined. Experiments in this sub-discipline thus examine how the brain mediates social cognition.

The experiment described here involved a reaching and grasping motion in a social context. This context was mediated by gender/sex differentiated interactions by individual participants in the experiment. The participants' task was to reach toward an object placed at the target location in front of them, to grasp it, and place it in a designated location. Participants were requested to act in three separate conditions; (1) alone (i.e. control/non-social condition) (2) towards a member of the same sex (3) towards a member of the 'opposite'² sex. The researchers investigated whether the mechanisms underlying the same action were dependent on the social context. They investigated whether gender/sex (here meaning a participant's interaction with persons of same sex or 'opposite' sex), had an influence on the kinematic pattern of motion. This would be established by comparing the social condition where the participant interacted with the experimenter(s), and the control condition, where the participant carried out the task in the absence of a human interaction.

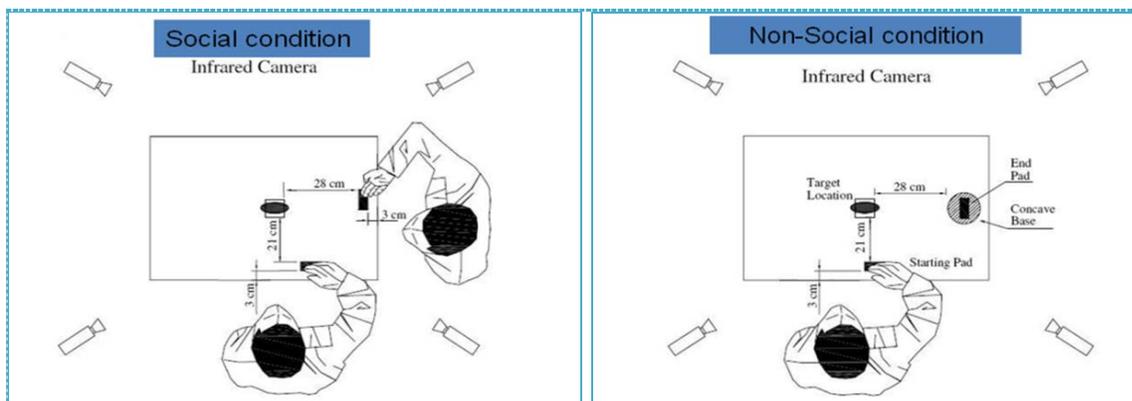


Fig 1a. and 1b. are a graphic depiction of the experimental setting produced by permission of the authors who first published this paradigm (Georgiou et al., 2007).

Movements were recorded using an ELITE motion analysis system (Bioengineering Technology & Systems [B|T|S]) consisting of four infrared cameras located at the four edges of the table as shown in the diagrams above.

Results as recorded by the experimenters demonstrated that the interaction of participants in a genderized context produced specific kinematic patterns. This conclusion was reached after making the following observations. First, that during the reaching action, a faster reaching speed was observed in the context where participants interacted with confederates of the 'opposite' sex (and not in the other conditions). Secondly, that following a faster reaching action, male participants exhibited slower hand-opening motion during the grasping action, while females did not show any reduction in speed for this condition.

The episteme that emerges from this experiment is gender/sex difference. The reaching action captured behaviour that seemed to be limited only to 'opposite' gender/sex interactions (as this effect was not observed for same-sex interactions), and the grasping action contained the quantitative gender/sex difference in performance between males and females that was sought. This experimental system thus becomes a space within which the epistemic object (gender/sex) is articulated and framed. This is what will be examined in the following sections.

GENDER, SCIENCE, BODY AND THE MATRIX OF POWER

According to gender studies theory, disparities observed between men and women in society do not result from biological attributes. They result from power relations that privilege some kinds of bodies and brains, and not others (Butler, 1993; hooks, 1991). Feminist researchers have been able to demonstrate the fact that gender/sex disparities in science, are historically relevant (Haraway, 1988). They have exposed the exclusion of women in academic spaces of knowledge production for centuries, and have argued that social roles allocated to women (only), e.g. raising children hinders women's advancement in fast track careers (Nature Neuroscience Editorial, 2006). Further, feminist researchers have demonstrated that power structures and biases are entrenched in the fabric of empirical research in the natural sciences (Bleier, 1985; Fausto-Sterling, 2000), and that women's psychological performance is often measured using the male norm (Gilligan, 1993). The fact that scientific research is expected to conform to particular gender/sex stereotypes further complicates this scenario. In line with various science studies researchers who demonstrate the cultural processes inherent in science, this paper argues that the social, historical, cultural and socio-political character of gender/sex plays an important role when defining difference in empirical results, and expounds on the process through which this difference is constructed and validated. The way scientific knowledge on gender/sex difference is organized is deliberate, non-trivial and depends on many actors/processes. I begin by highlighting the role of the body in this clever 'architectural' assemblage.

Natural scientists tend to introduce binary categories of male and female (what they often refer to as 'sex' as defined to them by the morphology of the body) in order to define or measure difference. The gendered body then becomes the material boundary dictating where gender/sex differences in cognitive skill are to be located and observed. Without this structural organization, the experimental system is (also) incapable of detecting and extracting gender/sex difference. Neuroscience research does not address the power structures that these demarcations reflect. This reduction hinders us from distinguishing the complexities of gender/sex relations and identities, and how these are shaped by power interactions and regulation (Kuria & Hess, 2011). Within these conceptualizations of difference, gender/sex is fully played out on the body and becomes a socially constructed object of discourse. It is often thought in the biological sciences, that these distinctions are hard-wired and hence distinct and permanent, but Hird (2000) and Klöppel (2010) among others have exposed the malleability of the human body by exposing the changeability of these categories, including the flexibility of the identities of male and female.

Biological sciences operate within the matrix of power that enables the establishment of categories and their definitions, and are an important power structure that defines what norms are to be acknowledged and embraced. Foucault (1990) describes the intimate relationship of sexuality to modern power structures; power's role is to fix parameters that define sexuality and to police the expression of gender/sex and sexuality. As Butler (1999) puts it, gender is a performance. It is an act that requires a stage for its appearance, and the body is where this performance is played out. Within the culture of constructing knowledge through scientific research, the experimental system is the platform that enables the emergence of this gender/sex performance; it systematically creates, transforms, codifies and amplifies the appearance of epistemic objects, here gender/sex.

With regard to the body, gender/sex and the brain, there is an implicit assumption that just as the hormones dictate the differentiation of the body, so do the hormones also order the brain (see Jordan-Young, 2010 for an in-depth discussion of the brain organization theory). Einstein (2007) locates this direct linkage of the hormone theory to the brain through the discovery of the hypothalamic-pituitary axis by Harris (1937), (see Raisman (1997) for a historical review). As far as linking gender/sex and mathematics ability to mental acuity is concerned, there seems to have been an explosion of these discussions following a model proposed by Fennema & Sherman (1976) to examine gender/sex difference in mathematics abilities. These researchers sparked discussions suggesting that there might be some biological basis for gender/sex differences in mathematics. In the following years, discussions relating underrepresentation of women and girls in science to mental, brain and psychological functions became popular. The Brain and Behavioural Sciences Journal 1988 special issue was for example dedicated to discussing the material nature of gender/sex differences in mathematics ability. In this issue, several authors (e.g. Benbow 1988; Halpern, 1988; Hines, 1988; Kimura, 1988; Nyborg, 1988; Zohar & Guttman, 1988) argued strongly for genetic and hormonal factors (in addition to environmental factors) as an explanation for the differences observed in cognitive performance. Current research has not discarded these deterministic ideas, but paradigms testing higher cognitive functions have shifted emphasis to the domain of the brain sometimes referred to in neuroscience as the seat of the mind and it seems that difference is now packaged within cognitive facilities e.g. empathy, stress management, economic choices, visual spatial abilities, and so on.

BIRTHING GENDER IN THE LAB

The emergence of gender/sex difference as a visible measurable outcome of an experiment requires a set of props. In the kinematic experiment described here, men and women were enrolled for the task through announcements that were posted all over the University campus. The participants enrolled themselves for the task for a small monetary fee. Once they were in the laboratory, their name and age were requested, but they were not usually asked about their gender/sex. In general, the experimenter made *that* judgement based on visual cues like clothing and physical appearance, i.e. body structure. Once the participants took their seats in the designated positions as shown in Fig 1, infrared reflective markers (0.25 mm diameter) were taped to the participants' wrist – the dorsodistal aspect of the radial

styloid process, the thumb – ulnar side of the nail, and the index finger – radial side of the nail. These markers were fastened using double-sided tape so that only the markers were exposed. Participants were then debriefed on the protocol of the experiment. They were asked to pick an object and place it into the hand of an experimenter or into a concave container after a tone of 880Hz (in a time frame of 200 milliseconds) was played. There were three conditions; 1. Same gender/sex interaction, 2. 'opposite' gender/sex interaction 3. Control/non social condition. There were 90 trials in total, 30 for each condition.

Reaching and grasping actions were captured by the infrared cameras tracking the markers on the hand. The four cameras (sampling rate 100 Hz) placed 120 cm away from each of the four corners of the table (Fig 1) detected and traced the motion of the markers in space as the hand moved during the reach-to-grasp task: the wrist captured the reach, whereas the index finger and the thumb recreated the grasping motion. The cameras transformed the marker's motion into cardinal points on a virtual 3D grid as shown below, created by a bioengineering software system known as the ELIGRASP software system.

Fig 2 below represents a reconstruction of the hand movement by the infrared markers (photo taken by author). The orange bar (T-shape) represented the x,y,z coordinates. The white dots connected with a red line represented the three markers on the wrist, thumb and index as points on a computer grid. The dots closer together represented the grasping action (index and thumb), whereas the point upon which the two red lines merge represented the wrist movement and mapped the reaching action.

What is interesting about the regime of data collection through experiment is the need for transformations (Latour, 1999; pp 24-79). A main function of experimental systems then, is to transform representations into measurable characteristics that can be detected by the equipment assigned with this task. The intangibility of perceived reality and a need to implement tools (i.e. table, computer, cameras, and infrared markers) and technology (ELIGRASP system) to map observations onto other reference frames demonstrates the intervention of science in the process of harnessing data from the lived world.

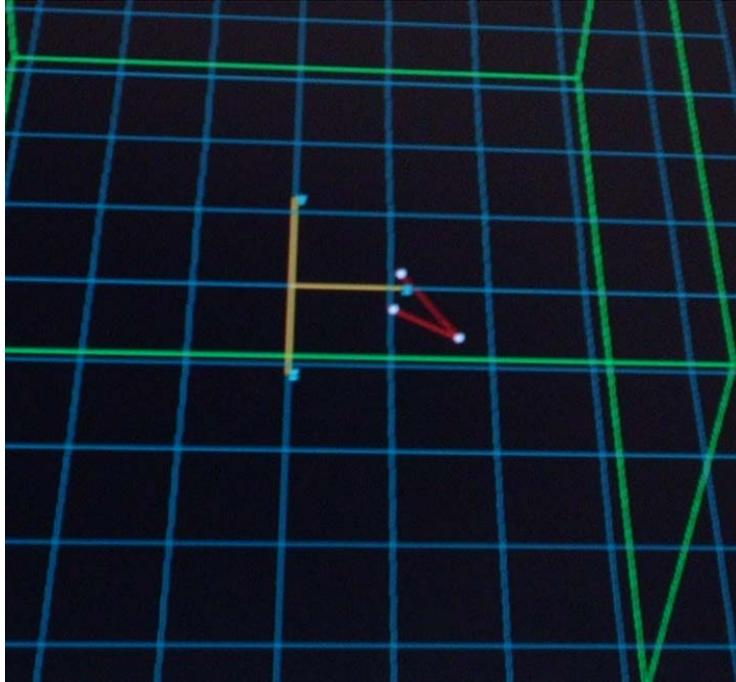


Figure 2: Hand movement by infrared markers

Another aspect of transformation regards the assigning of meanings to tools used: Gender/sex difference as it is understood by the experimenter is tagged to the data collected through sorting. In this experiment, data was stored according to the three forms of interactions, i.e. same gender/sex, 'opposite' gender/sex or control condition. In order to bring gender/sex into the laboratory, experimenters needed to arrange accompanying tools in a manner that these tools were able to pick out differences appearing within the defined gender/sex boundaries. This is to say, that the tools themselves have to be taught how to read this difference. Data collection in fact cannot take place without this organizing. As a result, the dialogues emerging from results obtained in such settings more often than not reflect the scientists' understandings of difference that are tied to the body, and the body to biology. Through this organized strict binary, it appears that one role of experimenting on gender/sex differences is to validate this cataloguing.

Statistical analysis was carried out to make comparisons between the three interactions. Statistical significance was found for the reaching action only during 'opposite' sex interaction where both men and women performed faster reaching actions. This fast reaching motion was not observed during same gender/sex interactions or control conditions. After this initial analysis, a second analysis was carried out to investigate what happened to the grasping motion during 'opposite' gender/sex interactions. A difference between the ways females and males performed the grasping action after the quick reaching motion was observed. Male participants demonstrated slower motion of hand opening during grasping, whereas females showed no changes in speed of hand opening during grasping.

In order to understand how these results were interpreted as representing gender/sex differences, we first need to comprehend the kinematic theory of hand motion during reaching and grasping actions. The outcomes in this experiment become relevant only in the context of previous research in the field. Previous research has established that the hand reaches its maximum opening at about 60% of the total time taken for hand motion during a grasping motion (Castiello, 2005). The hand-opening time, i.e. grasping, changes as a factor of the speed with which the hand reaches for an object. Researchers in the field of motor action have established that fast reaching actions result in a longer duration of hand opening during grasping (Rand, Squire & Stelmach, 2006). Researchers before them have defined this slowing down of the hand during grasp as a compensatory reaction that allows for an extended 'homing' phase that is thought necessary to ensure correct positioning of the fingers before contact with the object is made (Wing, Turton & Fraser, 1986; Wallace & Weeks, 1988).

In this study therefore, male participants exhibiting longer opening times for faster reaching action followed expected kinematics of grasping motion. Based on this contextualising of performance, the performance of female participants was seen as *defying* the established expectations. The inconsistency of female participants' performance to the standards established in the kinematics of motion led the scientists to conclude that the female participants 'underperformed' in this task despite the fact that both men and women succeeded in placing the object in the designated position.

THE MEANING OF DIFFERENCE

Difference appears not as the outcome of the experiment, but as a substance of the discourse created around the principles defining the experimental paradigm. Gender/sex difference is not visible in the terms of simple outcomes, i.e. observing that women and men perform faster reaching actions does not tell us anything about their performance, especially since they all succeeded in the final outcome of placing the object onto the designated area. However, when these outcomes are put within the framework of discourse in this field, we see that supporting theories are utilised to explain the findings according to what is generally held true in the field of research. For example, the reaching action can be explained in the following manner. Zanjoc (1965) observed behaviour that suggested to him that people experienced high arousal when performing an action in front of others. He called this the 'audience effect'. Zanjoc posited that the presence of one or more observers affects task performance by either enhancing it, or inhibiting it.

A study by Corston and Colman (1996) demonstrated that male participants showed facilitatory influences on a computer task in the presence of a female audience, whereas female participants showed an inhibitory effect in the presence of a male audience. It is important to notice that 'inhibitory effects' imply negative performance. If we are to follow the implied meanings of these propositions, it might be argued that 'opposite'-gender/sex interactions are likely to have a negative influence on performance of female participants. The associations made to outcomes observed during this genderized interaction may be used by experimenters (in this task) to legitimate their assertion that female performance in

this task demonstrated an 'underperformance' in the task. Inhibitory and facilitatory effects are an example of terms that the experimenter is provided with in the development of this episteme, setting into motion an evolution of thought, action and reaction to the collective discourse.

Neuroscientists have also shown that kinematic actions are executed by sensor motor and cognitive functions of the brain. A review paper titled 'The Neuroscience of Grasping' (Castiello, 2005) discusses the underlying principles of grasping actions. This aspect alone has great potential for misuse. Utilizing this single strand connecting the body to cognition, and cognition to the brain, a researcher may be able to lightly draw a conclusion that biological mechanisms manipulate the expression of certain behaviour. This is one reason that neuroscience explanations carry value-loaded meaning, which needs to be interpreted with caution (Weisberg et al., 2008).

IMPLICATIONS

Evidence-based practice involves using scientifically-based research to guide educational decisions regarding teaching and learning approaches, strategies, and interventions. Sexual dimorphisms in brain development (Lenroot et al., 2007; Lenroot & Giedd, 2010) are cited by the National Association for Single Sex Education in Public Education (NASSPE) as evidence to support single-sex education programs. Based on this research, NASSPE makes the conclusion that some gender differences are genetic and present from birth, while others develop later in childhood. These observations have not been without effect as exemplified by the director of the No Child Left Behind Act of 2001³ in the USA. Dr. Daniel Sax argues for hard-wired gender differences (Sax, 2005). In an article published in the New York Times (Weil, 2008), an elementary school changed its structure of training based on Dr. Sax's claims about girls and boys cognitive capabilities. There is a growing debate about how cognitive neuroscience research might contribute to educational policy (Ansari and Coch, 2006), and there is scepticism even from neuroscientists of policy maker's use of brain-research in education (Goswami, 2006).

It is unfortunate that the generalized opinion that men and women differ in cognitive abilities has permeated into classrooms where girls are treated differently with regard to expectations about their participation and competence. When *genderized* theories of girls' performance in science are normalized through policy and institutionalization, they become instruments that structurally establish stereotypes and assign differences in intellectual performance, limiting the chances of equal participation. Guiso and colleagues (2008) demonstrated that academic performance depends on culture and power structures. They showed that the gender-gap in mathematics disappears in more gender equal communities. Martens et al., (2006) have demonstrated that self-affirmation improves the performance of women in mathematical tasks and cognitive performance, hence the need to establish systems that explicitly encourage women. Additionally, girls' and boys' perceptions shape their gender identity and choice of activities (Dar-Nimrod & Heine, 2006; Coleman & Hong, 2008). Educational psychologists should therefore consider their moral responsibility when providing evidence for educational policy which attributes gender/sex to different levels of intellectual performance.

CONCLUSION

This paper has demonstrated that examining gender/sex in an experimental setting is not naïve. It involves a conglomeration of processes that allow for the construction and the emergence of difference. The implications of gender/sex research and understandings of the concept are far-reaching. This calls for a need for a balanced perspective on the part of policymakers whose role is to implement empirically presented results. Historically, policy and legislation have influenced the inclusion of women in science and math subjects globally. According to Sadker & Sadker (1995), women's occupational choices were restricted to careers in secretarial, nursing, teaching, or motherhood into the 1960s. Madigan (2009) expounds on the historical advancement of women's participation in Science and Technology subjects in the United States.

Policy-makers seeking to narrow the gender-gap in science should for example consider (even demand) the intellectual exchange between relevant stake-holders and cross-border interactions among disciplines interested in the subject. This could open up spaces for new ways of thinking about difference, and perhaps provide alternative ways of addressing the issues concerned.

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ENDNOTES

¹ Myra Hird, (2000) critiques feminists' dependence on a *'real' corporeal base on which gender operates*", p. 348. Butler (1990) argues for the non-existence of an inherent fe/male person by discussing the political nature of gender legislation and pre-defined norms. The terminology 'gender/sex' here, is set to subvert the demarcations created between the binary of gender and sex. The terminology embodies the understanding that even physical bodies with a biological sex, are malleable, changeable, and 'do-able' just as gender is.

² Opposite with " was introduced to question conformity to the heteronormative norm of binaries that enables the legitimate use of the term –opposites- when discussing gender/sex difference

³ The No Child Left Behind act of 2001 requires all government-run schools receiving federal funding to administer a state-wide standardized test annually to all students. Schools must make Adequate Yearly Progress (AYP) in test scores as a measure of how well students have been taught.

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