

**Research on Gender and Brain Differences**

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EXECUTIVE SUMMARY

Studies proclaiming innate sex differences in the brain are highly controversial on both scientific and ethical grounds within neuroscience.

The actual performance data for women on cognitive tasks, including mathematical skills, shows all but one of the gender gaps have been closed in the United States, the nation that once acted as the basis for most claims of female underperformance. The only remaining gap, spatial reasoning, has been shown to be responsive to training and is thus not attributable to innate differences.

Globally, math performance by females varies closely with the World Economic Forum's Global Gender Gap Index, showing better performance in countries with high equality and poorer scores in nations where there is more inequality.

This variation in scores, across cultures and over time, is commensurate with the prevailing scientific understanding of the brain, which holds that most of the brain's activity is guided by connections and pathways formed by learning, experience, and social arrangements.

By far, the main story is that males and females are more similar than different. And, average differences are usually only observable at the group level, in very large samples, and should not guide the treatment of individuals.

Other measures of attitudes, interests, behaviors, and preferences show a similar scheme: discernable average differences at the group level, probably due to socialization (and the resulting brain maps), but variation so high that these findings are inapplicable at the individual or small group level, such as in employment and education decisions.

Based on the trajectory of research to date, the chance is quite high that any study claiming a biological basis for discrepancies in cognitive performance due to sex will be disproven by subsequent studies.

Nevertheless, there remains a strong tendency for some scientists, the media, and the public to want a difference in biology present at birth to account for male and female performance or behavior. Consequently, isolated studies that purport to show such a difference are often highly publicized and they influence decision-making.

An ethical debate has arisen among neuroscientists over concerns that publicized, but dubious claims about brain differences will actually change the way that schools and employers treat females, thus reversing the gains—both in performance and in the brain—that have been documented.

Attention to this subject has caused the topic of stereotype threat to gain scope and urgency. Studies show that the best female candidates are the most affected by stereotype threat.

We advise that professionals with policy roles should be extremely cautious about allowing sensational findings about brain differences to influence large-scale practices and programs.

## Research on Gender and Brain Differences

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This report is intended to summarize and advise on the state of research in neuroscience on sex differences in the human brain. Within neuroscience itself, studies proclaiming innate sex differences are highly controversial on both scientific and ethical grounds. Such studies normally propose to explain cognitive differences in men and women, usually with a focus on the supposedly lower capability among females for mathematics, complex problem-solving, and spatial assessments, by asserting an innate and immutable difference in brain structure or function. In fact, however, such claims do not fit the actual performance data among females. Importantly, the assertions also do not fit with current scientific thinking about the way the brain maps and morphs in response to experience and learning. Some allege that this kind of study is normally performed in isolation from the ongoing scientific discourse and conducted in a post hoc manner—in other words, the studies are an opportunistic phenomenon. Further, based on the trajectory of research to date, the chance of any such study being disproven by subsequent research is quite high.

Because the popular media is quick to pick up and exaggerate studies claiming to find brain differences between the sexes, however, the impact of even one piece of research making these claims is considerably larger than often is merited. Perhaps most importantly, there is concern within the neuroscience community that reports of such studies feed prejudices among the larger society, especially within the schools, and thus have a negative impact, via stereotype threat, on the very learning patterns being researched.

In sum, professionals with policy roles should be extremely cautious about allowing sensational findings about brain differences to influence large-scale practices and programs.

In the following sections, this advice will be supported by a detailed analysis of

- the existing data on female cognitive performance,
- the current thinking about the plasticity of the brain,
- a case example of a recent, highly-publicized study,
- the media treatment of that study,
- the ethical controversy arising among neuroscientists,
- and the new concerns about the power of stereotype threat coming from the sum of these experiences.

Finally, a few comments will be made about practical implications for training programs addressing bankers and female entrepreneurs.

### Female Performance on “Male” Cognitive Tests

In the early 1980s, Benbow and Stanley published two studies in which they showed persistent gaps between male and female performance in the math sections of standardized tests (1980, 1983). These scholars insisted that their results proved that the different capabilities between males and females were not due to socialization and could not be surmounted by training. They further hypothesized that there were so many more boys at the high end of the distribution that males, as a class, must vary more than females and thus simply produced more geniuses. Though they did not explicitly say the cause was genetic, the intended implication was clear that an underlying biological difference of some kind was at work.

The study was based solely on a statistical analysis of young Americans' (under the age of thirteen) performance on the Scholastic Aptitude Test (the SAT, required for entering most tertiary education in the US) during a talent search for exemplary mathematical ability. Only ten years (from 1972 to 1982) of test data were analyzed, but the sample, totalling about 50,000 students, was deemed so large that such audacious generalizations were allowed.

Benbow and Stanley (1980, 1983) are now thoroughly discredited for reasons that also apply to new studies making biological claims about brain differences today (Hyde 2016). By 1990—less than ten years later—a meta-analysis of 100 studies showed that there were no gender differences between males and females in math ability, except for complex problem-solving and spatial reasoning. During the next decade, the number of girls taking advanced math classes in high school increased to the same level as boys—and by the turn of the 21<sup>st</sup> century, the gap that Benbow and Stanley had declared impossible to change by training had disappeared entirely, including the gap in complex problem-solving. (For more, Hyde 2005, Hyde et al 2008, and Zell et al 2015).

Testing data did show greater representation of boys in the highest percentiles of performance among white Americans in these new analyses. However, the relationship did not hold for Asian-Americans. International data showed that in Iceland, Thailand, and the United Kingdom, girls appeared in the highest percentiles in equal or greater numbers than boys. Further, the distribution could in no way explain the extremely lopsided gender representation in the math-intensive fields, such as engineering, in any of these countries. Thus, it was no longer possible to claim that biology explained why, for instance, there were more males among leading scientists or chess champions (Hyde et al 2008).

Indeed, by the late 1990s, statistical analysis showed that, actually, the larger number of men in any of these fields (from finance to computer science to engineering) would automatically produce more “superstars” just because of the greater probability of such gifted people emerging from a larger pool (Charness and Gerchak, 1996; Bilalic et al, 2008). Thus, it was expected, when the talent pools in such fields became more equalized, there should also be an equal number of males and females among the best talent.

Importantly, in 2008, Guiso et al demonstrated that the gender gap in math performance was quite a bit larger in some countries (such as Turkey) and was reversed in others (such as Iceland). Indeed, the difference in gender performance on these particular tests correlated strongly with the World Economic Forum’s Global Gender Gap Index; countries having high levels of gender equality had equal scores between the sexes and those with high inequality had a large gap in performance between males and females. Thus, the difference in performance suddenly seemed far more likely to be caused by stereotype threat or structural inhibitors (such as taboos against keeping girls in school), than by genes.

All these findings were consistent with the new discoveries being made possible by brain-imaging innovations. The emerging understanding of how the brain works declared that the main mechanism was a highly plastic system of connections (or pathways) that respond to experiences including learning, occupations, and prejudice. Indeed, the last standing male superiority in cognition, spatial rotations, provided a key proof point. Until only a few years ago, this one apparent “innate” difference was the final frontier in gender equality on cognitive tasks. However, it has now been shown that the brain is so plastic that females catch up with males on this capability *after only 10 hours of video game instruction* (Feng 2007, see also Uttal et al 2013). A recent study of primary school children showed no difference in any skill, including spatial reasoning (Lachance and Mazzocco 2006).

In sum, despite persistent beliefs that males and females have different cognitive abilities in mathematics—such that their vastly different representation in math-intensive fields, especially at the top, is justified—the performance evidence flatly shows that this is not true (see Hyde 2016, Hyde 2005, Hyde and Mertz 2009, Spelke 2005). Instead, research on infants, small children, and students at all levels “provides evidence that mathematical and scientific reasoning develop from a set of biologically based cognitive capacities that males and females share” (Spelke 2005, p. 950).

### Brain Dimorphism and Cerebral Plasticity

Human brains are *not* “sex dimorphic,” meaning they do not occur in two categorically distinct forms (Jordan-Young and Rumiati 2012, p. 307). Such categorical differences are acknowledged for the genitals, but “the question of how far these categories extend into human biology is still not resolved” (Joel et al 2015). One study analysed 1,400 human brains from four datasets for the distribution of white matter, grey matter, and connections (Joel et al 2015). The findings revealed that brains at the far end of the “maleness-femaleness” continuum are quite rare; instead brains are unique “mosaics” with some features broadly more common in females than males and vice versa. The findings were robust across sample, age, type of MRL, and method of analysis, and were corroborated by a similar analysis of personality traits, attitudes, interests, and behaviors of more than 5,500 subjects. The authors conclude:

Sex/gender differences in the brain are of high social interest because their presence is typically assumed to prove that humans belong to two distinct categories not only in terms of their genitalia, and *thus justify differential treatment of males and females*. Here we show that, although there are sex/gender differences in brain and behavior, humans and human brains are comprised of unique “mosaics” of features, some more common in females compared with males, some more common in males as compared with females, and some common in both females and males. Our results demonstrate that regardless of the cause of observed sex/gender differences in brain and behaviour (nature or nurture), human brains cannot be categorized into two distinct classes: male brain/female brain (p. 15468, italics mine).

Brain imaging technologies have drastically changed the way science understands the way humans develop and function mentally. The brain is now known to be highly malleable, very adaptive to environmental change, and the pathways and locales for thought extremely individualized. The “connectome”—or the map of pathways formed by connections in the brain—is created almost entirely by experience, environment, learning, not by genetics or materials present at birth. One neuroscientist explains it well:

The human brain is made up of 100 billion synapses which are the junctions between neurons, while there are only 6,000 genes involved in the nervous system. This means that there are not enough genes to control the building of our billions of synapses. In the course of embryonic development, the genes play a key role in designing the basic architecture of the brain. At birth, however, the brain is by no means “hard-wired.” Only 10% of the 100 billion neurons are already connected. The 90% of the remaining synapses will then be progressively constructed in ways which are influenced by family, education, culture and society. This ability of the brain to shape itself according to life experience is called “cerebral plasticity” (Vidal 2012, p. 297).

At this point, the very idea that there are “hard-wired” brain-based attributes that have an unavoidable impact on behaviors, interests, and capabilities is suspect. Largely because of the gendered influence of the social environment, males and females will predictably have differences

in averages for these things, but, by far, most are neither present at birth nor unchangeable. The relationship between body, mind, and gender, therefore, is now understood to be highly interdependent and not at all like the observable differences in genitalia. Though there are average differences in size and in the way different regions of the brain are recruited to perform tasks, these differences are (1) perceptible only at the group level, rather than being identifiable in individuals and (2) seem equally as likely to arise in response to gendered patterns in social roles and behaviors: “That is, brain differences may result from the very characteristics that are supposedly ‘hard-wired’ into the brain in the first place” (Jordan-Young and Rumiati 2012, p. 308).

Throughout life, learning certain skills or holding certain occupations actually changes not only the pathways of thought, but can also alter the physical structure and appearance of the brain. An oft-cited example of this phenomenon is a study done of taxi drivers that showed a thickening in the brain regions controlling spatial orientation and memory; importantly, this thickening was directly proportional to the number of years the cabbie had been driving (Maguire et al, 2002). Further research has not only shown similar phenomena in pianists and jugglers, but additionally has established that the brain matter and pathways associated with such specialized activities pull back and disappear when the subject stops engaging in the activity—a real case of “use it or lose it” (Draganski et al 2004; Glaser and Schlaug, 2003).

To the extent that such activities are gendered, therefore, we would expect that they would produce average sex differences in the connectome. But we would not predict dimorphic connectomes, because there are both male and female taxi drivers, pianists, and jugglers. Carothers and Reis (2013) conducted a meta-analysis of the degree to which a massive list of interests, behaviors, attitudes, and other psychological measures were “taxonic” by gender (“taxonic” is the behavioral equivalent of “dimorphic”). What this meta-analysis found was that all the psychometric measures, indicators of interest, and behavior propensity, including interest in science, were “dimensional,” rather than taxonic. “Dimensionality” refers to a difference of degree, not of kind. As the authors summarized:

Although gender differences *on average* are not under dispute, the idea of consistently and inflexibly gender-typed individuals is. That is, there are not two distinct genders, but instead there are linear gradations of variables associated with sex, such as masculinity or intimacy, all of which are continuous dimensions that people possess to some extent, and that may be related to sex, among whatever other predictors there may be. Of course, the term *sex differences* is still completely reasonable. In a dimensional model, differences between men and women reflect all the causal variables known to be associated with sex, including both nature and nurture. But at least with regard to the kinds of variables studied in this research, grouping into “male” and “female” categories indicates overlapping continuous distributions rather than natural kinds (Carothers and Reis 2013, p. 401, italics in original).

Indeed, multiple studies have now been done using large samples across measures for performance, ability, interests, behaviors, and psychology. The overriding pattern is more of similarity between the sexes than difference, a phenomenon now known as the “Gender Similarity Hypothesis” (Hyde 2005, updated by Zell 2015).

#### Case Example: A Recent Study

Despite all this new knowledge, there is a stubborn recurrence of studies asserting inborn differences between the sexes, either explicitly or implicitly. Let’s look at the most recent example.

A group of scientists coming out of Pennsylvania (Ingalhalikar et al 2014) published a study in January 2014 that claim to have found a sex difference in the “structural connectome.” Right away, the use of the modifier “structural” in the title is an instructive bit of rhetoric—the connectome is, after all, only the temporary total of provisional pathways a particular brain has devised for thought. What these scientists did was merely to take the connectome maps of a sample of 949 people and average them. They did, unsurprisingly, find an average difference in the maps between women and men. This does not, however, lead to a conclusion that the brains themselves are intrinsically different. It just means that the experiences of men and women differ in a systematic way, and so the pathways mapped differ accordingly.

The authors acknowledge early in the article that the connectome itself is a function of experience, but their rhetoric proceeds quickly to further imply that something permanent and dimorphic characterizes male and female original brains. They speculate that this unstipulated difference is what lies the pattern they see, even though what they actually observed was simply the average derived from multiple malleable pathways in many individual brains.

Two further aspects of the study are particularly disturbing. One is that the authors, after dividing their sample by age, comparing the age cohorts, and finding a widening difference going from younger subjects to older ones, pronounce that there is a developmental process that causes these alleged brain differences to become more emphatic over time. I want to underscore that this inference is being made from a cross-section of the existing sample, not from observance of such processes in the sample over time. Remembering the experience of Benbow and Stanley, as well as the currently-accepted model of brain plasticity, we can see that an equally good explanation for a widening difference going from young to old would be that something in the young subjects’ environment is different as compared to what the older subjects have experienced. This difference could be changes in the school curriculum, changing gender roles, the greater prevalence of video games, the introduction of smart phones, summer camps for “girls who code,” or any number of other shifts that might logically have changed the pathways this generation was creating in their brains. Neither of these explanations, however, would accomodate the reality that each individual’s brain maps and remaps over the course of a lifetime and so this average pattern may represent no developmental sequence at all.

The second disturbing aspect of the study is that the authors admit a similar study, published less than a year previously, had found no differences when doing the same analysis (Dennis et al 2013). Ingalhalikar et al casually dismiss the earlier study for having a smaller sample than their own. However, the difference in sample size is only  $n=439$  versus  $n=949$ . While in ordinary practice, this would be a significant difference in sample size, the potential for the same kind of meta-analysis that wiped out Benbow and Stanley’s theory must be considered. The difference in findings between Ingalhalikar’s 2014 and Dennis et al 2013 is precisely the type of thing that meta-analysis is designed to adjudicate. It is not at all out of the question (or even out of the ordinary) that a future meta-analysis, composed of thousands or even millions of datapoints would find no differences between the genders—indeed, that has been the pattern of discovery to date, as we have seen. As one scientist observed of this type of study: “Evidence has accumulated that whenever a large number of subjects are analyzed the differences between the sexes most often disappears, due certainly to the high inter-individual variability in brain functioning” (Vidal 2012, p. 300). It is easy to understand, then, why some neuroscientists reject such “sex differences in the brain” studies as being conducted in isolation from the ongoing discourse and with a post hoc approach to data (the post hoc approach, also sometimes called “data dredging,” can be appropriate in an exploratory situation, but the term is used derisively to refer to authors with data that do not conform to their *a priori* expectations and so reanalyse the same set repeatedly just to find *something* reportable) (Fine 2012).

Within days after the Ingahlalikar article appeared, the research was being skewered by other neuroscientists talking to a writer for [The Scientist](#). And, within nine months, a new study appeared that falsified the claims Ingahlalikar et al made by demonstrating a different explanation for the data (Hänggi et al 2015). Neither the new study nor the earlier one finding no difference was reported in the popular media.

### Media Influence

Unfortunately, few among the public read even “popular science” publications like [The Scientist](#). The mainstream media do not look so deeply into the logic and background of studies that claim sex differences in the brain. Instead, they tend to further overstate the claims, simplifying any nuance and ignoring any contradictory evidence, using extraneous observation and quotations to further sensationalize the data. The public has a strong appetite for such studies, so this kind of reporting “sells papers,” if you will. Indeed, the media consistently ignore studies that show no difference, as well as those that cast doubt on such “biological differences” between brains of the sexes.

The [Independent](#), for instance, reported the Ingahlalikar study uncritically, calling it “pioneering.” They quoted one author as saying, “What we've identified is that, when looked at *in groups*, there are connections in the brain that are *hardwired* differently in men and women.” I have italicized “in groups” and “hardwired” here to remind readers that these differences are only observable in groups and not individuals and also that there is really nothing here that can be properly called “hardwiring” at all. The same author then stooped to pure stereotyping to explain the greater integration between intuition and analysis suggested in the female map: “Intuition is thinking without thinking. It's what people call gut feelings. Women tend to be better than men at these kinds of skills which are linked with being good mothers.”

A similar series of events, this time casting aspersions on males, resulted from a study of the testosterone levels in the saliva of male traders in the City of London (Coates and Herbert 2008). The authors merely speculated that acutely elevated levels might affect the risk tolerance of individual traders and, even if only a few were thus affected, could have a serious affect on market stability. However, when the media got the story, it became an attribution of the 2008 crash to libidos and testosterone; hence, the aphorism that Lehman Brothers would have been better off as Lehman Sisters (Vidal 2012, p. 299). Again, within a few months, a study using better methods (Zethraeus et al 2009) reported a different finding, but the media did not report it.

If it were only about selling papers or getting clicks, this kind of reporting would not be a concern to neuroscience or to institutions like the World Bank. But what is happening is that the reports are having worrisome effects on some members of the public. For instance, unscrupulous educational “experts” are using these brain difference studies to argue for reinstating sex-segregated education, including different curricula that “recognize” the alleged pre-existing conditions in the brain (Eliot 2013). Some have even suggested on the basis of these studies that it is a waste of money to try and increase the representation of girls in math-intensive fields (see Kane and Mertz 2012 for discussion). Benbow, the lead author on the 1980 and 1983 studies reported earlier in this paper, did a follow up on the same cohort of high-achieving students after twenty years. What she and her colleagues found was that both males and females grew up to be successful and happy, but the females were more likely to choose organic rather than inorganic science and were also more likely to adapt career choices to serve work-life balance (Benbow et al 2000). These obviously culturally-constrained choices thus narrowed the future for talented young women, regardless of their starting ability compared to the males. It is easy to see how a half-century of educational gains for women could be wiped out by pervasive stereotype threat—and, given cerebral plasticity, that the brain pathways caused by those gains could disappear, too.

## The Ethical Controversy in Neuroscience

The controversial hypothesis that there are hardwired differences between the brains of males and females that contribute to sex differences in gender-typed behaviour is common in both the scientific and popular media. . . such claims, quite independently of their scientific validity, have scope to sustain the very sex differences they seek to explain. I argue that, while further research is required, such claims can have self-fulfilling effects via their influence on social perception, behaviour and attitudes. The real effects of the products of scientists' research on our minds and society, together with the fact that all scientific hypotheses are subject to dispute and disconfirmation, point to a need for scientists to consider the ethical implications of their work.

Cordelia Fine, writing in *Neuroethics*

In 2012, a special issue of *Neuroethics* was devoted to the subject of sex brain difference studies and what to do about them. In this issue, it is explained that the dominant paradigm in neuroscience holds that there is a testosterone influence on the embryonic brain that results in an "original" brain difference between boys and girls.<sup>1</sup> The scientists writing in this special issue give multiple forms of evidence and argument against the viability of this theory (e.g., there are two mutually contradictory accounts of how this happens, there is no way to do a controlled test of the premise, contradictory evidence is omitted, the temporary nature of hormonal influence is ignored, any atypical gender features are pathologized, other hormones also signalling the brain are overlooked, as well as blinders adopted to performance data) (Jordan-Yong and Rumiati 2012; McCarthy and Arnold 2011; Vidal 2012). It appears that, in spite of the seemingly overwhelming case against this theory, an underlying desire to prove males and females different, with males superior, is propelling some neuroscientists to keep trying to establish an inborn difference. Thus, the establishment paradigm "pushes inexorably towards the 'discovery' of sex/gender differences, and makes contemporary gender structures appear to be natural and inevitable" (Jordan-Young and Rumiati 2012, p. 306).

Some of the essays in this *Neuroethics* issue, like the one by Cordelia Fine quoted above, seem to suggest these studies should either not be done or should not be published (as similar studies purporting to show such differences between races are often not published). However, there is a countervailing need for more health research on the differences between men's brains than women's. The politics of that situation, too, are telling.

After a string of accidents in which women who took the prescribed dosage of Ambien, a tranquilizer, perished while driving many hours later, the US Food and Drug Administration ordered the manufacturer to cut their recommended dosage in half for women. As it turned out, the earliest trials of Ambien had shown that women processed the drug more slowly than men, but the researchers simply dismissed the findings as unimportant—until all these women were killed. Soon after, the Director of the National Institutes for Health and the Director of the NIH Office of Research on Women's Health took the unprecedented step of requiring all NIH-funded research to actively consider sex influences. This directive also followed a run of research showing that sex

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<sup>1</sup> It's important to note that "dominant paradigm" in the context of scientific research does not refer to a superior scientific stream, but to the power of the people adhering to a particular scientific belief. It is what Thomas Kuhn called "normal science" in *The Structure of Scientific Revolutions* and, indeed, Kuhn observed that many scientific breakthroughs occur as the result of a build up of data that contradict the dominant belief until, finally, the old paradigm crashes under the weight of the dissonance. However, Kuhn further observes that the dominant group resists the new paradigm until the bitter end—because they know it will discredit them and cost them their influence over others.



matters in a lot of health issues, “from the level of the intact human down to the level of ion-channel function, and everywhere in between” (Cahill and Aswad 2015, p. 1084).

The problem was, as Cahill and Aswad explained in *Neuron*, that neuroscientists had studied almost exclusively males—and they were still studying almost no females when this essay was published in 2015. Further, most of the time, “when sex differences are present, conceptual blinders can easily block them from view” (p. 1085). Consequently, there is a great need for neuroscience to do more intentional work on the female brain. Ironically, the little work that *is* being done tends to focus on trying to prove that women think differently (and less well) than men.

### Rising Concerns over Stereotype Threat

It has long been known that females will underperform on a cognitive task that is seen as “male,” even when they are capable of completing it, because of the anxiety produced by the expectation that their gender will cause failure. This phenomenon is called “stereotype threat” (Steele 1997). The upward trajectory of female accomplishment in cognitive domains where they were previously thought genetically disadvantaged, as well the new understanding of the dynamic brain processes that underlie such accomplishment, have given the term “stereotype threat” a larger scope and a new urgency.

Research has now further interrogated the conditions under which stereotype threat occurs and is most destructive, as well as its potential long-term effects on individuals, by studying both women engaging in “male” cognitive tasks (usually mathematics) and African-Americans across a wide range of learning conditions. Importantly for this advisory note and the IFC project under which it is being written, stereotype threat is now understood to apply primarily to those members of disadvantaged groups who are the most capable in a given domain, who are on the leading edge of their group in terms of both achievement and potential, and thus who represent the best hope for creating sustained change for the group as a whole.

In other words, it will be the female test-taker who has already mastered the mathematical challenge who will be most likely to suffer if stereotypes are invoked at the testing center—and it will be her performance that will correct completely if the threat is removed (experimentally this has been done by announcements that the test underway has been shown to have no gender bias in outcomes) (Steele 1997). The subjects who are most invested in a given domain are most vulnerable to challenge. Thus, stereotype threat is not something that attacks those who are simply less able or lacking in confidence, but exactly the opposite. It causes the reduction in performance by diverting energy to suppress negative thoughts, as well as producing anxiety that places extra demands on self-regulatory processes (Fine 2012, p. 288).

Similarly, in a school setting where stereotypes are regularly invoked (as often happens, unfortunately, in areas of study still dominated by males, such as finance and engineering), it will be these capable pioneers who will be most affected. Indeed, it will not only be the ones who are most technically capable, but those who are most committed to the domain in question (MBA programs, a doctoral course in engineering), who will suffer the impact most keenly.

What happens over time, however, is not a drop in confidence among those experiencing chronic stereotype threat, as was previously thought. Instead, the women remain confident in their own abilities, but must adjust their assessment of the domain in order to maintain their own self-esteem. So, they increasingly devalue the domain and often ultimately disengage altogether, frequently changing career course as a result. This phenomenon could, for instance, explain the very high dropout rate for female finance professors, who tend to leave tenure-track posts early in

the process, despite equal likelihood of successful promotion, thus creating a chronic shortage of women in this domain.

Around the world, female entrepreneurs consistently resist coming into banks to apply for credit, thus forgoing business growth, sometimes knowingly. Thus far, no one really knows why this happens—often, the assumption is made (without evidence) that women just don't want their businesses to grow. Stereotype threat is a very compelling potential explanation for this very broad-based phenomenon.

The possibility that stereotype threat can be discerned operating at large group levels—female entrepreneurs, women professors of finance—thus causing industry or discipline-level inequality, has caused the phenomenon to rise in perceived importance among neuroscientists as well as social scientists. Indeed, meta-analysis has already shown that the stereotype threat on SAT performance led to an underestimation of female performance. Another found that the difference was as twice that for more difficult math tests. The conclusion: “The degree of undermining of ability indicated by these meta-analyses suggests that stereotype threat effects are likely to be of real practical significance in competitive and demanding educational and work settings” (Fine 2012, p. 288).

Knowing that environmental influences such as prejudice and gender expectations for performance actually cause the brain to map differently, some neuroscientists worry that recent achievements in learning among females could be dampened, even reversed, by a belief in ingrained brain differences gaining ground among the public, literally leading to a widespread regression in brain mapping among females. The very fact that such studies have had such a ready audience among educators proselytizing for single sex education and different curricula for boys and girls makes this fear quite real (Eliot 2013).

### Implications for Practice

There is concern among neuroscientists that studies such as Ingalhalikar et al (2014) affect women in the workplace and in enterprise by bolstering existing prejudices among bosses, lenders, investors, recruiters, and co-workers, giving the people with power the opportunity to justify old attitudes with “the latest science.” In fact, research has already shown that being told of such “scientific evidence” increased acceptance of gender hierarchy, produced more resistance to change, and bolstered support for sex discrimination in the workplace (Keller 2005; Dambrun et al 2009; Yzerbyt et al 1997; Bern 1993; Morton et al 2009). Corporate training programs that assert brain sex differences are explicitly singled out as a threat (Fine 2012, p. 290). By raising the profile and status of such prejudices, existing barriers to advancement for women are shored up, and, unfortunately, the best female candidates suffer most from the increased stereotype threat.

Thus, in programs designed to help women achieve in areas currently dominated by males, it is better *not* to raise the issue of alleged brain differences because this topic explicitly evokes stereotype threat. Instead, better outcomes might be had by following steps that have shown the capability to “lift the stereotype threat,” such as emphasizing the promise and achievements of female employees and customers, avoiding remedial treatment, and consciously communicating respect (Shapiro, Williams and Hambarchyan 2013).

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