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Information Sheet: Critically Thinking About the Brain and Gender Differences

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In January 2005 the president of Harvard University, Larry Summers, spoke at the Conference on Diversifying the Science & Engineering Workforce. In this now famous speech, Dr. Summers suggested that the reason fewer women succeed in science and math careers may be due to innate gender differences. Educators were stunned that such a credible and prominent academic authority would make these statements. They could easily imagine a situation where a female grade school student, or her teacher, hears Dr. Summers' comments and accepts them as true because they come from the president of an Ivy League institution. These remarks demonstrate that well-educated people can be ignorant about fields outside their own and exemplify the need to apply critical thinking to the source of information before considering an idea as valid.

Of the many questions that Dr. Summers' statements provoke, none is more important than asking what scientific data, if any, his claim is based upon. Summers supported his opinion with only anecdotal information, which is a poor scientific practice. In his talk he cited "a woman he worked with at the Treasury Department" who said that only three of the 22 women in her graduate school class were working full time. He also mentioned his twin daughters, who when given trucks to play with pretended the trucks were dolls saying, "Look, the daddy truck is carrying the baby truck." Additionally, Summers stated that his conclusions were based on "a fair amount of reading the literature and a lot of talking to people." Obviously, developing a theory based on the behavior of your friends, children, and other acquaintances does not allow generalization to the rest of the population.

Another central question is whether Dr. Summers engaged in any mathematical or statistical analysis to quantify his opinion. He claimed to have conducted "a very crude calculation" on data from the book *Women in Science* (Xie & Shauman, 2003) and implied that his statistics (he did not specify the exact type, and the authors of *Women in Science* said his statistics were "uninformed") show that five times as many men are "high-end" candidates for math and engineering positions at the nation's top universities. Even if this statement were true, such a rudimentary analysis does not provide enough evidence to allow an assertion of fact. These statements in no way demonstrate "innate gender differences in math and science aptitude."

While Dr. Summers later said that he was being intentionally controversial to "provoke thought on this question and provoke the marshalling of evidence to contradict what I have said," his statements nonetheless represent an example of propagating a scientific myth rather than testing it with skepticism and critical thinking.

To highlight the importance of approaching what is presumed to be accepted scientific fact with skepticism, this review examines three popular mainstream beliefs related to the field of neuroscience. These myths provide valuable opportunities for students to apply critical thinking skills. Discussing and investigating these myths will help students develop the ability to distinguish scientific facts from mainstream opinion and will provide educators with a number of useful educational applications.

Myth 1: Men have larger brains than women have and are therefore more intelligent.

Modern science confirms that the average male brain is slightly larger than the average female brain, but the notion that the average man is more intelligent than the average women is not supported. Individuals with large brains are not smarter than individuals with average- or below-average-sized brains; in fact, no relationship between overall human brain size and mental ability has ever been established (see Wanjek, 2002, for review). It is more accurate to interpret the difference in brain size by noting that the average male brain is slightly larger, with the added information that it shrinks with age at a rate faster than the average female brain. The average female brain may be slightly smaller because it is more efficient at transferring neural signals than is the male brain. In neuroscience, the size of a structure (anatomy) and its function (physiology) have little relationship.

- Early biologists observed that in the animal kingdom, the larger an organism's brain, the more advanced the animal's behavior (Linneaus, 1806). Scientists interested in the relationship between brain size and human intelligence developed the myth that the average man possessed a larger brain than did the average woman and is therefore more intelligent (Hamilton, 1935).

- Using flawed estimates of brain size, researchers concluded that the male brain was larger than that of the female (Morton, 1849; Hooton, 1926; Von Bonin, 1934; Blinkov & Glezer, 1968; Haack & Meihoff, 1971). Accurate tests have since been conducted using magnetic resonance imaging (MRI), which provides a highly detailed image of the brain by using a powerful magnetic field.

- MRI studies have shown that the average male brain is about 12% larger than average female brain. Importantly, this finding does not account for the fact that the average male body is about 17% larger than the average female body (Raz et al., 2004; Sowell et al., 2007).

- By using brain weight and controlling for differences in body size, Schoenemann (2004) determined that the average male brain is about one-quarter pound larger than the average female brain.

- The difference in brain size may be that it is larger because the male brain shrinks with age, whereas female brain size is affected very little with age (Witelson, Beresh, & Kigar, 2006).

- The corpus collosum, the major connective pathway that links the two sides of the brain, is proportionately larger in women than in men (Dubb, Gur, Avants, & Gee, 2003; Shin et al., 2005).

- No relationship between overall human brain size and mental ability has been determined (Wanjek, 2002).

Myth 2: Men and women think differently.

While it is true that for a few very specific behaviors the average woman and man *perform* slightly differently, it is not scientifically valid to draw the conclusion that the genders "think" or "behave" differently. Male and female brain anatomy is organized identically, and with slight exceptions in the corpus collosum and hippocampus, brain structures are proportionately the same size in both genders. Overall, far greater similarities than differences exist in male and female cognitive and behavioral processes

- Research finds that, on average, women outperform men in a variety of verbal reasoning tasks (Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003; Gur et al., 2000; Shaywitz et al., 1995), and men exhibit some advantages over women in behaviors related to spatial navigation (Ross, Skelton, & Mueller, 2006; Moffat, Hampson, & Hatzipantelis, 1998).

- The two areas of the brain that process the meaning of words and the production of speech, Wernicke's and Broca's areas, are approximately 20% larger in the average female brain than in the average male brain (Harasty, Double, Halliday, Kril, & McRitchie, 1997) and more active when tested by imaging techniques during language tasks (Ruytjens, Albers, van Dijk, Wit, & Willemsen, 2007; Gauthier, Duyme, Zanca, & Capron, 2009).

- The hippocampus, a brain structure responsible for maintaining cognitive maps during spatial navigation, is larger and denser in the male brains than female brains and, on average, is more active during goal-directed spatial behavior in humans (Iaria, Chen, Guariglia, Ptito, & Petrides, 2007; Madeira & Paula-Barbosa, 1993).

Myth 3: Men have masculine brains; women have feminine brains.

While it is true that certain hormones play different roles in the development of male and female sex characteristics, the brain and body of both genders require all classes of sex hormones to function properly.

- Stereotypical gendered behavior is often justified by the idea that testosterone is responsible for the "masculine" characteristics of males and estrogen is responsible for the "feminine" traits of females.

- This myth is misleading because many of the hormones that play a significant role in the development and maintenance of the male and female nervous system do not fit into gender-specific categorizations.

- Progesterone, which is traditionally considered a "female" hormone, is responsible for enabling brain cells to rapidly communicate in both men and women (Martini, Magnaghi, & Melcangi, 2003).

- Testosterone, classically considered to be a "male" hormone, plays a crucial role in the brains of both men and women and is responsible for converting progesterone into estrogen. Lack of testosterone in women can result in accelerated bone loss, fatigue, depression, high cholesterol, and low blood pressure (Davis, McCloud, Strauss, & Burger, 2008; Maia, Casoy, & Valente, 2009).

- Estrogen, commonly known as a female hormone, promotes neuronal growth, contributes to repairing damaged neurons, and improves blood flow in both male and female brains (Birge, 2000; Nourhashemi, Gillette-Guyonnet, & Andreu, 2000).

Recommendations and Applications for Practitioners

Myth 1: Men have larger brains than women have and are therefore more intelligent.

Examining this myth should underscore the similarities between the genders and demonstrate that minor differences in head and brain size between boys and girls does not significantly affect learning or behavior. In addition to the valuable exercise of exploring the details of this myth, educational applications could be based on the idea that variation in gender head size can account for some minor sensory differences between boys and girls. By age 4, the average boy's head is 1.5 cm larger than the average girl's head.

This may explain why the hearing threshold for women is about three decibels lower (more sensitive) then the threshold for men, but men are better than women at locating sounds in their environment (Eliot, 2009). Hearing differences between boys and girls might be considered for classroom seating arrangements, and changing the distance to the speaker's voice may be an effective strategy (Sax, 2005).

Myth 2: Men and women think differently.

Spatial skills can easily be taught in classroom environments using computer-based technologies, and girls should have access to them as early as possible. ST Math (meaning spatiotemporal math), software developed by the MIND Research Institute, uses stimulating visual exercises to teach fractions, proportionality, and symmetry. Encouraging girls to use such programs assists with visuospatial development and promotes technological fluency. Girls may also refine their visual and spatial behaviors by playing chess; participating in sports that involve throwing, passing, and catching; and using Legos or similar toys to build and construct three-dimensional models. Ways to promoting boys' language and literacy skills include providing reading material such as nonfiction books about sports and technology and introducing computer typing games early in grade school. It is also important to get boys comfortable with writing early in their lives. Girls keep diaries or write letters to their friends more commonly than boys do, and activities such as these would help boys develop their language skills

Myth 3: Men have masculine brains; women have feminine brains.

Exploring this myth reveals that boys and girls are hormonally quite similar, so it is not surprising that many of the same educational activities benefit both genders. Musical training, specifically on a piano or electric keyboard, significantly improves spatiotemporal abilities in boys and girls (Rauscher, Shaw, & Levine, 1997). Complex full body movements, such as swinging, leaping, and cartwheeling, stimulate the brain's vestibular system (the inner ear sense that contributes to balance and spatial orientation) and enhance important reflexes and motor development in girls and boys (Eliot, 2000). Additionally, fine motor skills are responsible for mapping physical connections across the cerebral cortex and many other parts of the brain, so activities like painting, drawing, typing, or cutting refine coordination and are important throughout all ages of development.

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