A Tale of Two Hormones

Patricia Hausman, Ph.D.

presented at the National Academy of Engineering SE Regional Meeting
Atlanta, GA · April 26, 2000

Thank you inviting me to speak here today. I am honored to share this podium with such a distinguished group.

In case you haven't noticed, I am the renegade du jour. Most of the physical sciences bore me silly. Efforts to attribute my apathy to "masculinist bias" in the curriculum amuse me to no end. I think "feministic bias" is more accurate. Wherever you go, you will find females far less likely than males to see what is so fascinating about ohms, carburetors, or quarks.

Heroic efforts to put a "female-friendly" face on voltage, current, and resistance are not going to change this. Women who are interested in physics need no special spin, and those who are not can see through one. Reinventing the curriculum will not interest me in learning how my dishwasher works. It is a thing, and things bore me.

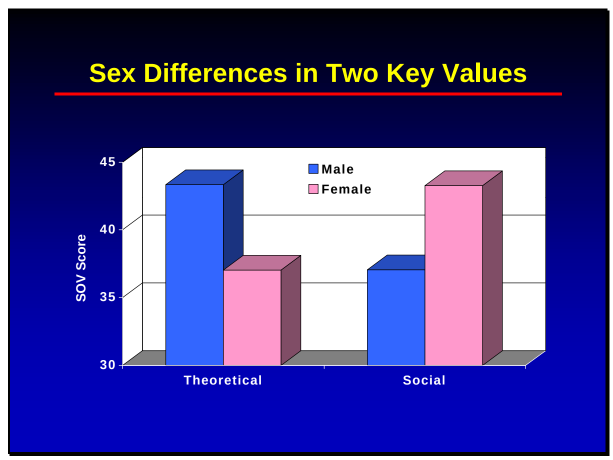
People are another story. They are fascinating. But they lose me when they argue that the underrepresentation of females in engineering results from parents allowing their daughters to wear pink or play with dolls instead of Lego. Or when they claim that even though qualified females who want to study engineering are free to do so, they face barriers that are subtle or even hidden.

I propose a radical alternative. It is that these barriers are difficult to detect because they don't exist. And that the question, "why don't more women choose careers is engineering" has a rather obvious answer: ***Because they don't want to***.

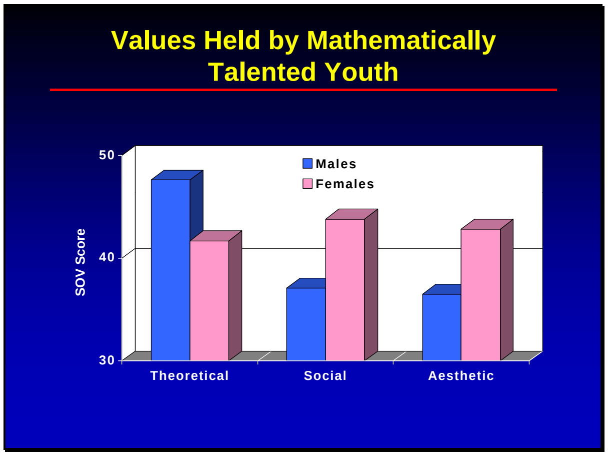
Of course, this suggestion is heresy to many. But to me, it is a matter of scientific evidence. Much of it comes from vocational psychology, a sub-discipline of the behavioral sciences that focuses on occupational choice and career success. It is the place to start for expert answers to today's question.

One of its more enduring concepts is the Theory of Work Adjustment. It predicts that career success depends on the degree of fit between the individual and the work environment. Fit has two basic elements. The first is satisfaction—how well the environment fulfills an individual's needs. The second is called satisfactoriness. Most of us think of it as performance–-how well an individual meets the requirements of the workplace.

Many factors that influence satisfaction are related to the substance of particular jobs. These can also be measured using any number of psychological tests. I'd like to mention two with time-honored histories.

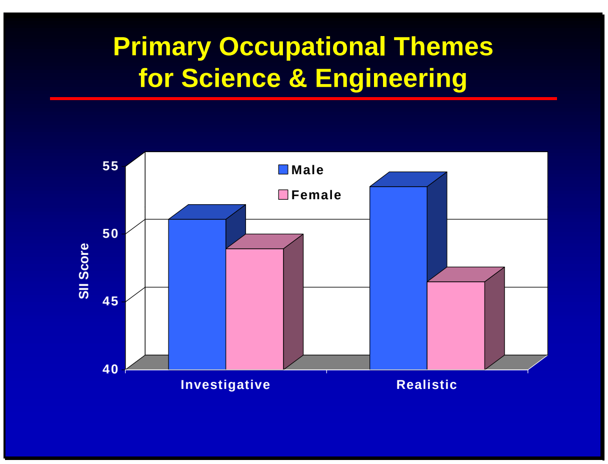


The first is the Study of Values. It assesses the importance we place on six basic values. Those who enjoy the physical sciences typically put far more emphasis on theoretical than social values. The average male shows precisely this pattern; the average female, its opposite.



Especially relevant to today's discussion are values of mathematically talented young people. These findings come from a sample of mathematically gifted junior high school students who took summer math enrichment courses. All had the ability to succeed in math-intensive careers. But the boys were far more likely to have the pattern of values that predicts satisfaction in such careers. Their career choices mirrored these differences.

My second example is the Strong Interest Inventory (SII). This excellent tool assesses interests in six occupational themes. For engineers, the realistic theme is typically first and foremost. Individuals with realistic interests tend to be mechanically inclined or enjoy working with nature. Engineers also show interests in the investigative theme, indicating an empirical orientation.



Sex differences on these two themes help us understand why males are overrepresented in engineering**.** They average higher scores on both. However, the "gender gap" on the all-important realistic theme dwarfs that of the investigative. This pattern helps explain why females reject engineering in favor of other sciences, where investigative interests are paramount. Also noteworthy is that neither theme has responded much to changing sex roles. The SII has been used continuously since the 1930s. Yet, in comparisons made fifty years later, average scores by sex on these two themes had hardly changed.

Interests of Mathematically Gifted 10th Graders

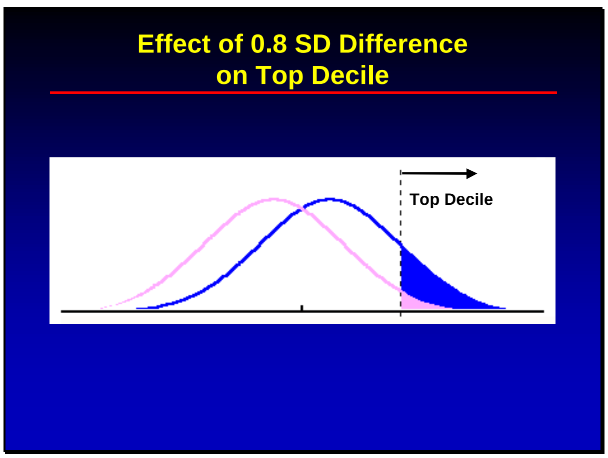
Rank	Boys	Girls
1	Physical Science	Literature
2	Biology / Medicine	Art
3	Sports	Social Service
4	Hunting / Fishing	Biology / Medicine

The SII also assesses interests in about two dozen specific areas. Again, we see strikingly different patterns by sex among the mathematically gifted. These results are from a sample of high school students who scored in the top 1% of mathematical ability. The boys were intensely interested in the physical sciences; the girls were not. This means that as a group, the males were much more likely to find satisfaction in these fields.

These results highlight another surprising finding: that ability and satisfaction are often unrelated. What ability predicts is the second element of fit: performance. A good fit between ability pattern and the demands of the job is by far the best predictor of performance.

Contrary to common belief, success in engineering requires more than mathematical aptitude. Also important is a set of abilities that include spatial, mechanical, and practical aptitudes. One spatial aptitude, 3-D mental rotation, is likely to be very important in engineering. As the name implies, this is the ability to mentally visualize objects rotated in three-dimensional space.

On average, the sexes are fairly similar in cognitive abilities. But the spatial-mechanical domain is an exception. The sex difference on tests of mechanical aptitude and 3-D mental rotation usually averages between 0.8-1.0 standard deviations, and, needless to say, favors males. This far exceeds the sex difference in mathematical reasoning ability. That difference is also highly relevant, but in the interest of time, I leave it for another day.



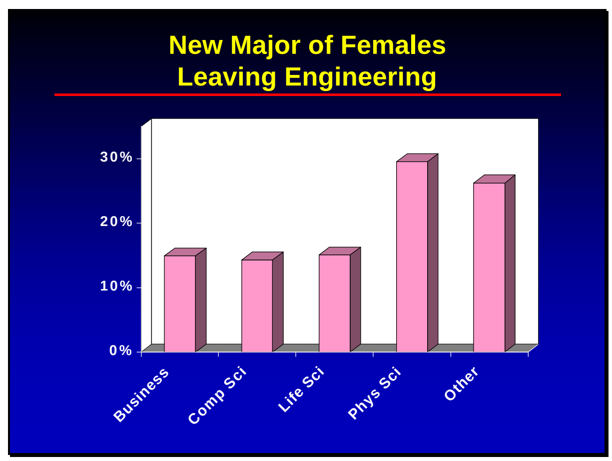
A sex difference of this magnitude is enough to result in a lopsided ratio of males to females at the top of the range. But there is another factor at work: the tendency of males to be more variable. For some aptitudes, this has a huge downside for males, making them more likely to fall at the very bottom of the scale. But due to the large average sex difference, the most noteworthy impact of greater variability on spatial-mechanical aptitude is a magnification of the sex imbalance at the top of the range.

This effect is apparent among high scorers on relevant subtests from the Armed Services Vocational Aptitude Battery. The numbers show that while some women have the technical giftedness that predicts success in engineering, such a pattern is far more common among males.

Sex and Technical Giftedness

	Ratio of M to F	
Subject	***top 10%***	***top 5%***
Arithmetic reasoning	**2:1**	**2:1**
Electronics information	**8:1**	**11:1**
General science	**3:1**	**7:1**
Mechanical reasoning	**8:1**	**11:1**

Of course, using less stringent standards, such as the top quintile, reduces the sex imbalance. It does not come close to eliminating it.



Recent data on choices made by females who switched from engineering to a new major provide evidence of the importance of mechanical interests and abilities**.** Sixty percent of these women stayed in the sciences, but opted for majors where mechanical interests are not as critical--the computer, life, or other physical sciences. Some of these fields also require less spatial-mechanical ability than engineering, which is also significant.

I see this as an example of people sorting themselves, over time, into fields that fit their interests and abilities. What I don't see is much support for claims that science is a "chilly climate for women." Were this so, why would three of five women who leave engineering opt for another scientific field?

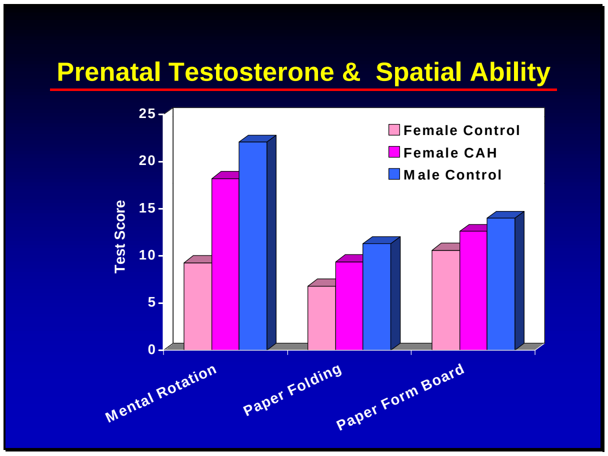
This brings me to the question of where values, interests and abilities come from. Many say socialization, and therefore that these characteristics can be readily changed. I find the evidence against this view overwhelming. Sex differences in behavior emerge in the earliest days or months of life. Long before socialization begins, girls preferentially attend to people and boys to blinking lights, geometric shapes, and three-dimensional objects.

I also find that existing evidence contradicts many assumptions about how parents and teachers socialize girls. For example, socialization theorists argue that girls "learn" to underperform in math. But if this were so, females would not outperform males in some areas of math throughout life. Nor can socialization theorists explain why, in most studies, girls do not lag boys in other areas of math until late in elementary school. This timing corresponds to the onset of puberty and prompted me to consider sex hormones.

I found compelling evidence that these hormones do affect personality and mental abilities. I also found the topic surrounded by layers of taboos. But I still believe that the purpose of the university is to encourage, not stifle, free inquiry. In this spirit, I would like to share a few findings that I consider noteworthy. Due to time constraints, I will limit these to effects in females.

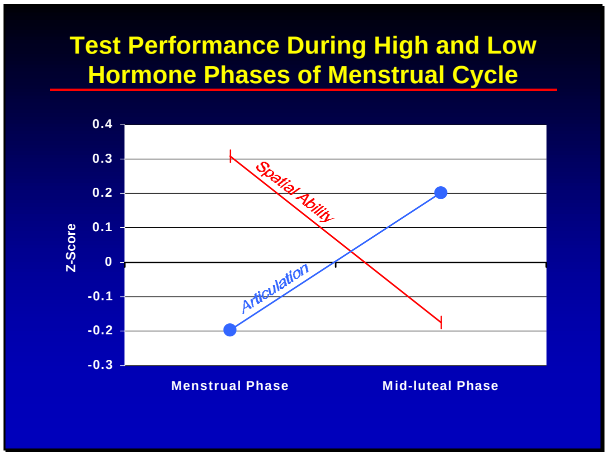
The first finding is that exposure to testosterone during a key phase of fetal development appears to influence spatial ability and some aspects of personality. Several lines of evidence lead to this conclusion. Let me mention one particularly dramatic example.

Girls afflicted with a condition called congenital adrenal hyperplasia are exposed to much higher levels of testosterone in the womb than normal females. Their condition is typically controlled shortly after birth. Yet, these girls retain toy preferences, energy levels, and spatial ability that trend in the male direction.

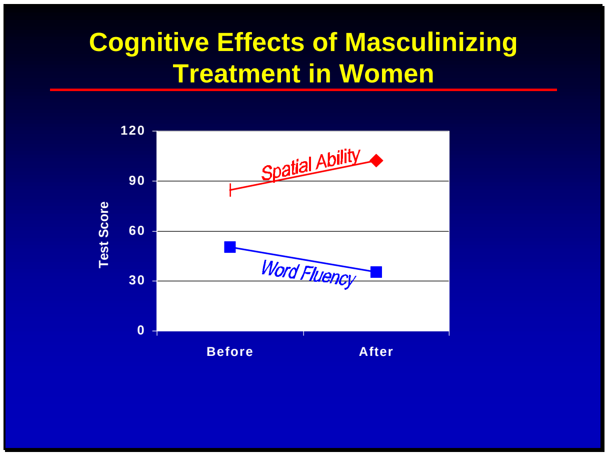


The prenatal environment leaves permanent effects on the brain. Preferences for playing (and working) with objects may originate in this process, which is different in males because they produce their own testosterone during gestation.

Prenatal estrogens probably have a role as well, but I want to focus instead on effects in adult women. Optimal spatial ability seems to occur with exposure to intermediate levels, suggesting a curvilinear relationship.



Changes in abilities that occur over the female menstrual cycle provide evidence that one or more estrogens influence cognitive performance. Spatial ability is higher during the low-estrogen menstrual phase than during the mid-luteal phase, when hormone levels are high.



Research has also found that spatial ability increases and verbal fluency decreases after women are treated with testosterone. This suggests the relative balance of male and female hormones may be the most significant factor. Regardless, I suspect that many women simply have too much estrogen for optimal spatial ability, though this gives them advantage in other areas.

We have a way to go before we fully understand these relationships. But obviously, responsibility for hormonal differences lies with Mother Nature. An ample supply of estrogens and limited levels of testosterone help women do what she wants us to do: be fruitful and multiply. This reproductive agenda has been her top priority for two million years. I doubt she will change her mind anytime soon.

None of this is meant to suggest that hormones alone determine abilities and personality–far from it. Relative differences do provide a parsimonious explanation for variation both within and between the sexes. But I do not see a simplistic explanation here. To the extent that hormones shape our values, interests, and abilities, they influence how we use our environments. These decisions, in turn, affect which characteristics we choose to develop most fully. Add to this our genetic and experiential uniqueness, and I see a complex picture.

Admittedly, my tale of two hormones does not end with females achieving parity with males in the field in the absence of major social engineering. This is the one kind of engineering that gives me great pause. I have no fear for women who possess the requisite interests and abilities, but for those seduced by incentives to enter a field they would have otherwise avoided. Such individuals are unlikely to find long-term satisfaction in the field, an outcome that is obviously undesirable. A first step toward preventing it is to stop asking questions that assume that the null hypothesis is forever. When it comes to sex differences in relevant characteristics, it was rejected long ago.

A better question is whether females are underrepresented in engineering relative to the numbers who possess the predictors of both satisfaction and success. It is possible that the answer is yes. But given what I know right now, I would not put any money on it.