EMBO reports

Aptitude or attitude?

Lawrence Summers' recent remarks reflect what little progress has been made in the public's understanding of why women are under-represented in science

In January this year, Lawrence Summers, the President of Harvard University (Boston, MA, USA), spoke at a conference on 'Diversifying the Science & Engineering Workforce', which was convened by the US National Bureau of Economic Research. In his speech, he proposed explanations for the low representation of women in the higher ranks of science and engineering. His remark that there are "issues of intrinsic aptitude" that explain why men are better suited than women to the hard sciences, such as mathematics, physics and engineering, caused an uproar in the USA and elsewhere. Summers later apologized for his comments but the issue of women's representation in the sciences dominated major US news outlets for weeks.

Summers' remarks highlight a deeper problem with the way in which society perceives the role of women. Although 'socialization' factors were once believed to be responsible for the inequality between men and women, feminism, affirmative action and equal access to tertiary education should have redressed the balance. If society is not to blame, perhaps biology is at fault? Indeed, a number of studies, books and articles insist on some kind of genetic factor or evolutionary history that makes women different. This view remains popular, despite various recent studies and surveys, such as the worldwide Programme for International Student Assessment (PISA) study, that suggest the opposite.

What is clear, however, is that women are disappearing from the ranks: women comprise more than 50% of undergraduates and 40% of postdoctoral researchers, but only 29% of faculty at the assistant professor level. On average, 13.2% of the full professorships in Europe are held by women (EC, 2003) and the number is increasing only slowly. If, as Summers suggested, there is an aptitude difference between the sexes, is equal representation realistic? The verdict is still out, but these differences are too small to explain the large disparities in the workplace. Instead, there seems to be a number of other factors that keep women away from the higher ranks in science and other professions.

There is a danger in taking test results at face value, and drawing conclusions about aptitude based on only one study. Boys, for example, score slightly higher than girls on the mathematics section of the Scholastic Aptitude Test (SAT), a standardized test taken by US high-school students before applying to college (see sidebar). However, by the same token, the PISA 2003 study would suggest that Finns, Koreans, Japanese and Hong Kong Chinese are the most intelligent people in the world, given that their students' performance is far superior to that of US and German students, for example. Needless to say, this is not the conclusion drawn—the results are explained by differences in teaching, culture and attitude. Although PISA also found that males performed better than females in mathematics in a large number of countries, no statistically significant difference was found in one-third of the countries, including the top performers Finland, Hong Kong and Japan. In Iceland and Thailand, girls consistently score better than boys in

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TESTING APTITUDE

The PISA (Programme for International Student Assessment) 2003 study tested the mathematical abilities of 15-year-old students in 40 participating countries. Significant differences in the overall performance in the mathematics section of the test between male and female students were observed in 27 countries. However, the top-performing countries—Finland, Hong Kong and Japan—showed statistically significant differences between girls and boys in only 1 out of 4 sectors tested. In Iceland and Thailand, girls consistently outperformed boys.

TIMSS (Trends in International Mathematics and Science Study) tested fourth-, eighth- and twelfth-grade students in maths and science between 1994 and 1995. In the first group they found statistically significant differences in the performance of girls and boys in favour of boys in only three out of the 16 participating OECD countries; in the second group, in 6 out of the 16 countries; and in the third group, in 14 out of the 16 countries. The two exceptions in the last category were the USA and Hungary. In summary, girls perform worse in mathematics as they progress through school.

The SAT (Scholastic Aptitude Test) is taken by American high-school students (grades 11 or 12) and is used by colleges and universities for admission decisions. The average scores on the mathematics section for girls is 35 points below the average for boys. However, the SAT overpredicts male performance and underpredicts female performance when comparing the test results to the actual performance of college students (www.fairtest.org/facts/genderbias.htm). In fact, males score 33 points higher on the mathematics section of the SAT than females who go on to earn the same grades in college mathematics courses.

mathematics tests (OECD, 2003). "The wide variation in gender gaps among countries suggests that the current differences are not the inevitable outcomes of differences between young males and females and that effective policies and practices can overcome what were long taken to be inevitable outcomes of differences between males and females in interests, learning styles and, even, in underlying capacities," wrote the authors of the PISA study.

Summers linked women's under-representation in the sciences to mathematical abilities, but how would one explain similarly low numbers of women in the humanities or medicine, in which mathematical skills are not a major requirement? Obviously, the aptitude argument does not hold and could even be reversed, since female students consistently outperform males in the reading and literacy sections of PISA. It is therefore valid to wonder why women do not dominate the humanities, medicine or law. In fact, women comprise the majority in many fields at the undergraduate level, but this trend is reversed at the professorial level. Obviously there seem to be factors at work other than genetically linked aptitudes.

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One of these factors may well be society's perceptions of women, which are further encouraged by bestsellers, such as *Men Are From Mars, Women Are From Venus* by John Gray or *Why Men Don't Listen And Women Can't Read Maps* by Allan and Barbara Pease, that provide a pseudoscientific explanation for gender differences. These books, and others like them, proclaim that men and women have developed different capabilities due to their distinct roles over most of human evolutionary history—man as the hunter, woman as the childbearer. There is probably a grain of truth hidden there, but the roles ascribed by the authors are one-dimensional and certainly not based on fact. Instead, they support long-held prejudices about innate gender differences that lead men to have better map-reading skills and women to be good caregivers.

By contrast, *Same Difference* by Rosalind Barnett and Caryl Rivers (Brandeis University, Waltham, MA, USA and Boston University, Boston, MA, USA, respectively) relies on scientific literature to thoroughly disprove these gender myths. The authors highlight the similarities between the sexes and deplore the fact that despite a wealth of publications, these old stereotypes still persist and are taught in the classroom. The danger is that this revival of stereotypes in popular books will hamper further progress and even question what has been achieved so far.

To investigate the power of such stereotypes, Mahzarin Banaji, professor of social ethics at Harvard University, and colleagues have developed the Implicit Association Test (IAT) to uncover unconscious biases. The majority who took the test, men and women alike, found it easier to associate men with science as opposed to women with science. Surprisingly, this was also true for female scientists who took the test. Furthermore, about 80% of the participants associated men with a "work" category and women with a "family" category. Banaji concluded that the results show the pervasive power that cultural biases have—even on those who are themselves victims of such bias (Cromie, 2003; Vedantam, 2005). Her research is supported by Madeline Heilman, professor of psychology at New York University (NY, USA), and others who showed that men are usually more positively assessed than women when identical CVs are sent out for appraisal, independent of the gender of the evaluator (Heilman *et al*, 2004). Obviously, women have ingrained these stereotypes as much as men.

It comes as no surprise then that women who have the 'aptitude', and who have for the most part forsaken family responsibilities, do not receive the same rewards as men. In 1999, the Massachusetts Institute of Technology (MIT; Boston, MA, USA) published a report in which the MIT School of Science admitted not having given their female professorial staff the same compensation as their male colleagues in terms of pay, space, monetary resources and committee positions (Bailyn, 1999). More generally, income gaps of up to 30% between men and women working in comparable positions are reported in the USA and Europe each year (EC, 2005b).

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The dearth of women in higher positions is usually explained by the image of a leaky pipeline in which women disappear at every stage from undergraduate student to full professor. In her book *Aufstieg oder Ausstieg?*, Inken Lind from the Center of Excellence Women and Science in Bonn, Germany, analysed a wealth of studies that investigated the problems of women in science and came to the conclusion that the leaky pipeline model does not adequately reflect reality (Lind, 2004). Instead, the studies point to an accumulation of seemingly small disadvantages and discouragements that add up to block the careers of women. Similarly, Yu Xie, professor of sociology at the University of Michigan, Ann Arbor, USA, and Kimberlee Schauman, assistant professor of Sociology at the University of California Davis, USA, criticize the pipeline model, as it implies that there are no problems at the entry point, and that any policies implemented to stop the leaks will have no effect on encouraging women to enter the sciences. They came to the conclusion that women are discouraged early on from entering science and engineering (Xie & Shauman, 2003). The list of small stumbling blocks is long and includes girls' fear of being unpopular with boys if they are perceived as science nerds, doubts about being able to combine family and career, societal misperception of the working mother, and exclusion from informal networks, to name a few. It takes a lot of dedication to overcome these barriers, most of which men do not have to face.

Reducing the problem to mere aptitude is clearly wrong, but treating women as 'men in skirts' ignores biology as well. It is women who give birth to children, and raising children takes time. The question, then, is if society wants to ignore the consequences of letting women carry the bigger part of the burden. In most European countries the birth rate is below the level necessary to renew the population and the consequences for pension schemes are becoming evident. The European Commission predicts a shortage of qualified workers in the near future and has

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suggested that qualified women could partly fill this gap (EC, 2005a). This dilemma can only be solved by combating stereotypes and by finding new ways to combine both family and career.

Sylvia Ann Hewlett, founder of the US National Parenting Association, thus argues for flexible working hours and more possibilities for women to re-enter their careers after a break (Hewlett *et al*, 2005). In a survey of 2443 women with professional or graduate degrees, Hewlett and colleagues found that 37% had interrupted their careers, 44% of these for family reasons. By contrast, only 24% of the 653 men who were surveyed had interrupted their careers, mostly for a change or further training. Only 12% of these men cited family reasons. Although the average length of the break was only 2.2 years, the cost to the women was extremely high in terms of income and career prospects. A significant proportion of women (38%) said that they had deliberately chosen a position with fewer responsibilities and lower compensation than the job for which they were qualified in order to fulfil their family responsibilities. Another 36% of the total surveyed had worked part-time for some time in an attempt to balance their work and personal life. Hewlett suggests that limiting the possibilities for women to re-enter or pursue their careers commensurate with their capabilities and qualifications costs the employer and society a great deal in terms of lost talent.

In his analysis, Summers made the mistake of comparing apples with oranges. He based his analysis of the career prospects of men and women on the assumption that both are sent into the race as equals. This is clearly not the case. It is difficult to estimate the damage his remarks have caused, given his role as President of one of the most prestigious universities in the world. But given the intense media coverage of his speech, his words have most certainly been read by many more people than all the subsequent studies, responses and counterarguments combined. Only a thorough understanding of all the differences in male and female career paths and outcomes will lead to effective measures that could level the proverbial playing field.

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Engendering creativity in the biomedical sciences

Innovation can be stifled inadvertently or intentionally. Fortunately, there are several ways in which scientists can foster creativity

In the early 1950s, Ludwik Gross found that a virus could transmit leukaemia: ground-up, filtered leukaemia cells induced a malignancy when injected into infant mice (Gross, 1951). This finding was anathema to the biological establishment—Gross commented that some oncologists "even doubted my integrity; one of the well-known pathologists […] refused to shake my hand when I greeted him before one of my lectures" (Kevles, 1997). Gross, who later won the Lasker prize, might today have found himself hauled up on a charge of scientific misconduct or even fraud for announcing such a controversial discovery (Kevles, 1997). In the 1960s, Howard Temin faced resistance—even ridicule—when he suggested that viral RNA could generate complementary DNA. "I'll give Howard's idea the amount of time it's worth—none," said a leading virologist during a meeting at the time. About a decade later, Temin was awarded the 1975 Nobel Prize in Physiology or Medicine for his discovery. In the 1970s, J. Michael Bishop and Harold Varmus faced similar problems when they proposed the oncogene theory of carcinogenesis, which won them the Nobel Prize in 1989 (Kevles, 1997).

> … many factors conspire to hinder creativity on a broader scale among scientists

Pioneers whose work engenders such paradigm shifts are rare. Nevertheless, even prosaic 'puzzle solving' research within current paradigms needs creative, innovative scientists to rethink experimental protocols, modify hypotheses and strengthen theoretical frameworks. Challenging the consensus is the *sine qua non* of science. Yet Giovanni Fava, from the University of Bologna, Italy, recently argued that a "cult of mediocrity" pervades science (Fava, 2005). Fava