

men and women in high-level careers in mathematics and science" (p. 950), but the mean differences in current *Gc*/domain knowledge provide a much clearer picture of why there is such a differential representation. There are data that suggest that gender differences in personality, interests, and/or motivation account for some of the differences in domain knowledge (see, e.g., Ackerman et al., 2001), but that issue goes beyond the scope of Spelke's (2005) article and this comment.

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There Is More to Aptitude Than Cognitive Capacities

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Spelke's (December 2005) critical review is a research-based rebuttal (though implic-

itly) of Summers's (2005) speech that posited a hypothesis that one of the reasons why women are underrepresented in math, science, and engineering may be sex differences in *intrinsic aptitude* for mathematics and science. Putting aside the question of whether the empirical evidence was sufficiently reviewed, the way Spelke conceptualized aptitude as a static rather than a dynamic quality (namely, cognitive capacities) rendered her critique of the "differences in intrinsic aptitude" hypothesis less effective in many respects.

Spelke (2005) decided to focus on the question of "Do men and women have equal cognitive capacities for math and science careers?" (p. 950). This question represents a narrow, perform-on-demand view of aptitude, as aptitude concerns not only what one *can* do when given a task (i.e., capacity) but also what one *will* do (i.e., conation) and *how* one will do (i.e., strategy deployment and style) given a situation. For example, Spelke identified gender differences in strategy use and then dismissed them simply because strategy use does not reflect capacity and is correctable with instruction (p. 954). However, as Lohman (1994) pointed out, the seemingly innocuous strategic and stylistic differences in female students' tendency to use phonological-sequential-string processing and male students' tendency to use analog-image processing may in the long run handicap female students for learning advanced mathematics. Here, aptitude manifests itself as propensity, not capacity, and is nonetheless important for learning and performance as well as their developmental trajectory.

Spelke (2005) also decided to leave out affective dimensions such as preferences, motives, and attitudes and to focus exclusively on cognitive capacities. The question is, how much remains when the affective component is left out? For example, Spelke reviewed the literature on whether infants and toddlers show sex differences in their preferences for objects versus people. Such a preference, either way, is not an issue of cognitive capacity, but an affective and conative one, what Panksepp (1998) referred to as the "seeking system" (p. 144) of the brain. Before we know anything about "capacity," affect has already made choices as to what is attractive in an array of stimuli. A more dynamic, contextual conception of aptitude is theoretically more viable because molar-level intellectual functioning in real-life contexts is never a mechanical switching on and off of some invariable perform-on-demand capacity, but rather a dynamic interplay of cognition (both automatic and

controlled processes), affect, and conation (Snow, Corno, & Jackson, 1996). Affect and conation regulate attention and cognition not only quantitatively but also qualitatively (Dweck, Mangels, & Good, 2004), and they sometimes transform cognition. John Stewart Mill, for example, asserted that males excel on tasks that "require most plodding, and long hammering at single thoughts" (quoted by Darwin, 1896/1972, p. 564). Empirical support (or the lack thereof) aside, most of us would agree that such "plodding" and "hammering" reflect a motivational disposition rather than a cognitive capacity. Yet it can deeply influence the nature of cognition and its related developmental trajectory.

It was not accidental that Spelke (2005) retained the term *intrinsic aptitude* (p. 950) that Summers (2005) used in his speech, *intrinsic* meaning *biological*. Much of the "intrinsic aptitude" that Spelke reviewed involves putative *biologically primary abilities* for mathematics, to use the distinction Geary (1995) made between biologically primary and secondary abilities. This is understandable under the neonativist and evolutionary psychology theoretical frameworks. However, as Geary pointed out, for the most part, mathematical learning involves biologically secondary abilities, which build on biologically primary abilities yet can only be nurtured through cultural provisions. Indeed, Spelke (p. 954) cited Geary's research showing that girls' mathematical reasoning can be improved by telling them to use spatial strategy. This finding suggests that aptitude is likely developmental in nature, subject to both genetic and environmental influences. If so, insistence on finding or denying biologically based "intrinsic" sex differences seems unproductive as a research fixation. A more productive approach is to identify what might constitute *inaptitude* for mathematical or scientific ways of thinking and, when such inaptitude, if any, emerges in females (or males for that matter), what instructional strategies may remedy the condition. Empirically, the claim that purely biologically based differences in abilities were measured and investigated is itself misleading. Most, if not all, of the cognitive abilities empirically known to us are developed, rather than innate, ones. Posing the question of sex differences in terms of "intrinsic aptitude" will inevitably lead to a simplistic yes-or-no answer, when aptitude likely reflects a complex interplay of nature and nurture.

By focusing on "intrinsic aptitude," Spelke (2005) also neglected another important consideration; that is, aptitude is relative to the level of task demands. A

person who has high *aptitude* for doing undergraduate math work may become *in-apt* in the face of more advanced work. What Summers (2005) had in mind was mathematical or scientific expertise and creativity of a caliber worthy of a position in first-tier universities in the United States. Two possibilities along Summers's line of thinking follow. One is that there may exist *threshold* requirements for certain aptitudes, cognitive or motivational, depending on the domain involved and what levels of expertise or creativity one aspires to achieve. The second one is that small initial differences may engender large differences as a long-term developmental outcome. Looking at these issues is more meaningful and fruitful than looking at the "intrinsic aptitude" question. Much of the evidence Spelke presented, particularly the infancy research, may not even be relevant to the question of why there are so few women in math, science, and engineering, because the measures involved are at best weakly correlated with performance on later, more complex, cognitive tasks.

Snow (1992) lamented that the concept of *aptitude* in the history of psychology has lost its functional significance as a potent force in learning and performance and been reduced to a technical term useful only for predictive purposes. While critiquing a capacity view of sex differences, Spelke (2005) herself seemed to fall into the trap of considering aptitude as static, context-free, reducible to cognitive elements, even explainable in terms of biologically primary abilities. Ultimately, the question Spelke formulated may be intractable. Rather than dismissing all the evidence that males and females differ in abilities and propensities, wouldn't it be more productive to focus on the match or mismatch between student aptitudes and instructional methods and on how a more optimal learning condition can be fostered for both males and females with their distinct learning profiles? Wouldn't denying possible gender differences also carry a cost in that regard?

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Cognitive Styles Partly Explain Gender Disparity in Engineering

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Spelke (December 2005) reviewed an assortment of studies showing how rare the differences are between genders in mathematics ability. Yet she also mentioned that academic faculties of U.S. universities in the mathematics-related fields of science and engineering are predominantly male. Aside from differences in gender roles, some of the disparity may also be due to gender differences in cognitive styles, particularly the styles best matched to science and engineering. The data sets from scoring services of the Myers-Briggs Type Indicator (MBTI), published in the *Myers-Briggs Type Indicator Atlas of Type Tables* (MacDaid, McCaulley & Kainz, 1994), demonstrate that significantly more men than women prefer objective evaluation of experience, which Jung termed the "think-

ing" function (Jung, 1962). Significantly more women prefer subjective evaluation of experience, which Jung termed the "feeling" function. In one random sample of 659 women from 2,000 households in 300 counties across the United States, only 34% of participants were "thinking" types, not "feeling" types. In another sample of 4,973 women 15 to 17 years of age who submitted MBTIs for scoring by the Center for Applications of Psychological Type, only 32% were "thinking" types. In another sample of 4,811 women 40 to 49 years of age, only 40% were "thinking" types. This contrasts sharply with the incidence of "thinking" types among men who completed the MBTI. For instance, in a sample of 6,814 adult male college graduates who submitted MBTIs for scoring by the Center for Applications of Psychological Type, 70% were "thinking" types. Of 12,637 male college students of traditional college age, 63% were "thinking" types. Of 23,240 males taking Form F of the MBTI, 63% were "thinking" types.

Data gathered using another measure of thinking style also show gender differences in the same direction as that indicated by the MBTI data sets. In a validation sample of 400 adults (A. Gregorc, personal communication, January 19, 2006), Gregorc found the abstract-random style to characterize a small but significantly higher percentage of women than men on the Gregorc Style Delineator (Gregorc, 1982). The abstract-random style of thinking is associated with a predisposition for empathy and tuning into the emotions of others. It is predominant among psychotherapists, artists, and art collectors of both genders (Gridley, 2006a).

If preferred cognitive style, not just mathematical ability, helps aim an individual toward career selection, then greater homogeneity among certain styles should be expected in a given profession than in the population at large. In the total population of 232,557 in the data bank of the Center for Applications of Psychological Type, only 42% were "thinking" types, whereas 64% of the total population of 986 engineers in that sample were "thinking" types. Such homogeneity should exist despite gender, and this is precisely what I found (in a study submitted for publication in 2005, "Personality Differences Between Artists and Engineers") among 93 women and 53 men who were professional engineers. There were no significant gender differences in their scores on any scales of the Intellectual Styles Questionnaire (Sternberg & Wagner, 1991). This was further corroborated among 26 women engineers who completed another measure of