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Development of Math Attitudes and Math Self-Concepts: Gender Differences, Implicit–Explicit Dissociations, and Relations to Math Achievement

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Three hundred and ninety-one children (195 girls; M_{age} = 9.56 years) attending Grades 1 and 5 completed implicit and explicit measures of math attitudes and math self-concepts. Math grades were obtained. Multilevel analyses showed that first-grade girls held a strong negative implicit attitude about math, despite no gender differences in math grades or self-reported (explicit) positivity about math. The explicit measures significantly predicted math grades, and implicit attitudes accounted for additional variance in boys. The contrast between the implicit (negativity for girls) and explicit (positivity for girls and boys) effects suggest implicit–explicit dissociations in children, which have also been observed in adults. Early-emerging implicit attitudes may be a foundation for the later development of explicit attitudes and beliefs about math.

Children's learning of mathematics is linked not only to their academic skills, but also to their attitudes ("I enjoy math") and their beliefs about math ("I am a math person"). Early attitudes and beliefs about math have been identified as powerful longitudinal predictors of later achievement and academic choices in science, technology, engineering, and mathematics (STEM; Ceci, Ginther, Kahn, & Williams, 2014; Gunderson, Ramirez, Levine, & Beilock, 2012; Master & Meltzoff, 2020). Early gender differences in children's attitudes and beliefs about math are important to understand because they are thought to be one stream of development that feeds into current societal inequities. The particular inequity raised here concerns the underrepresentation of women in STEM at later educational stages and in the workforce (Ceci et al., 2014).

Robust gender differences in children's attitudes and beliefs about math are well-established in older children (late elementary school and early middle school; Cvencek, Meltzoff, & Kapur, 2014; Else-Quest, Hyde, & Linn, 2010), with boys demonstrating more positive attitudes and beliefs about math than girls on a variety of measures (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005). Such differences exist despite the fact that girls generally receive higher classroom grades than boys in mathematics at this age (Lindberg, Hyde, Petersen, & Linn, 2010). It is currently unknown when gender differences in children's attitudes and beliefs about math first become evident, and this is relevant for theories of social–cognitive development, as well as for informing the design of interventions directed at improving STEM interests and achievement in the United States and internationally (Cvencek et al., 2020; Master & Meltzoff, 2020).

Studies that simultaneously investigate *both* attitudes and beliefs about math in the same children are rare. The few studies that have assessed both in the same children are confined to older children, well beyond elementary school (Ganley & Vasilyeva, 2011; Vandecandelaere, Speybroeck, Vanlaar, De Fraine, & Van Damme, 2012). In part, this is due to the scarcity of appropriate instruments to differentially assess these constructs during elementary school (Adelson & McCoach, 2011). In this article, we report a novel measure of children's attitudes toward math that can be used with

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