Predictors of First Graders' Arithmetic Strategy Choices

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Background: Males' and females' aptitude for or interest in mathematics, as evidenced by standardized test scores and STEM-related career choices, seems to diverge at some point in development. Although gender differences in objective mathematics achievement do not become apparent until adolescence, gender differences in mathematical strategy choices are evident in elementary school (Spelke, 2005; Carr & Jessup, 1997). As early as first grade, girls prefer to perform arithmetic using "overt" counting strategies, while males prefer to use "covert" retrieval or mental calculation.

Young females typically display higher levels of self-discipline than young males, and this phenomenon may be related to girls' reliance on low-risk, "perfectionistic" arithmetic strategy choices: counting with blocks or on fingers as if to check the solutions that boys often arrive at through higher-risk insight strategies (Carr & Jessup, 1997). American students of either gender who use overt strategies, such as counting on their fingers or using manipulatives, solve complex arithmetic problems less accurately than students who use covert strategies (Shen, Vasileyva, & Laski, 2015). Additionally, among high-achieving adolescents, those who use covert strategies report more positive attitudes toward mathematics than those who use overt strategies (Gallagher, 1992). These findings suggest that girls establish preferences for maladaptive mathematical strategies by first grade, or perhaps even earlier.

Purpose: The current study seeks to address a gap in the literature by identifying some of the individual skills and characteristics that account for both gender and individual child differences in arithmetic strategy choices. On the basis of previous literature, mathematics anxiety, executive function skills, and risk tolerance were assessed as predictors of arithmetic strategy choice in both boys and girls (Cragg & Gilmore, 2014; Ramirez, Gunderson, Levine, & Beilock, 2013; Levin, Hart, Weller, & Harshman, 2007). Research has not yet established any particular cognitive profile related to overt or covert strategizing, and the present study seeks to explain differences in strategy choice beyond gender differences.

Method: *Population*: A multicultural, economically diverse sample of first grade students from a Mid-Atlantic elementary school was recruited and assessed. *Research Design:* Risk tolerance was measured by Levin et al.'s (2007) Cups Task, which has been found to reveal both gender and individual differences in the amount of risky choices children make in order to win prizes or avoid losing prizes. Executive function skills were measured by Wechsler's (1986) WISC digit span working memory task, Ponitz et al.'s (2008) Head Toes Knees and Shoulders cognitive inhibition task, and Cartwright's (2002) adaptation of a Multiple Classification Card Sorting Test of cognitive flexibility. Executive function tasks typically demonstrate no consistent gender differences and have been used to explain variance in mathematics performance. Math anxiety was assessed using Ramirez et al.'s (2013) Children's Math Anxiety Questionnaire. Arithmetic strategy choice was measured using an interview procedure developed by Carr and Jessup (1997). Children were asked to solve both simple and complex addition and subtraction problems, and then asked to describe the strategies they used to arrive at the solution. Observations of the children's behaviors, such as counting on fingers or private speech, as well as children's accuracy in arithmetic were recorded. Each child's gender, age, and classroom teacher were also noted for use in analysis.

Data Analysis and Results: Preliminary correlational analyses have confirmed previous research suggesting that female students are more likely than male students to use "overt" counting strategies, such as counting on fingers or with counters in order to solve arithmetic problems. Male students are more likely to rely on "covert" strategies such as decomposition, counting "in their heads," or guessing. Additionally, our novel results demonstrate a positive

relationship between covert strategy use and accuracy on arithmetic problems; a negative relationship between covert strategy use and math anxiety; and a positive relationship between covert strategy use and a tendency toward risk taking. Further multiple regression analyses with this data set will clarify the importance of math anxiety, executive function skills, and risk tolerance as moderators of the relationship between gender and strategy choice.
Conclusions: The current study aims to look beyond gender differences in order to clarify some patterns of cognitive abilities that enable adaptive strategizing in early arithmetic. Applications of this study could help children experience early success in mathematics. This study was limited by a small sample size (N = 63) and a single data collection site. Subsequent research could recruit a larger sample and use more sophisticated analyses, such as structural equation modeling or hierarchical linear modeling, to model relations between identified predictors, as well as identify additional salient predictors. Additional research could also examine the social or cultural variables that contribute to these differences, and attempt to determine how early in development these differences in strategy emerge. Future educational research could focus on interventions aimed at closing the gender gap between early strategy choices. Broad implications for this study are relevant to early intervention efforts to diversify the scientific community, particularly by promoting young females' early interest and success in mathematics.

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