American Psychological Association

Developmental Psychology

0012-1649/19/$12.00

2019, Vol. 55, No. 4, 687–702
http://dx.doi.org/10.1037/dev0000658

Chilean Kindergarten Children's Beliefs About Mathematics: Family Matters

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This study examines the relations among parental beliefs and practices about mathematics, children's beliefs about mathematics, participants' gender, and family socioeconomic status (SES). The study was conducted in Chile, a country with significant gender gaps in standardized test results in mathematics, with boys receiving significantly higher scores than girls. One hundred eighty Chilean kindergarteners (M_{age} = 5.6 years) of low and high SES completed both implicit and explicit measures of their beliefs about mathematics. Children's mothers and fathers also completed adult versions of these tests, as well as measures of home numeracy practices. This combination of child and parental assessments (both mother and father), including both implicit and explicit measures, provided a wider range of measures than in previous studies. On implicit measures of math–gender stereotypes, boys showed the math = boy stereotype significantly more strongly than girls did. Both fathers and mothers showed this stereotype on both implicit and explicit measures. Fathers also linked me = math (math self-concept) more strongly than mothers on both implicit and explicit measures. Kindergarten girls' implicit math self-concept was explained by a combination of parents' math self-concepts and SES. Taken together, these results show that by 5 years of age children are already developing beliefs about "who does math" in their culture, and that parental beliefs and practices are significantly linked to children's stereotypes and self-concepts about mathematics before they enter formal schooling.

Keywords: math–gender stereotypes, math self-concepts, parental beliefs, SES, identity development

Supplemental materials: http://dx.doi.org/10.1037/dev0000658.supp

Early mathematical skills are critical for later career success in science, technology, engineering, and mathematics (STEM; Denton & West, 2002; Geary, 2011; Gunderson, Ramirez, Levine, & Beilock, 2012; Uttal, Miller, & Newcombe, 2013). Building early and positive beliefs about mathematics can have cascading effects for STEM skill development (Newcombe et al., 2009; Watts, Duncan, Siegler, & Davis-Kean, 2014). In addition, gender stereotypes about mathematics may contribute to gender differences in attitudes, participation, and performance in STEM fields (Smeding, 2012; Steffens, Jelenec, & Noack, 2010).

Do children come to school with beliefs and stereotypes about "who does mathematics?" To address this developmental question, one needs to examine children's beliefs about mathematics and their relations to family factors before first grade. This current study investigated stereotypes in Chilean children, and how mothers' and fathers' beliefs about mathematics, as well as parental involvement in mathematics-related activities, contribute to children's beliefs about mathematics by 5 years of age, before they start formal schooling.

The Value of Studying Children in Chile

Studying early beliefs about mathematics in young children from Chile is important for three reasons. First, Chile has one of the largest gender gaps in the international PISA mathematics

This article was published Online First December 20, 2018.

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Support for this research was provided by the grants from the Chilean National Fund of Scientific and Technology Development (Fondecyt N° 1150156) and the U.S. National Science Foundation (SBE-1640889; HRD 1661285). Thanks to participating principals, teachers, mothers, fathers, and students, and to our research assistants for their valuable work.

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assessment. Among the 72 countries who participate in this international testing, the gender gap in mathematics (with boys scoring higher than girls) is greater than 20 points in only six countries, one of which is Chile (Organisation for Economic Co-operation and Development [OECD], 2015). This pattern is also observed in the Chilean standardized national school achievement test, taken in eighth and tenth grade, where this gender gap in mathematics achievement is twice as large for low socioeconomic status (SES) students compared to high SES students (Measurement System of Education Quality [SIMCE], 2013). Career choice and access to the better-paid jobs are also not equally distributed by gender in Chile. In 2012, 50% of Chilean parents reported that they expected their sons to work in STEM fields versus only 20% with such expectations about their daughters (OECD, 2015; see also Stoet, Bailey, Moore, & Geary, 2016). A gap of this magnitude was only present in two other OECD countries. In fact, in the last 25 years, fewer than 20% of undergraduate STEM students in Chile were women (Blázquez, Álvarez, Bronfman, & Espinosa, 2009).

Second, a recent debate across the social sciences has questioned the generalizability of research findings obtained from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) cultures (Henrich, Heine, & Norenzayan, 2010). The oversampling of North American participants, in particular, might skew our understanding of child development and family interactions. The current work examines understudied child populations in Chile and applies cognitive-developmental science to a non-WEIRD sample. To our knowledge, no previous studies have tested beliefs about mathematics in parents and their young children from developing countries (Chile qualifies as a developing country; United Nations, 2016).

Third, there is a growing Latino student culture in the United States. Latinos are the fastest growing ethnic group in the United States, and about 25% of all public school children are Latino (Lopez & Velasco, 2011). Given the continuing increase of immigrants from Latin America, it is important for U.S. educators and developmental psychologists to understand how the parental systems function in Latino cultures, and how parental beliefs and practices about mathematics may be related to young children's own developing beliefs about mathematics (Rivas-Drake & Marchand, 2016).

Preschool Children's Beliefs About Mathematics

Young children's interest in mathematics and other STEM fields is linked both to academic (e.g., skills and facts) and nonacademic (beliefs and attitudinal) factors. We focus on two types of nonacademic beliefs that are linked to children's early interest in mathematics. The first is children's belief about whether boys or girls are more likely to participate in mathematical activities. If this takes a societally characteristic form, it can be called a *math–gender stereotype*, the stereotype that *math = male*. Previous research suggests that gender gaps in mathematics are driven at least in part by pervasive cultural stereotypes about who does mathematics (e.g., Cvencek, Kapur, & Meltzoff, 2015; Kurtz-Costes, Rowley, Harris-Britt, & Woods, 2008). The second is a *math self-concept*—that is how strongly the child links *me* and *math* ("I consider myself to be a math person").

The available studies (mostly in WEIRD samples) suggest that boys and girls do not differ in their math self-concepts at the very youngest ages tested so far (Marsh, Ellis, & Craven, 2002), however it is also reported that by late elementary school, girls begin to rate their mathematical ability lower than boys do, even though girls do not rate their ability lower than boys do in other domains (Cvencek, Meltzoff, & Greenwald, 2011; Herbert & Stipek, 2005). Children's stereotypes and self-concepts about mathematics tap two differentiable beliefs that children may hold, and they can interact in interesting ways. Stereotypes refer to beliefs about a generalized social group to which one may or may not belong ("math = boys"), whereas self-concepts refer to the self ("me = math"). For example, gender-related stereotypes about academic ability and "brilliance" are acquired early and have an effect on children's stated interests (Bian, Leslie, & Cimpian, 2017). Such stereotypes have been implicated in undermining young girls' mathematical performance, their forming identification with this academic subject, and their aspirations about the future (Coyle & Liben, 2016; Master, Cheryan, & Meltzoff, 2017). Although research shows that young elementary schoolchildren in K–2nd grades hold some math–gender stereotypes (e.g., Ambady, Shih, Kim, & Pittinsky, 2001; Cvencek et al., 2011; Galdi, Cadinu, & Tomasetto, 2014; Heyman & Legare, 2004; Steele, 2003), to our knowledge, only one previous study has examined the age of acquisition of math–gender stereotypes by extending downward to include a preschool sample (del Río & Strasser, 2013). No previous research has systematically examined whether and how kindergarten children's gender stereotypes about mathematics may be related to children's emerging math self-concept and how these beliefs relate to the beliefs and practices of the children's own parents.

Turning now to math self-concepts, the classic developmental research in this area has focused on elementary and secondary school students (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Wigfield et al., 1997), with less attention given to the math self-concepts before children enter formal schooling.

Implicit and Explicit Beliefs About Mathematics

Human behavior is not only guided by conscious (explicit and controlled) processes, but also by more unconscious (implicit and automatic) processes (Gawronski & Payne, 2010). Traditionally, explicit measures have been used to investigate stereotypes and prejudice in children. However, prior studies have also highlighted the challenges of asking children as young as kindergarten to introspect and verbally report about themselves and their social groups as required by most explicit measures (Killen, McGlothlin, & Henning, 2008; Olson & Dunham, 2010). Recent research suggests that implicit measures may provide a useful tool for bypassing these linguistic and introspective challenges. Critically, the empirical results demonstrate that implicit math–gender stereotypes and implicit math self-concepts are significant predictors of children's actual mathematics achievement—accounting for additional variance over and above the explicit measures (e.g., Cvencek et al., 2015; Steffens et al., 2010).

Development of Implicit and Explicit Beliefs About Math

To date, only a few studies have assessed both implicit and explicit math–gender stereotypes in the same children. Research

using a child-friendly adaptation of the Implicit Association Test (IAT) with U.S. elementary schoolchildren documented implicit math–gender stereotypes as early as 1st–2nd grade (Cvencek et al., 2011). Galdi et al. (2014) also found evidence of implicit math–gender stereotypes at age 6 among Italian girls (but not boys) and that implicit stereotypes were not consistent with children's explicit stereotypes (see also Tomasetto, Galdi, & Cadinu, 2012). Other work also suggests that implicit stereotypes may emerge before explicit ones in children (Ambady et al., 2001; Steele, 2003).

Work with U.S. and Singaporean 1st–5th grade boys and girls, found that stronger math–gender stereotypes (i.e., the belief that boys = math) are associated with stronger math self-concepts for boys and weaker math self-concepts for girls (Cvencek et al., 2011; Cvencek, Meltzoff, & Kapur, 2014). In addition, these studies found that math self-concepts are weaker and less stable than math–gender stereotypes.

Taken together, these results suggest that (a) math stereotypes may develop before math self-concepts, and (b) implicit stereotypes and implicit self-concepts may precede explicit ones. In part for these reasons, this would translate to an expectation that the implicit—explicit correspondence will be weak for stereotype measures (if implicit stereotypes are evident before their explicit counterparts are) and nonexistent for math self-concept measures (if neither implicit nor explicit math self-concepts are in place at ages at which stereotypes are already evident). The current study provides relevant data.

Parental Beliefs and Practices About Mathematics

Parental involvement in mathematical practices at home has been studied as another potential contributor to children's beliefs about, and achievement in, mathematics (Kleemans, Peeters, Segers, & Verhoeven, 2012; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010; Manolitsis, Georgiou, & Tziraki, 2013). The activities in which parents engage with their children at home may communicate beliefs and expectations held by these parents regarding their children and mathematics (Eccles, 1983). Specifically, activities and gender labeling in home interactions may serve to reinforce the pervasive views—either parents' personally held beliefs or societal stereotypes—about which activities and domains are more appropriate "for boys" versus "for girls" (Coyle & Liben, 2016; Leaper & Farkas, 2015; Martin & Halverson, 1981; Simpkins, Fredricks, & Eccles, 2015).

Parents who have positive beliefs about their child doing mathematics and/or have more positive math self-concepts themselves, tend to engage in higher frequency of mathematics-related activities at home (Gunderson et al., 2012). Parents of prekindergarteners who report enjoying doing mathematics with their children engage more often in numeracy practices at home (Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000), and parents who have higher expectations about the importance of mathematical skills for their children's success in first grade report a higher frequency of home numeracy practices (del Río, Susperreguy, Strasser, & Salinas, 2017; Skwarchuk, Sowinski, & LeFevre, 2014). Similarly, parents who possess stronger math self-concept report higher expectations for their children's mathematical skills, thus engaging with them more frequently in numeracy activities at home, compared to parents with weaker math self-concepts (Simpkins, Fredricks, & Eccles, 2012). Research has also shown that mothers who are more confident about their mathematical skills are better at conveying mathematical content and scaffolding their child's learning during homework (Caspe, Woods, & Lorenzo Kennedy, 2018; Hyde, Else-Quest, Alibali, Knuth, & Romberg, 2006).

Parents' stereotypes could also influence their differential engagement in mathematical activities with their sons and daughters. In many Western countries, there is a stereotype held by adults that mathematics is a male domain (e.g., Leslie, Cimpian, Meyer, & Freeland, 2015; Nosek et al., 2009). Research on the intergenerational transmission of beliefs suggests that children's own beliefs about mathematics may arise at least in part as a function of their parents' beliefs and stereotypes (Berkowitz et al., 2015; Pruden & Levine, 2017; Upadyaya & Eccles, 2015). This is in line with the results of a meta-analysis investigating parents' and children's gender schemas, which showed that parents who had a more traditional gender schema had children with gendered cognition of themselves and others (Tenenbaum & Leaper, 2002). Parents who hold more firmly rooted math–gender stereotypes are more likely to explain science to their sons than to their daughters, and also use more cognitively demanding speech with their sons than with their daughters (Crowley, Callanan, Tenenbaum, & Allen, 2001; Tenenbaum & Leaper, 2003).

To date, research on parental involvement and parents' beliefs has typically relied on maternal data only (Tracey & Young, 2002). There is an increasing call for the inclusion of fathers, and not only mothers, to illuminate more fully the role of the home environment and parenting factors on children's mathematical outcomes (e.g., Bhanot & Jovanovic, 2005, 2009; Jacobs & Bleeker, 2004). To our knowledge, only two studies have examined both fathers' and mothers' beliefs about mathematics with children as young as 5- to 6-years-old. Tomasetto, Mirisola, Galdi, and Cadinu (2015) found that the relation between fathers' evaluation of their child's mathematical ability and child's own self-perception of ability remained significant even after controlling for the effect of mother's evaluation. A study by del Río and colleagues (2017) found that—although both maternal and paternal numeracy expectations were related to mathematical practices at home with their kindergarten children—only maternal practices predicted children's numeracy outcomes. In the current study, we are examining how both mothers' and fathers' beliefs and practices about mathematics are related to children's math self-concept, and whether mothers' and fathers' involvement may be differentially associated with their sons' and daughters' beliefs. Because traditional gender roles within Latino families are known to contribute to shaping children's beliefs (Rivas-Drake & Marchand, 2016), we investigate statistical path models involving differential links between maternal and paternal beliefs and practices and children's math self-concepts.

SES and Individual Differences in Math Self-Concepts

SES has been shown to be associated with early mathematical skills in young children (Dearing et al., 2012; Galindo & Sonnenschein, 2015; Melhuish et al., 2008). The quality of the home learning environment is related to the availability of educational resources and children's academic performance (Fan & Chen, 2001; Jeynes, 2005). SES is also a significant predictor of families' involvement in different kinds of numeracy activities with their

children: It has been reported that low SES families tend to offer fewer numeracy activities and resources (Saxe et al., 1987; Susperreguy & Davis-Kean, 2016). This difference in home numeracy activities may be related to both the development of mathematical skills and of mathematical beliefs such as stereotypes or self-concepts.

Another pathway through which SES may be related to children's own views of mathematics is through societal expectations. In Chile, schools are highly segregated by SES and thus students are grouped in homogeneous schools. The educational results of each school sector (public, charter, and private) on the Chilean standardized tests show an important gap between low and high SES schools. The scores of schools on the standardized tests of mathematics and language in Chile (SIMCE) are public, and annual rankings of schools are published in the newspapers. Consequently, Chilean families and children from different neighborhood schools are well aware of social expectations regarding their educational achievement, putting students from a low SES background at risk of being susceptible to these expectations from an early age.

Several studies have shown that parental expectations are related to an increase in students' mathematical achievement, and that SES can be a moderator of these relations (Murayama, Pekrun, Suzuki, Marsh, & Lichtenfeld, 2016; see also Benner, Boyle, & Sadler, 2016; Bicer, Capraro, & Capraro, 2013; Stull, 2013). Using structural equation modeling techniques and data from a national cross-sectional study, Davis-Kean (2005) found that SES was a predictor of parental expectations, and that these expectations, in turn, are related to achievement through parents' practices. In other words, low SES families showed lower expectations and, consequently, parents demonstrated less supporting academic practices.

Aims of the Current Study

It is informative to examine the developmental relation between children's math stereotypes and their math self-concepts; and it is also important to additionally examine the interplay between parental beliefs and practices and their relations to the development of children's own beliefs.

To address this point, we used path analysis, a technique that allows the examination of multiple pathways simultaneously to identify both direct and indirect effects of predictors. This path analysis was conducted to assess several theoretical predictions that are derived from the five interrelated lines of previous research. First, capitalizing on research in elementary students that shows that children hold stereotypes about which gender is more strongly associated with mathematics (Ambady et al., 2001; Cvencek et al., 2011; Galdi et al., 2014; Heyman & Legare, 2004; Steele, 2003), we examined the possible relation of children's own stereotypes about mathematics and gender to their emerging math self-concept. For consistency, we also examined whether parents' stereotypes were associated with parents' self-concepts. Second, following research about the relation of parents' beliefs and their engagement in mathematical activities with their children (Blevins-Knabe et al., 2000; del Río et al., 2017; Gunderson et al., 2012; Hyde et al., 2006; Simpkins et al., 2012; Skwarchuk et al., 2014), we examined paths from parents' beliefs, stereotypes, and self-concepts, to their mathematical practices at home. Third, based on findings that parents with more traditional gender schema had children with gendered cognition of themselves and others (Tenenbaum & Leaper, 2002), we also evaluated the relations of parents' self-concepts to children's self-concepts and stereotypes. Fourth, given the known association of SES with mathematics achievement and the mathematical home environment (Dearing et al., 2012; Fan & Chen, 2001; Galindo & Sonnenschein, 2015; Jeynes, 2005; Melhuish et al., 2008; Saxe et al., 1987; Susperreguy & Davis-Kean, 2016), we also examined the role of SES. Fifth, taking into account the part that traditional gender roles may play in differentiating parents' behaviors toward their sons versus daughters (Rivas-Drake & Marchand, 2016), we examined the above-mentioned relations for both mothers' and fathers', and took into account the child's sex. Some of these models are causal in nature, but the path analyses themselves do not provide clear evidence of causal direction (we return to this issue in the Discussion section).

Such messages are likely to be related to a child's motivation to pursue particular activities in the short run. In addition, over time, children are expected to develop their own self-perceptions and interests, based on their parents' messages and behaviors as well as on their own experiences, and these self-perceptions will ultimately affect their future task choices (Jacobs & Eccles, 2000). For example, parents who value math and believe that their children excel at it might convey this to the child by engaging in a range of math-promotive behaviors (e.g., positive comments, playing math games with the child, enrolling the child in an engineering camp). Such messages are likely to help children develop high values and more positive self-perceptions of math abilities. Of course, it is important to acknowledge that parents' and children's beliefs are likely to influence each other reciprocally.

Beyond the path analysis, we sought to make three novel contributions. First, we measured both explicit and implicit beliefs in the same children, thus providing a more comprehensive assessment of children's developing beliefs about mathematics than either type of measure taken alone. Based on the extant literature, we expected to find significant relations between these variables in the case of implicit measures (but did not predict this for the explicit, self-report measures because previous work found them to be less sensitive in preschool children). Second, few previous studies of young children have examined the relation between children's math–gender stereotypes and self-concepts and the corresponding measures in both parents. This is an important gap because parents are likely to be a strong source of identity development in children, and mothers and fathers might have distinct roles. We hypothesized differential links between parental beliefs and practices and children's math self-concept, depending on the gender of the parent and the child. Third, no previous study has examined the early development of math–gender stereotypes and their relation to children's math self-concepts as early as 5 years of age. At the broadest level, this study aimed to examine the relation between parents' and children's beliefs about mathematics in the family environment, especially as it pertains to the emergence of students' math self-concept at early ages. Based on previous literature with older children, we expected math–gender stereotypes to emerge earlier and influence math self-concepts rather than the other way around.

Method

Participants and Setting

The data reported in this study were collected between March and June of 2016, using a sample of 5-year-old children and their parents in Chile. The procedures of this research were approved in advance by both the Santiago School District, as well as the University Diego Portales institutional ethics committee, as project #067–2014, "La matemática es un asunto de niños: estereotipos de niños y niñas de kínder, sus familias y educadoras" ["*Math is for boys: Kindergarten children, teacher and parents math-gender stereotypes,*" Fondecyt N°1150156]. Recruitment was done through schools. Principals were contacted by phone and then in person to explain the procedures of the study. Parents were contacted during Parent–Teacher Association meetings to explain the study procedures, and they were asked to give written consent for their participation and that of their children.

The study was conducted in eight urban schools in Santiago, Chile, four of which were public schools that primarily served students from low-income families, and the other four were private schools that served children from higher income families. There is high socioeconomic segregation within the Chilean educational system (Valenzuela, Bellei, & de los Ríos, 2014), which means that, in any given school, children's SES will be very similar. Also, we used household income declared by parents as an individual measure for children's SES (low SES families came from households that are actually considered to be low-income by Chilean standards).

Children. Our sample included 180 kindergarten children (87 girls). Kindergarten is the first mandatory educational level in Chile, and the last before formal education that begins with 1st grade. The mean age of children was 5.6 years (SD = 0.37, age range = 4.4–7.1 years). Children's age was not significantly different between low and high SES. Children were evaluated during a one-on-one session with a researcher in a quiet room provided by the schools. All children gave verbal assent to participate. The measures were administered in a single session lasting 20–30 min. Children were tested individually in a separate quiet room outside of their classroom while seated at a desk.

Parents. One hundred eighty families (99 from low SES, 81 from high SES) were recruited. Each family included a participant child plus two parental figures. The mother's and father's ages were: mother age, M = 36.3 years, SE = 6.8; father age, M = 38.9 years, SE = 8.5. On average, low SES parents had an educational level lower than a high school diploma, whereas high SES parents were above a high school diploma. The father group included not only biological fathers, but also encompassed male father figures living in the homes of the targeted children, including grandfathers, male partners, and adult brothers (19 cases). The parents' evaluation was done at their home, and a small monetary incentive (equivalent to U.S. $30) was offered for their participation. Out of the total 180 children and their parents, 171 (82 female) presented complete data on all tasks, and these families constituted the analytical sample of this study.

Materials

Each test session began with a 3–5 min description of the study, during which children were familiarized with the test apparatus (i.e., electronic tablet with a 20.3 cm screen). The children were told that they would be "asked to play a computer game and to answer some questions." For both children and parents, the order in which implicit and explicit measures were administered was counterbalanced. The numeracy beliefs and practices questionnaire was administered to parents after the implicit and explicit measures.

Children's tasks. All children completed two implicit and two explicit measures.

Implicit measures. For the implicit tasks, children completed a child-friendly adaptation of the adult IAT. The child-friendly adaptations of the IAT used in this research (described below) were based on a pictorial, color-coded Child IAT version developed and validated for use with preschool children (see Cvencek, Greenwald, & Meltzoff, 2016, for details). Children are asked to rapidly sort the stimuli belonging to four categories by using two response keys. The Child IAT is based on the principle that it is easier to give the same response to items that are associated than if they are not. Children, similarly to adults, find certain associations to be more natural or "congruent," and they respond to them with more facility.

Implicit measure of math–gender stereotypes. This Child IAT measure assessed the stereotype of associating social group with academic subject (math = boys). This is referred to as a math–gender stereotype. During the math–gender stereotype Child IAT, children responded to images representing the categories of math, reading, boy, and girl. The math and reading categories were each represented by pictures of items related to the subjects (e.g., calculator, numbers, book, and letters). Four pictures of children were used to represent each of the two gender categories. In one task, math and boy images shared a response key, as did reading and girl images. This is termed the "congruent" task because it aligns with the common stereotype. In the other task, the assignment of the math and reading images was reversed.

The math–gender stereotype Child IAT score (D) was calculated using the scoring algorithm developed by Greenwald, Nosek, and Banaji (2003), where D score is calculated by first (a) computing the difference between the mean response latencies of the congruent and incongruent tasks for each subject, then (b) dividing that by the pooled standard deviation. For the math–gender stereotype IAT, D was scored so that it had the computational upper and lower bounds of +2 (math = boys) to −2 (math = girls), with a rational value of 0 indicating an equally strong association of math with both genders (i.e., a D score of 0 indicated the child's mean response latency in the math = boys task was statistically equal to that of the math = girls task).

Implicit measure of math self-concept. The implicit measure of math self-concept was another Child IAT. This measure assessed the degree to which the child associated him- or herself with math (me = math). The math self-concept measure followed the same format as the math–gender stereotype IAT, with one exception: Instead of the boy and girl categories, the categories me and not-me were included, along with math and reading. The me and not-me categories were represented by two sets of novel flags: one set that had been given to the child ("my flags"), and another set which did not belong to the child ("not my flags"). This is based on a social psychology phenomenon termed the *mere ownership effect*. Children, just like adults, who receive an item as a gift (i.e., acquire its ownership) evaluate that item more favorably than do

people who examine an identical item but do not own it (Beggan, 1992). Cvencek et al. (2016) provide extensive psychometric validation of the use of small flags as proxies for the self in Child IAT measures. In one test block, math and me images shared a response key, as did reading and not-me images. In the other test block, left versus right assignment of the math and reading images was reversed.

The math self-concept Child IAT *D* was computed in a similar fashion as the math–gender stereotype measure, with the computational upper and lower bounds of +2 (me = math) to −2 (me = reading), with a rational value of 0 indicating an equally strong association of self with both academic subjects (i.e., a D score of 0 indicated the child's mean response latency in the me = math task was statistically equal to that of the me = reading task).

Explicit measures. For the explicit tasks, children completed two pictorial Likert-scales. The explicit measures of math–gender stereotypes and math self-concepts were administered as four Likert-scale questions based on Harter and Pike's (1984) Pictorial Scale of Perceived Competence and Acceptance for Young Children. Cvencek et al. (2011) validated these pictorial measures as indicators of math–gender stereotypes and math self-concepts (see also Cvencek et al., 2015; Paz-Albo Prieto, Cvencek, Llácer, Escobar, & Meltzoff, 2017).

Measures assessing each of the two constructs consisted of two questions. For each question, children were shown two pictures of a child character and responded by reporting: (a) which of the two characters (boy or girl) they believed possessed an attribute (e.g., liking math) to a greater degree, and (b) whether the character possessed the attribute "a little" or "a lot." This was done by pointing to two different-sized circles (1.1 cm and 2.3 cm in diameter, respectively) to indicate less versus more possession of the attribute.

Explicit measure of math–gender stereotypes. The self-report measure of math–gender stereotypes was administered as two Likert-scale questions. In one item, a picture of a boy doing mathematics was presented next to a picture of a girl doing mathematics, and the child was asked which one was believed to like math more. After making a selection, the child was asked to decide if the character in the picture liked math a little more or a lot more. A second item followed the same format as the first item, but the characters in the pictures were reading instead of doing mathematics; the children were asked to decide who liked to read more. The explicit math–gender stereotype measure was computed as a difference score that ranged from +2 ("boy character likes math more than he likes reading") to −2 ("girl character likes math more than she likes reading"), with a rational value of 0 indicating that the child picked the boy and girl character as both liking math (and reading) equally (in increments of .5).

Explicit measure of math self-concept. The self-report measure of math self-concept was similar to the pictorial math–gender stereotype measure. For each question, children were shown two pictures of a child character—one engaged in mathematics, the other in reading—and responded by selecting which same-sex character was more like the self. The explicit math self-concept measure was scored as a difference score that ranged from +2 ("same-sex character doing math is more like me") to −2 ("same-sex character doing reading is more like me"), with a rational value of 0 indicating that the child picked the same-sex character that was doing mathematics and the same-sex character that was doing reading as both being equally like him or her (in increments of .5).

Parents' tasks. Parents completed the corresponding adult versions of implicit and explicit stereotype and self-concept measures as their children, as well as explicit measures of home numeracy practices and beliefs.

Implicit measures. For the implicit tasks, parents completed two standard, adult IATs: One IAT measured math–gender stereotypes and another IAT measured math self-concepts. Both implicit measures were derived from previously published IATs with adults (Nosek, Banaji, & Greenwald, 2002) and used the same scoring conventions as the corresponding Child IATs (see above).

Implicit measure of math–gender stereotypes. The implicit measure of math–gender stereotype for parents was an IAT with the same categories as the math–gender stereotype Child IAT, but with the following, written category labels: mathematics, language, male, and female. Where the Child IAT used pictures to represent the four categories, the adult IAT used only text stimuli (e.g., "subtraction," "verbs," "him," "she"). The math–gender stereotype IAT for parents was scored using the same *D* scoring algorithm that was used with children (Greenwald et al., 2003).

Implicit measure of math self-concept. The implicit measure of math self-concept for parents was an IAT with the same categories as the math self-concept Child IAT, but with the following, written category labels: *mathematics*, *language*, *self*, and *other*. Where the Child IAT used pictures to represent the four categories, the adult IAT used only text stimuli (e.g., "algebra," "poetry," "myself," "them"). The *D* scoring algorithm used for the math–gender stereotype IAT was also used to score the math self-concept IAT for parents (Greenwald et al., 2003).

Explicit measures. Parents also completed three explicit measures pertaining to math–gender stereotypes, math self-concepts, and parental numeracy expectations and practices.

Explicit measure of math–gender stereotypes. The self-report measure of math–gender stereotype for parents was administered as two Likert-scale questions, one each for mathematics and language: "Please rate how much you associate mathematics [language] with males or females" (Nosek et al., 2002). Responses were selected from a scale of 1 (*strongly male*) to 7 (*strongly female*), with a midpoint option of 4 (*neither male nor female*). Following Nosek et al. (2002), by taking the difference between the mathematics and language ratings, the explicit stereotype measures were made comparable to the implicit measures: Rational zero points were provided by the measures' construction as difference scores that have expected values of zero when the constructs being measured are absent.

Explicit measure of math self-concept. The self-report measure of math self-concept for parents was administered as three Likert-scale questions (Nosek et al., 2002). Two questions asked how much the subject agreed with the statements, "I consider myself to be a mathematical [language] person. (Me considero a mí mismo/a como una persona matemática [de lenguaje])." Responses were selected from a scale of 1 (*strongly disagree*) to 7 (*strongly agree*), with a midpoint option of 4 (*neither disagree nor agree*). A third item asked, "Do you consider yourself to be more mathematical or linguistic? (¿Se considera a sí mismo como más matemático/a o más de lenguaje?)." Responses for this item were selected from 1 (*strongly a mathematical person*) to 7 (*strongly a language person*), with a midpoint option of 4 (*neither a mathe-*

matical nor a language person). Similar to the math–gender stereotype measure, the explicit math self-concept measure was also computed as a difference score between mathematics and language ratings.

Home numeracy expectations and practices questionnaire. Both parents also completed an adapted Spanish version of the Parents' Home Numeracy Questionnaire on paper (Skwarchuk et al., 2014). This questionnaire included a series of home numeracy activities in which parents reported the frequency with which they involved their children in mathematical practices at home, on a scale ranging from 1 (*rarely or never*) to 5 (*most days per week*). Some sample items include, "I help my child learn simple sums (e.g., 2 + 2)," "I encourage my child to do mathematics in his/her head," "We talk about time with clocks and calendars," and "I help my child weigh, measure, and compare quantities;" and also activities such as, "I teach my kid to recognize written numbers," "We play board and card games," or "We sing songs that include numbers." Two scales, one for mothers and one for fathers, were created by averaging the 13 items for each parent.

Parents also reported how much they agreed with the importance of their child reaching specific numeracy benchmarks before starting Grade 1, on a scale of 1 (*unimportant*) to 5 (*important*). These benchmarks included counting to 10 and counting to 100, among others. Following Skwarchuk et al. (2014), parents indicated the importance of six numeracy benchmarks. The resulting ratings were averaged to create the mothers' and the fathers' numeracy expectations scales.

Data Reduction

Based on the three previously published exclusion criteria from the Child IAT literature (i.e., excessively fast or slow responding, excessive error rates; Cvencek et al., 2011), data for 17 participants were excluded from the analyses. The final sample included 163 children (80 girls; 83 boys) who had valid data for at least one of the two Child IATs (none of the parents met any of these exclusion criteria). For the path analyses, missing data were treated using Full Information Maximum Likelihood in Mplus, which provides unbiased estimates in these cases (Graham, 2009). Therefore, the final sample for these models was 171 cases (82 mothers and 89 fathers).

Analysis Plan

First, we examined the means of the implicit and explicit measures. Scores for each group of participants (girls, boys, mothers, and fathers) were compared against its neutral point. For all implicit measures, the neutral point was the rational zero point of each Child/adult IAT; for all explicit measures the neutral point was the midpoint of the scale (see above). Testing for the significant differences from zero allows us to evaluate whether math–gender stereotypes and math self-concepts are evident in each group of participants and if so, in which direction. In the case of child participants, these tests provide developmental evidence for the emergence (or lack thereof) of implicit and explicit math–gender stereotypes and math self-concepts at 5 years of age.

In addition, for each measure, we compared boys' scores to girls' scores, and mothers' scores to fathers' scores. Testing for male–female differences in math–gender stereotypes and math self-concepts for children and parents allows us to evaluate whether the construct (stereotype vs. self-concept) is evident in one gender more strongly than in the other.

Next, we examined correlations between children's and parental scores on all measures. Testing for parent–child relations allows us to evaluate how stereotypes about mathematics may transfer from parents to children.

Finally, we conducted path analyses to provide estimates of the magnitude and significance of hypothesized relations between our measured variables. Using path analyses with Mplus (Muthén & Muthén, 1998–2015), we tested models for predicting children's explicit and implicit math self-concepts. These models allow us to evaluate how well the proposed cognitive, parental, behavioral, and demographic factors predict math self-concepts of 5-year-olds.

Results

The results are organized in five sections. Presented first are the results of implicit and explicit stereotype measures, followed by the results of implicit and explicit math self-concept measures. Presented next are the analyses of the explicit measures of parental numeracy beliefs and practices at home. Finally, the full models of direct and indirect effects on children's early implicit math self-concepts are presented. Table 1 shows correlations between SES, child gender, and our child and parent measures (the correlation table that presents these results separately for girls and boys can be found in the online supplemental material).

Math–Gender Stereotypes

On the IAT measure, the implicit math = male stereotype was significantly different from zero (and in the predicted, stereotypic direction of math = male) for fathers, $t(170) = 6.79$, $p < .001$, $d = 0.52$, mothers, $t(170) = 6.53$, $p < .001$, $d = 0.50$, and boys, $t(80) = 2.62$, $p = .01$, $d = 0.29$, but not for girls, $p = .66$ (see Figure 1, top panel). There was a sex difference in how strongly the children held the math–gender stereotype: Boys associated *math* with *male* significantly more strongly than did the girls, $t(156) = 2.02$, $p = .04$, $d = 0.32$. No statistical difference was found for the strength of the implicit math–gender stereotype for mothers and fathers, $p = .94$.

On the explicit measure, the math = male stereotype was statistically significant (again in the stereotypic direction) for fathers, $t(170) = 5.98$, $p < .001$, $d = 0.46$, and mothers, $t(170) = 8.52$, $p < .001$, $d = 0.65$, but the explicit measure was not significant among either the kindergarten boys or the kindergarten girls, $ps > .40$ (see Figure 1, bottom panel). No differences in the strength of the stereotype were found between explicit math–gender stereotypes of mothers and fathers, $p = .12$, nor between boys and girls, $p = .61$. However, we found that mothers of boys had stronger explicit math–gender stereotypes than fathers of boys, $t(88) = 2.47$, $p = .02$, $d = 0.35$.

Math Self-Concepts

The math self-concept measures addressed how the individual participant identified with mathematics. On the implicit math self-concept measure, the me = math association was significantly different from zero for fathers, $t(170) = 5.30$, $p < .001$, $d = 0.41$,

Table 1
Correlations (Pearson's R) for SES, Gender, and All of the Children's and Parents' Implicit and Explicit Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. SES	—																
2. Child's gender	−.02	—															
3. Child's Im. MGS	−.11	.16*	—														
4. Mother's Im. MGS	−.12	−.04	−.10	—													
5. Father's Im. MGS	.002	−.002	.03	−.06	—												
6. Child's Ex. MGS	.08	−.04	−.10	−.08	−.02	—											
7. Mother's Ex. MGS	.08	.09	−.14	.17*	−.11	−.10	—										
8. Father's Ex. MGS	.11	−.09	−.03	−.02	.20**	.13	−.001	—									
9. Child's Im. MSC	.13	.10	−.02	−.11	−.07	−.04	−.01	.06	—								
10. Mother's Im. MSC	.18*	.06	.02	−.30**	.13	.06	−.04	.17*	.10	—							
11. Father's Im. MSC	.28**	−.02	.03	.03	.27**	−.03	.05	.10	−.12	.09	—						
12. Child's Ex. MSC	.01	.03	−.02	−.14	−.13	.03	−.03	−.14	.14	.07	.01	—					
13. Mother's Ex. MSC	.14	−.03	−.17*	−.21**	−.003	.15	−.16*	.003	.08	.29**	−.08	.12	—				
14. Father's Ex. MSC	.28**	−.05	−.05	−.01	.11	.10	−.03	.13	−.05	.02	.20**	−.04	.02	—			
15. Mother's NP	−.20**	−.11	−.08	.14	−.06	.01	−.02	−.02	−.09	−.15*	−.02	.08	−.07	−.05	—		
16. Father's NP	−.17*	−.01	.0001	.10	.15*	−.06	.14	−.04	.07	−.12	−.01	.05	−.11	.05	.26**	—	
17. Mother's NB	−.05	.03	.04	.05	.07	.06	.01	.08	−.01	−.03	−.03	.05	.12	.04	.35**	.26**	—
18. Father's NB	−.09	−.02	.05	.07	.07	.04	.10	−.05	−.06	−.12	.01	.09	−.03	.10	.19*	.42**	.39**

Note. SES = socioeconomic status; Ex. = explicit; Im. = implicit; MGS = math–gender stereotype; MSC = math self-concept; NP = numeracy practices; NB = numeracy beliefs.
* $p < .05$. ** $p < .01$.

approached significance for kindergarten boys, $t(81) = 1.73$, $p = .09$, $d = 0.19$, but was clearly not significant for mothers or for kindergarten girls, $ps > .96$ (see Figure 2, top panel). Fathers had significantly stronger implicit math self-concepts than mothers, $t(170) = 3.99$, $p < .001$, $d = 0.41$. No statistical difference was found between implicit math self-concepts of boys and girls, $p = .22$.

On the explicit math self-concept measure, the me = math association was significantly different from zero in the positive direction for fathers, $t(170) = 5.02$, $p < .001$, $d = 0.38$, and the me = math association was statistically significant from zero in the negative direction for mothers, meaning that they identified significantly more strongly with linguistics than with math, $t(170) = -3.60$, $p < .001$, $d = -0.28$ (see Figure 2, bottom panel). As expected, fathers identified with mathematics significantly more strongly than mothers, $t(170) = 6.13$, $p < .001$, $d = 0.66$. For both boys and girls, the explicit math self-concept was not significantly different from zero, $ps > .70$. The difference between boys' and girls' explicit math self-concepts was not significant, $p = .71$.

Parental Numeracy Practices and Parental Numeracy Beliefs

On the parental measure of numeracy practices at home, both mothers and fathers reported a mean frequency of home numeracy practices greater than the scale midpoint, $ts > 3.12$, $ps < .002$, $ds > 0.24$ (see Figure 3). Mothers reported that they were involved in numeracy practices with their child significantly more frequently than fathers did, $t(169) = 4.18$, $p < .001$, $d = 0.39$. No significant differences were observed for mother or father practices in relation to children's gender ($p = .16$, for mothers; $p = .90$, for fathers).

On the parental measure of numeracy expectations, mothers and fathers both reported an importance of numeracy significantly higher than the scale midpoint, $ts > 2.31$, $ps < .03$, $ds > 0.17$ (see Figure 3). There was no significant difference between mothers' and fathers' beliefs of how important numeracy was for their children before starting first grade, $p = .12$.

Path Analyses

We tested models to explain children's math self-concept. Predictors of the child's self-concept were child stereotype, household income declared by parents (SES), parents' home numeracy practices, and parents' math self-concepts. Parents' math self-concepts were also entered as predictors of child stereotype. Parents' numeracy beliefs, their stereotypes, and their self-concepts were entered as predictors of their home numeracy practices and SES, and the parents' math–gender stereotypes were entered as predictors for their self-concepts.

Fit was assessed by using the three most commonly recommended fit indices (Hu & Bentler, 1999). As recommended (Jackson, Gillaspy, & Purc-Stephenson, 2009; Klem, 2000; Yu, 2002), a good fit was indicated by three preliminary tests. First, a good fit was indicated by having a chi-square (χ^2) value that was not statistically significant. Second, the Root mean square error of approximation (RMSEA; a measure based on the noncentrality parameter) should have values less than 0.10 to indicate adequate model fit for RMSEA, or values around .06 to indicate good or excellent fit (Hu & Bentler, 1999). Third, the comparative fit index (CFI) was used, because—unlike some of the less restricting indices—it pays a penalty for every estimation parameter added. CFI values greater than 0.85 indicate acceptable model fit (Bollen, 1989; Watkins, 1989). Both models (i.e., using both implicit and explicit measures) met these three criteria and thus are reported here.

The fit of the model with implicit measures was good ($\chi^2 = 64.53$, $df = 54$, $p = .16$; RMSEA = 0.048; CFI = 0.915). Importantly, it showed significant paths to implicit math self-concept of children. The model (see Figure 4) revealed that

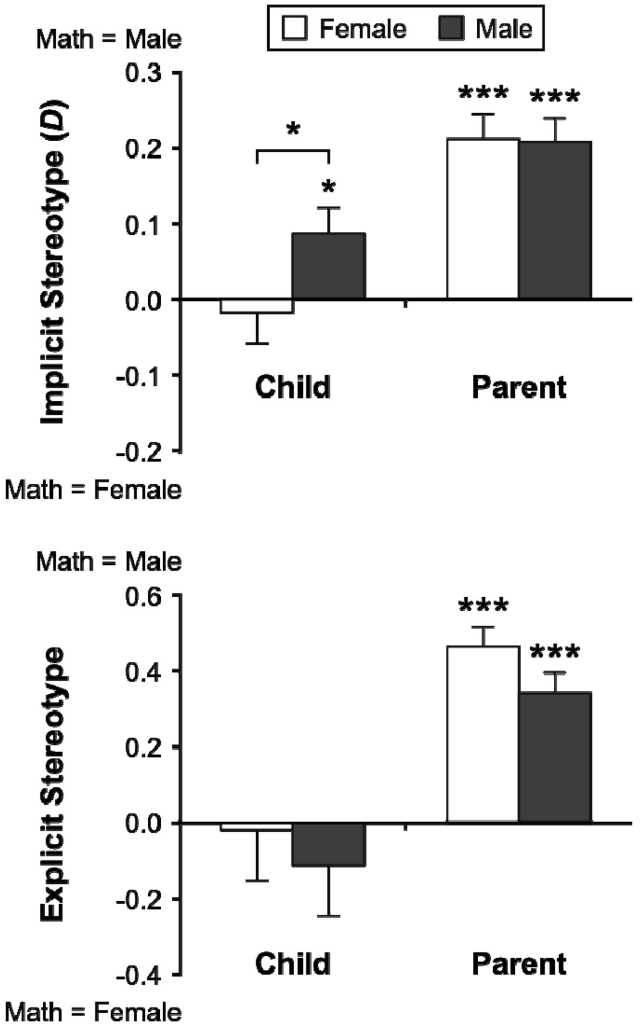

Figure 1. Implicit (top) and explicit (bottom) math–gender stereotypes of Chilean 5-year-old children and their parents. Asterisks above a bar indicate difference from the neutral value of zero. Asterisks above a bracket indicate male-female difference. * $p < .05$. *** $p < .001$. Error bars represent *SE*s.

girls' math self-concept was directly related to SES (girls from high SES have higher math self-concept than girls from low SES) and related to their fathers' and mothers' math self-concepts. Fathers' math self-concept (the degree to which they self-identified with mathematics) had a significant negative path to their daughters' math self-concept ($B = -0.35$, $p < .001$), while the path of mothers' self-concept was positive for daughters ($B = 0.20$, $p = .01$). In addition, the frequency with which fathers engage in home numeracy activities with their daughters had a significant positive effect on their daughters' math self-concept ($B = 0.29$, $p = .03$). Surprisingly, mothers' math self-concept had a negative effect on their involvement with mathematical activities with their daughters ($B = 0.24$, $p = .02$). In the case of boys, none of the variables in the model accounted for significant variance in their math self-concept. To determine whether girls' and boys' models were significantly different, we fitted a model in which all predictors of child self-concept were constrained to be equal for boys and girls (see Klem, 2000). This model had significantly worse fit than the model where predictors of self-concept were allowed to vary between boys and girls ($\Delta\chi^2 = 12.87$, $df = 6$, $p = .04$).

The fit of the model with explicit measures was also good, but in this case, the constrained model (in which paths are set to be equal for boys and girls) and the unconstrained model (in which they are allowed to vary across genders) had similar fit ($\Delta\chi^2 = 4.1$, $df = 6$, $p > .05$). Although the constrained model was slightly more parsimonious, we report the unconstrained model in the main text (for completeness, the constrained explicit model is reported in the online supplemental material) so that it can be compared to the (unconstrained) implicit model. The fit of the unconstrained model (see Figure 5) was good ($\chi^2 = 58.69$, $df = 54$, $p = .31$;

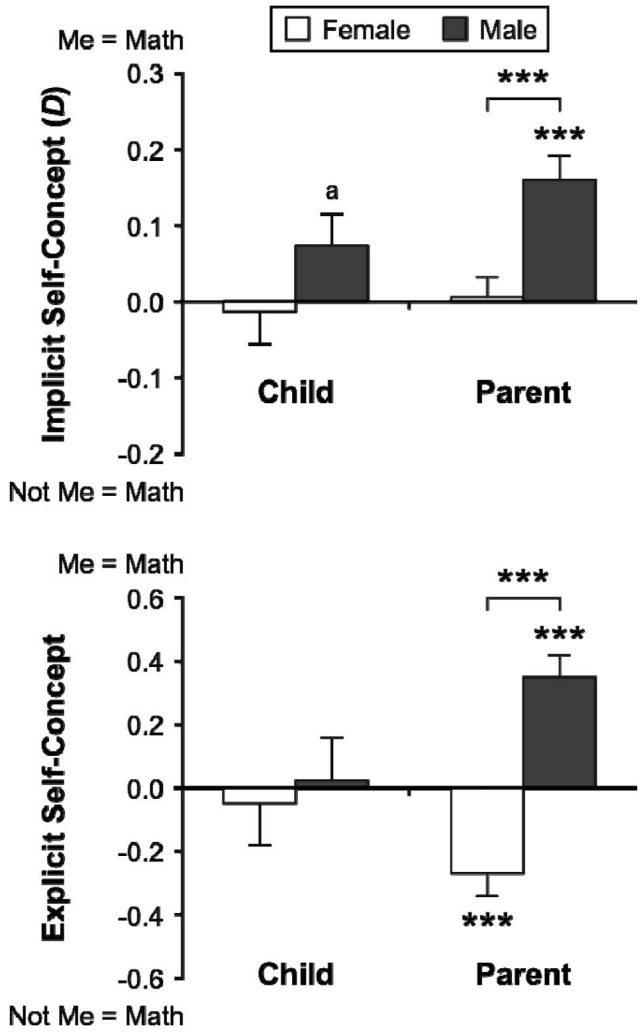

Figure 2. Implicit (top) and explicit (bottom) math self-concepts of Chilean 5-year-old children and their parents. Asterisks above a bar indicate difference from the neutral value of zero. Asterisks above a bracket indicate male-female difference. [a] $p < .01$. *** $p < .001$. Error bars represent *SE*s.

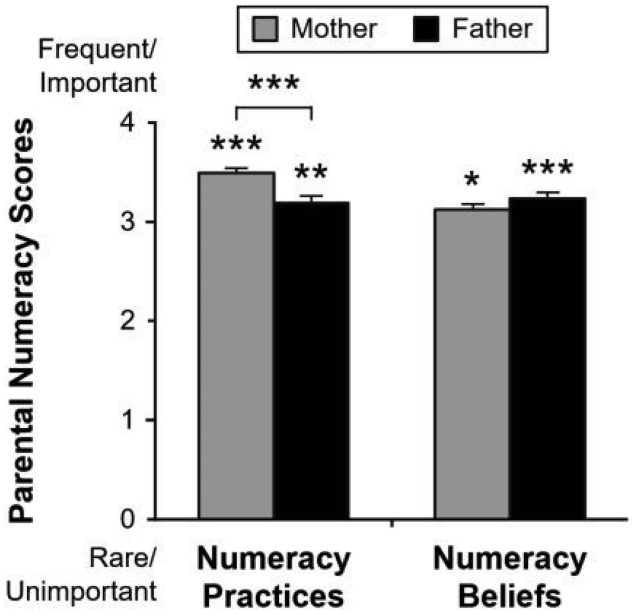

Figure 3. Numeracy practices at home and beliefs about the importance of numeracy of Chilean mothers and fathers. Asterisks above a bar indicate difference from the midpoint. Asterisks above a bracket indicate male–female difference. * $p < .05$. ** $p < .01$. *** $p < .001$. Error bars represent *SE*s.

RMSEA = 0.032; CFI = 0.942). However, there were no significant contributions to the child's explicit math self-concept for any of the gender groups which may explain why the constrained and unconstrained models function equally well.

Discussion

This study systematically tested 5-year-old children's beliefs about mathematics by examining: (a) children's stereotypes and math self-concept, (b) parental math–gender stereotypes and math self-concept, (c) parental beliefs about the importance of mathematics and their home numeracy practices (expectations), and (d) family SES. Several significant results emerged that are relevant to theories about STEM learning and stereotypes, the intergenerational transfer of beliefs, identity development, and home practices.

First, sex differences were found on implicit measures of kindergarteners' math–gender stereotypes (with boys holding the math = boy stereotype significantly more strongly than girls). Second, both mothers and fathers demonstrated highly significant math–gender stereotypes, and fathers held the me = math self-concept more strongly than mothers. Third, girls' implicit math self-concept was linked directly to their family's SES and parents' math self-concepts. Significant indirect paths from parents' gender stereotypes to children's self-concepts were observed for the fathers of daughters.

Children's Early Math–Gender Stereotypes and Math Self-Concepts

As early as kindergarten, Chilean boys already demonstrate implicit math–gender stereotypes. This finding contributes novel information to the literature. First, it is the earliest demonstration of implicit math–gender stereotypes to date. Previous research with elementary-school students in the United States (Ambady et al., 2001; Cvencek et al., 2011), Canada (Steele, 2003), and Italy (Galdi et al., 2014) showed later emergence for this stereotype.

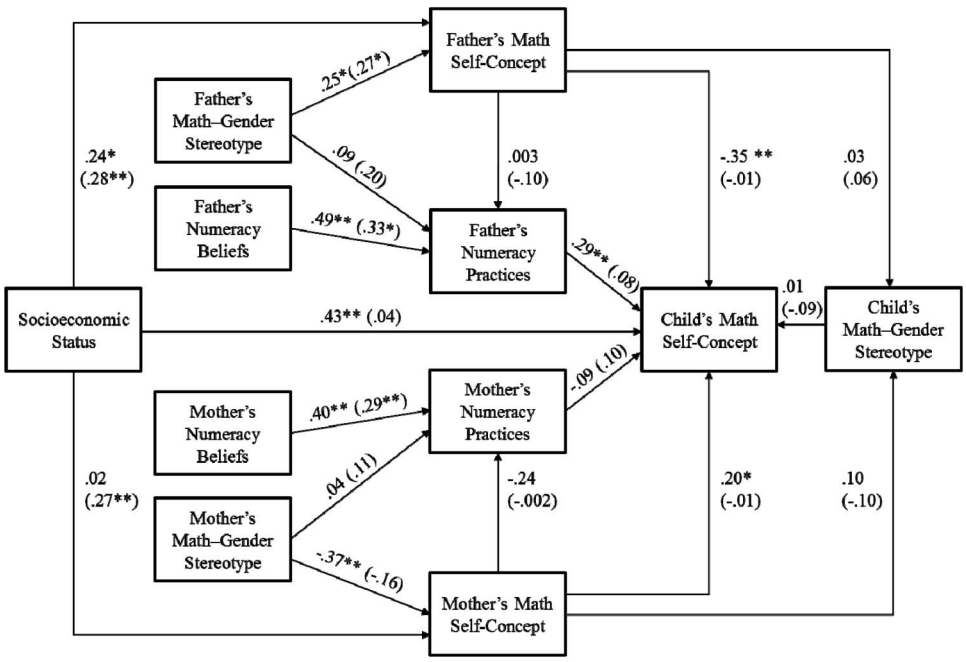

Figure 4. Conceptual model of *implicit* math self-concept for girls and boys and standardized coefficients for the final (unconstrained) model. Standardized coefficients for girls are outside the parentheses; standardized coefficients for boys are inside the parentheses. * $p < .05$. ** $p < .01$.

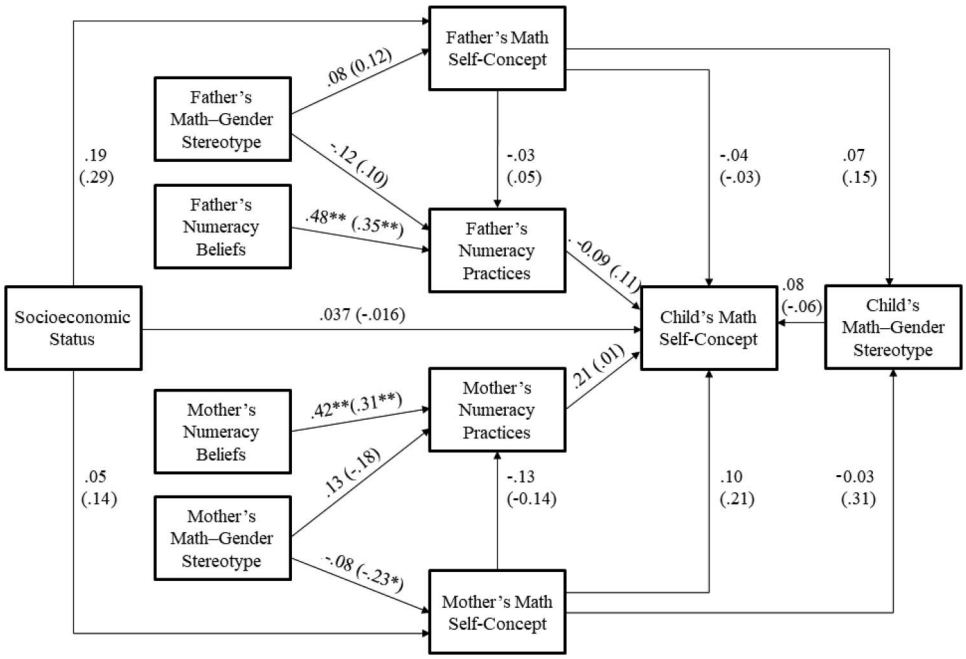

Figure 5. Conceptual model of *explicit* math self-concept for girls and boys and standardized coefficients for the final (unconstrained) model. Standardized coefficients for girls are outside the parentheses; standardized coefficients for boys are inside the parentheses. * $p < .05$. ** $p < .01$.

The early emergence of the math–gender stereotype in Chilean boys makes sense because the data show that the adult stereotypes and the gender gaps in children's standardized mathematics achievement (assessed in Grade 8 and 11) are more pronounced in Chile than in the United States, Canada, and Italy (Nosek et al., 2009). The current study shows that in a culture with large and persistent gender gaps in mathematics (one of our motivations for selecting Chile as a testbed), implicit math–gender stereotypes may be acquired as early as 5 years of age.

Second, boys, but not girls, demonstrated a significant math–gender stereotype. It is also true in North American samples that the math–gender stereotypes are more pronounced in males than in females (Nosek et al., 2009). In the three available studies with implicit stereotype data (Ambady et al., 2001; Cvencek et al., 2011; Steele, 2003), more than 83% of K–2 boys demonstrated implicit math–gender stereotypes, in contrast to approximately 56% of K–2 girls. In the current study sampling much younger children, the percentage of children who demonstrated the implicit math–gender stereotype was also higher for boys (65%) than for girls (44%) at age 5. Why would boys be more prone to adopt these stereotypes at such an early age? One possible explanation is suggested by gender schema theory (Martin & Halverson, 1981). The overall schema guides cognitive processing of gender information by providing children with information—at the level of labels (e.g., "for boys")—about what kinds of activities are most suitable for each gender. If parents and the wider culture strongly hold the pervasive stereotype that mathematics is "for boys" and label a variety of activities involving numeracy as being for males, then children who identify with being a boy may naturally register this stereotype and over the course of development begin applying this stereotype to themselves.

Third, we speculate that the prominent societal stereotype that mathematics is for boys more than for girls is registered at a very young age perhaps through some form of "statistical learning" about regularities in the ambient environment. Thus, in terms of developmental order of acquisition, we believe that math–gender stereotypes are acquired before math self-concepts—children seem first to register the regularities exhibited in the culture about their social group (stereotypes) and then, over the course of development, to internalize them by applying these cultural expectations to themselves (self-concepts). For converging data with young children see Cvencek et al. (2011), and for older children and adolescents, see Eccles (1987), Evans, Copping, Rowley, and Kurtz-Costes (2011), and Marsh (1986). However, this is not a settled issue in the literature, because the appropriate fine-grained experiments have not yet been done. This order of emergence and mechanisms by which stereotypes may interact with self-concepts is an empirical question deserving of more study.

Fourth, these findings extend prior results. Whereas del Río and Strasser (2013) assessed Chilean kindergarteners' explicit stereotypes about mathematics, the current study assessed both implicit and explicit stereotypes, and kindergarteners' implicit and explicit math self-concepts. Using this combination of measures, we found that boys demonstrated a gender stereotype (math = boys) on implicit measures (see Figure 1). A similar pattern of effects was also obtained with the implicit math self-concept measures (see Figure 2). The finding that 5-year-old children are demonstrating gender differences on implicit but not on explicit measures of both stereotypes and self-concepts is interesting developmentally. Children seem to first register stereotypes via their implicit cognitive systems even when they are not able to introspect and explicitly verbalize their stereotyped inklings. Implicit measures may capture

nascent representations that do not rise to the level of conscious awareness, which can be assessed through Likert-scales and self-report measures. The current results add to the growing literature showing that implicit measures are a useful tool for investigating young children's beliefs and attitudes that children may have difficulty expressing in words (e.g., Cvencek, Fryberg, Covarrubias, & Meltzoff, 2018; Dunham, Baron, & Banaji, 2016).

Parents' Math–Gender Stereotypes and Math Self-Concepts

Chilean parents demonstrated both implicit and explicit math–gender stereotypes, and both were highly significant. Post hoc analyses indicated that the strength of those parental stereotypes did not significantly vary for parents of girls versus boys (see the online supplemental material). This suggests that cultural stereotypes permeate minds of adults, regardless of their own personal experience with raising a son or a daughter.

Chilean parents also demonstrated math self-concepts that were in line with those gender stereotypes: Fathers identified with mathematics and mothers did not. Although mothers demonstrated neutral self-concepts on implicit measures (i.e., equally strong associations of *me = math* and *me = language*), they reported a strong identification with language on explicit measures. It is common in adult studies for the implicit and explicit measures to be divergent (e.g., Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005), but why would such an effect occur in this particular domain? One possible explanation may be that, regardless of their working status—only a third of the workforce in Chile is female—women are responsible for most of the household chores, including caretaking of children (Ministry of Labor, 2017). Because caretaking duties often involve reading to children at bedtime (and perhaps not doing bedtime mathematical puzzles), mothers may come to identify strongly with language, and also, Chilean society has a strong literary tradition of female writers (e.g., Isabel Allende, Gabriela Mistral), which may also contribute to Chilean females in explicitly identifying themselves more with language than with mathematics.

It is also noteworthy that, for parents, the explicit and implicit stereotypes were strongly in the same direction as one another, and the same was true between explicit and implicit self-concepts. For children, however, such evidence was weak or nonexisting. Further research may help clarify why this might be the case.

Girls' Early Math Self-Concepts

In this sample of Chilean kindergarteners, girls' and boys' math self-concepts were related to different family factors as discussed below.

Differential relations between mothers' and fathers' math self-concepts to girls' math self-concepts. Mothers' math self-concepts were positively related to girls' self-concepts, whereas fathers' math self-concepts were negatively related to girls' self-concepts. Children generally tend to identify with the parent of their own gender (Maccoby, 2003), and for girls, this would mean their mothers. Because Chilean mothers do not identify with mathematics, as our results show, then girls may not identify with mathematics either. One specific process by which the weak math self-concepts may transfer from mothers to their daughters is mothers' less frequent use of mathematics-related language with their daughters than with their sons (Chang, Sandhofer, & Brown, 2011). Such differential home numeracy practices for sons versus daughters may be especially influential in children's early development. Another possible process may derive from mothers providing girls with fewer opportunities to play with mathematics-related games (Bleeker & Jacobs, 2004; see also Master, Cheryan, Moscatelli, & Meltzoff, 2017). Such parental practices might result in mothers conveying the message—either explicitly or implicitly—to their daughters that "math ≠ girls." Girls are highly exposed to strong parental messages about what is appropriate to do as a female (see Martin, 1995).

A related finding is that fathers' math self-concepts were negatively associated with their kindergarten girls' math self-concepts. This is consistent with evidence suggesting that fathers' implicit gender stereotypes about mathematics and language predict children's math–gender stereotypes (Galdi et al., 2014). If girls do not primarily identify with their fathers, then they also may not identify with the qualities that fathers exhibit (father = math; therefore me ≠ math). Consequently, young girls may begin to adopt the view that mathematics is not for them, not only because they identify with their mother (who does not identify with mathematics), but also because they do not identify with their father (who does identify with mathematics). This would be consistent with the theoretical viewpoint that young children tend toward a state of "psychological balance" or cognitive consistency among their identities, beliefs, and attitudes (Cvencek et al., 2014, 2016).

We also found, however, that the negative association of fathers' stereotypes and self-concepts with young girls may be attenuated by fathers' mathematics-related practices: The frequency with which fathers do engage in home numeracy activities with their daughters was positively related to their daughters' math self-concept. One possible implication of our findings is that, despite stereotyped beliefs that fathers may hold about mathematics and gender in general, their engaging in mathematics-related activities with their own daughters in terms of overt behavior may have a beneficial effect on their daughters' emerging math self-concepts.

We would like to underscore that the findings reported here do not necessarily represent causal relations. Alternative explanations may exist for the association between parents and children's variables in this study. For example, these associations may be due to a third factor. Some candidate factors could be: (a) the influence of the child's teacher on the belief system of both child and parent, or (b) family specific events or experiences that have caused similar attitudes toward mathematics in both parents and their children. Moreover, children's own behaviors and preferences could themselves influence their parent's views about gender and mathematics or their tendency to get involved in mathematical activities with their child. Future work should set out to explicitly test these alternative explanations for the associations between parents' and children's variables through experimental and quasi-experimental studies.

Relation between SES and girls' math self-concepts. The path modeling found that girls' math self-concepts were associated directly with SES, even after taking into account the parents' measures. This suggests that the effect of SES is not exhausted by parental processes and reaches children through other mechanisms as well. In Chile, TV and other media are likely candidates for

conveying messages to children about how people from different social classes and gender are expected to behave. Moreover, some studies suggest that children from lower SES are exposed to relatively larger amounts of media (Dennison, Erb, & Jenkins, 2002), and thus may be more likely to receive gender stereotypes portrayed through media, influencing their developing beliefs about who does mathematics. Another possible bridge between SES and the child's math self-concept is the extended family, which is of great importance in Chile and other Latin American countries. Highly frequent contact with grandparents is common in Chilean families, and this may multiply the impact of societal stereotypes about gender that are likely to be more pronounced by those raised in more traditional times.

Limitations and Future Research

The current study has four limitations. First, future research could explore other factors not included in this study that might help us better explain the sources of young children's early developing math stereotypes and math self-concepts. For example, teachers are socializing agents that may provide input about who does and does not do mathematics. In elementary school, it has been shown that teachers' gender stereotypes about their students' mathematical ability can lead students to endorse math–gender stereotypes themselves (Gunderson et al., 2012; Keller, 2001). The inclusion of kindergarten teacher data, an age group that has yet to be studied, could help further illuminate this topic.

Second, the measure of explicit stereotypes assessed stereotypes about mathematical liking, which are conceptually distinct from those about underlying mathematical ability (Master, Cheryan, Moscatelli, et al., 2017). For example, stereotype threat is triggered in young children by the stereotypes about ability and not by the liking stereotypes (Galdi et al., 2014). How early children acquire stereotypes about mathematical ability is an important avenue for future work (see Bian et al.'s, 2017, related work on the acquisition of gendered beliefs about "brilliance"). A related issue is that the measure of explicit stereotypes used here did not offer children "both" as a choice for their answer. Note, however, that the measures used are statistically capable of revealing no stereotyping (i.e., a score of, or close to, zero). Other explicit measures of gender stereotyping in children (e.g., Liben & Bigler, 2002), which allow for "both" responding, may be useful in future investigations.

Third, in our attempt to make explicit measures directly comparable to IAT measures and parental measures directly comparable to the child measures, we (a) relied heavily on the use of one- and two-item measures, and (b) assessed math–gender stereotypes solely in relation to reading–gender stereotypes. Nevertheless, it is worth noting that two-item measures often exhibit similar or higher internal consistency ($\alpha s > .75$) as multidimensional math self-concept measures that are based on six items when used with children (Marsh et al., 2002). In addition, reading is a natural contrast to mathematics because (a) reading and mathematics education are mandated from the first grade onward and (b) standardized tests across many countries have reading and mathematics portions. Future studies will profit from measuring math stereotypes and math self-concepts as multidimensional constructs (Marsh et al., 2002).

Fourth, the present study is based on correlational data. An alternative explanation of the direction of effects reported here could be that girls who are good at mathematics—and who believe that mathematics is "for them"—may elicit different numeracy practices from their parents. We made a concerted effort to test several alternative models in our path analyses but recognize that these analyses do not provide clear causal direction. Theoretical models that place the analytic emphasis on the interdependent effects of the child and environment (e.g., family, school, and cultural agents) to examine the bidirectional relations will be useful in documenting transactional processes in children's cognitive and social-emotional development (Bronfenbrenner, 1979; Sameroff, 2010). It would also be useful for further studies to be conducted in a longitudinal manner, which would allow us to trace societal, family, and gender issues in the same children over time. We found that the math–gender stereotypes of the preschool children do not (yet) match the very strongly stereotyped views of their parents (see Figure 1). Further developmental and longitudinal work, using both implicit and explicit measures over time, will be labor intensive, but of great interest, based on the groundwork laid here.

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Received July 19, 2017
Revision received August 28, 2018
Accepted October 8, 2018 ■