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Cognitive consistency and math–gender stereotypes in Singaporean children

Dario Cvencek [a,*], Andrew N. Meltzoff [a], Manu Kapur [b]

[a] Institute for Learning and Brain Sciences, University of Washington, Seattle, WA 98195, USA
[b] Department of Curriculum, Teaching, and Learning (CTL), National Institute of Education, Singapore 637616, Singapore

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ABSTRACT

In social psychology, cognitive consistency is a powerful principle for organizing psychological concepts. There have been few tests of cognitive consistency in children and no research about cognitive consistency in children from Asian cultures, who pose an interesting developmental case. A sample of 172 Singaporean elementary school children completed implicit and explicit measures of math–gender stereotype (*male* = *math*), gender identity (*me* = *male*), and math self-concept (*me* = *math*). Results showed strong evidence for cognitive consistency; the strength of children's math–gender stereotypes, together with their gender identity, significantly predicted their math self-concepts. Cognitive consistency may be culturally universal and a key mechanism for developmental change in social cognition. We also discovered that Singaporean children's math–gender stereotypes increased as a function of age and that boys identified with math more strongly than did girls despite Singaporean girls' excelling in math. The results reveal both cultural universals and cultural variation in developing social cognition.

Introduction

Cognitive consistency refers to an intra-individual psychological pressure to self-organize one's beliefs and identities in a balanced fashion. Despite the widespread influence of the concept of cognitive consistency in theories of adult social psychology, there has been relatively little research on cognitive consistency in Asian countries and none with Asian children. It is currently unknown whether the

* Corresponding author. Fax: +1 206 221 6475.
E-mail address: dario1@uw.edu (D. Cvencek).

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principles of cognitive consistency operate across diverse age groups and cultures. Asian cultures such as Singapore pose an interesting test of theory because consistency is a drive to balance representations bearing on the *self*, and Singapore is classified as a "collectivist" culture with less emphasis on the individual than in Western cultures (Brewer & Chen, 2007). We assessed the math–gender stereotypes held by Singaporean elementary school students, along with their math self-concepts and gender identity, to provide the first developmental test of cognitive consistency in an Asian society.

On standardized math assessments, Singaporean children outperform North American children. Based on two standardized international evaluations of school achievement, the Trends in International Mathematics and Science Study (TIMSS) and the Program of International Student Assessment (PISA), Singaporean children rank near the top of the international rankings. For example, Singapore has participated in every cycle of TIMSS testing (1995–2007), and its elementary and middle school students—both boys and girls—were among the top three in the world in mathematics in each assessment. Moreover, Singaporean girls scored higher than Singaporean boys. The math–gender stereotypes of Singaporean elementary school children have not been assessed. Thus, we do not know whether Singaporean girls—who are among the world leaders in math achievement (including both genders)—hold the pervasive North American stereotype that "math is for boys."

In North American children (hereafter "American"), there is a strongly held stereotype about who does math. Both boys and girls demonstrate stereotypical beliefs that mathematics is associated more with males than with females (Ambady, Shih, Kim, & Pittinsky, 2001; Cvencek, Meltzoff, & Greenwald, 2011; Gunderson, Ramirez, Levine, & Beilock, 2012; Heyman & Dweck, 1998; Steele, 2003). Traditionally, these stereotypical beliefs about gender and math have been measured through explicit measures, for example, by explicitly asking children how much they *like* math or who they think is *good at math* and relying on their self-report (e.g., Eccles, Wigfield, Harold, & Blumenfeld, 1993; Herbert & Stipek, 2005; Heyman & Legare, 2004; Lummis & Stevenson, 1990).

More recently, psychologists have adopted testing procedures that do not rely on verbal self-report but instead tap more unconscious, implicit, and automatic aspects of cognition (Bargh, 1994; Devine, 1989; Jacoby, 1991). The implicit measurement of social cognition derives from social psychology literature (Greenwald & Banaji, 1995; Greenwald et al., 2002), and recently implicit methods have been adapted for use with young children (e.g., Baron & Banaji, 2006; Cvencek, Greenwald, & Meltzoff, 2011; Killen, McGlothlin, & Henning, 2008). In this framework, children who strongly associate the category *math* with *boy* (relative to *girl*) can be said to exhibit the math–gender stereotype, at least at an implicit level. It has been proposed that the implicit social cognition may be shaped by early developmental experiences to a greater extent than the explicit cognition (Liben & Bigler, 2002; Rudman, 2004), which suggests a value of using both types of measures to explore development. In the current experiment, we assessed math–gender stereotypes using *both* implicit and explicit measures with the *same* children in Singapore.

According to Steele's (2003) stereotype stratification model, it possible that one might not find evidence of children having a stereotype about boys' and girls' math ability because targets of a negative stereotype might think of themselves as belonging to a subgroup to which the negative stereotype does not apply. One of our foci in this study was assessing children's implicit associations between a social group and an academic domain (i.e., *boy* = *math*). This does not prejudge whether or not children have the explicit belief that boys *like* math or whether they personally endorse the stereotype about the math *ability* of boys and girls. Our implicit measure may be more akin to the formulation that *math* = *boys* or math "goes with" boys than it is about "liking" or a reflection on the underlying "ability" of boys versus girls. These constructs may or may not overlap, and admittedly there is no magic bullet for assessing math–gender stereotypes in the developmental literature at this time.

Cvencek, Meltzoff et al. (2011) showed that math–gender stereotypes emerge by second grade in American children, and these stereotypes do not significantly change through fifth grade. Aside from Lummis and Stevenson's (1990) study, which was restricted to explicit (self-report) measures, there have been no other investigations of math–gender stereotypes in Asian elementary school children, and there is no such work using implicit measures.

Studying the development of math–gender stereotypes and math self-concepts in Singaporean children presents an interesting test for theory because of Singaporean children's excellence in mathematics (Mullis, Martin, & Foy, 2008). Two alternatives are equally plausible. On the one hand, Singaporean children might not adopt the stereotype that math is for boys. On the other hand, Singaporean children live in an English-speaking culture that is permeated with American media (Abhijit, 2006; IMDb, 2013), and they too may catch the stereotype that math is for boys.

The need for cross-cultural and developmental assessments

Three interconnected associations are involved in children's developing identity about mathematics. The first is *gender identity,* which is how strongly a child identifies with being either *boy* or *girl.* The second is the child's belief about the connection between *math* and *boy* or *girl* (i.e., a belief about a *social group* and "who does math"); when this develops in accordance with the societally predominant beliefs, it can be called *math–gender stereotype.* The third is a *math self-concept,* which is how strongly the child connects *me* and *math* (a belief about the *self*—whether I identify with math). These three constructs are logically and empirically separable; in this study, we examined whether these three concepts exhibit cognitive consistency or are in "balance" with one another.

The idea of cognitive consistency has roots in classic work in social psychology (Festinger, 1957; Heider, 1946; Osgood & Tannenbaum, 1955). Balanced identity theory (Greenwald et al., 2002) is a reformulation of Heider's (1946) balance theory and is typically used in research with adults (Nosek, Banaji, & Greenwald, 2002). Although two studies tested for balanced identity in children, they both used American samples. Dunham, Baron, and Banaji (2007) investigated disadvantaged Hispanic children's race-related attitudes and self-esteem and reported no developmental change in cognitive consistency; Cvencek, Meltzoff et al. (2011) investigated American children's math–gender stereotypes and math self-concepts and reported an increase in cognitive consistency as a function of age. Thus, whether children from an Asian culture will undergo developmental change in academic-related cognitive consistency is currently unknown.

Based on empirical research, a theoretical distinction has been made between "individualistic" and "collectivist" cultures, with the United States being cited as an example of the former and Asian countries, such as Singapore, considered as examples of the latter (Hofstede, 1980; Oyserman, Coon, & Kemmelmeier, 2002). Collectivist cultures are said to hold that being a harmonious *group* member is of central importance (Brewer & Chen, 2007; Kim, 1994; Markus & Kitayama, 1991). It has been further argued that cognitive consistency in collectivist cultures operates at the level of group norms (Hoshino-Browne, 2012; Hoshino-Browne et al., 2005). It is possible, therefore, that in collectivist cultures maintaining harmonious relationships between groups may be more important than maintaining the cognitive consistency among one's own individual beliefs. It is noteworthy that research on cognitive dissonance (which draws on cognitive consistency) with Asian participants reported an absence of attitude change as a result of forced compliance (e.g., Heine & Lehman, 1997). In this research, Asian adults were relatively tolerant of a mismatch between their internal attitudes and their behavior without this generating cognitive dissonance, which has been interpreted as evidence that Asians are not strongly motivated by cognitive consistency (Markus & Kitayama, 1991; see also Gawronski, 2012). It also bears consideration that cognitive consistency may exist in both cultures, but there may be a difference in what constitutes the basis of that consistency; a balance among individual beliefs may be the primary driver for consistency in individualistic cultures, whereas group beliefs/values may be the primary driver for cognitive consistency in collectivist cultures.

In terms of beliefs about social groups, such as linking math to gender, people from collectivist cultures may be able to tolerate mismatches between stereotypes and personally held beliefs about the self—one's own self-concepts. Thus, it is worthy of test, with an uncertain answer at this time, whether boys and girls in a collectivist culture will feel the same level of internal pressure as do American children to organize self-relevant stereotypes (math–gender stereotypes) and self-relevant identities (math self-concepts) in a cognitively balanced fashion.

Arnett (2008) argued that psychological research often focuses too narrowly on American samples. Medin, Bennis, and Chandler (2010) introduced the *home-field disadvantage* hypothesis, according to which a particular cultural group (e.g., American participants) should not be taken as a research standard because it limits the generalizability of results. The current study was motivated for the reasons suggested by Medin and colleagues; that is, using a population of Singaporean elementary school boys and girls would allow us to broaden the inferences that can be drawn beyond the single study of American children's implicit math–gender stereotypes.

The current study adds to existing research in four specific ways. First, we examined whether principles of *cognitive consistency operate in children* from an Asian culture. Second, we assessed *math–gender stereotypes* in children from Singapore, a country in which children excel in math; do such high-performing children still hold the stereotype that *math = boy*? Third, we tested for *developmental changes* in both math–gender stereotypes and cognitive consistency across the elementary school years. Fourth, we used *both implicit and explicit measures* in the same Singaporean elementary school children, providing converging information about developing social cognition.

Method

Participants

This study was part of a larger one about Singaporean math. The current report represents the findings related to the evidence for the cognitive consistency obtained with implicit and explicit measures of gender identity, math–gender stereotype, and math self-concept. The study took place in three elementary school sites in Singapore. Students' teachers were informed about the study and given consent forms. Schools mailed the consent forms to the parents, and completed forms were collected by the teachers. During the 2011–2012 school year when these data were collected, the student enrollment in each of these schools ranged between 1400 and 1800 per year. The math curriculum in all of the schools consisted of a combination of individual practice and group activities to create able problem solvers. The English curriculum in the schools aimed to encourage students to read and also to think critically about what is read.

All participants were drawn from the first, third, and fifth grades at the three participating schools. A total of 172 children (83 boys and 89 girls) were tested. None of the children had repeated a grade. The mean ages for children attending each of the three school grades were as follows: Grade 1, $M = 7.36$ years, $SD = 0.37$; Grade 3, $M = 9.38$ years, $SD = 0.30$; and Grade 5, $M = 11.38$ years, $SD = 0.34$. The sample sizes and gender breakdown of the participants were as follows: Grade 1, $n = 55$, 29 boys and 26 girls; Grade 3, $n = 61$, 26 boys and 35 girls; and Grade 5, $n = 56$, 28 boys and 28 girls. According to the school records, the children in our sample were 84.9% Chinese, 7.6% Indian, and 7.6% Malay, with 1 student listed as multiracial.

Procedure

Children were tested in groups of up to 4 in a separate quiet room outside of their classroom, with each child seated at a desk facing a laptop computer. The test session began with a 3- to 5-min description of the study, during which children were familiarized with the room and apparatus. Children were told that they would be "asked some questions" and then would "play a computer game." The methods were largely the same as in a study of American elementary school children (Cvencek, Meltzoff et al., 2011), with a few departures to (a) ensure sensitivity to culturally appropriate practices associated with testing in Singaporean schools and (b) allow for more complete counterbalancing of experimental conditions.

Implicit Child IAT measures

The Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) is a computerized categorization task that measures relative strengths of associations among concepts without requiring self-report. A child-friendly adaptation of the adult IAT method that is suitable for elementary school children has been described in detail by two teams (Baron & Banaji, 2006; Cvencek, Meltzoff et al., 2011). Here we used the one reported by Cvencek, Meltzoff et al. (2011). It modifies the adult methodology by using sounds to communicate concepts and using large response buttons instead of a typical computer keyboard. The procedure was used to assess gender identity, math–gender stereotype, and math self-concept.

During the administration of three Child IATs, children sorted stimuli from the following six categories: *boy, girl, math, reading, me,* and *not-me.* Each category consisted of four exemplar stimuli. For example, for the category *math,* the exemplars were addition, numbers, graph, and math (see the Appendix for the full list of categories and the exemplar stimuli). To reduce the need for reading in this young sample, each stimulus was spoken in a female voice. The speech emanated from a speaker below the screen and was synchronized with the onset of the written stimulus on the screen. Error responses were followed by a red question mark appearing on the computer screen. After committing an error, children could not advance to the next trial until they provided the correct response. For each of the three Child IATs, a *D* score was calculated using the scoring algorithm from Greenwald, Nosek, and Banaji (2003), which constrains the resulting scores to have bounds of −2 and +2. This algorithm was successfully used previously with elementary school children (Cvencek, Meltzoff et al., 2011).

Child IAT stimuli adaptations for Singapore

To ensure cultural sensitivity, each stimulus was spoken by a Singaporean native. For the *boy/girl* stimuli, we used eight common Singaporean boy and girl names (see Appendix) derived from a pilot study. In this pilot work, Singaporean elementary school students ($N = 150$) were asked to write down five boy names and five girl names. Their responses were tallied, and the eight most frequently listed boy and girl names were used in the experiment. For the *math/reading* and *me/not-me* categories, we used the words listed in the Appendix, which were used previously by Cvencek, Meltzoff et al. (2011). Except for these changes, the procedure was the same as in Cvencek, Meltzoff et al. (2011). Each of the three Child IATs followed the same protocol, which is described in detail below using the math–gender stereotype measure.

Math–gender stereotype Child IAT

During the math–gender stereotype Child IAT, children first practiced sorting *boy* and *girl* stimuli. Each stimulus was presented in the middle of the computer screen, and each child was asked to sort the stimuli by pressing one of two response buttons. For example, they responded to *boy* stimuli by pressing the left response button and responded to *girl* stimuli by pressing the right response button. Then children sorted *math* and *reading* stimuli using the same two response buttons. These two single-discrimination tasks were 16 trials each.

Next children completed two *combined* tasks in which all four categories were represented simultaneously. Each combined task consisted of two blocks of 24 "practice" trials and 24 "test" trials, yielding a total of 48 trials for each of the combined tasks (the order of the combined tasks was counterbalanced across participants; see below for full counterbalancing details). In the first combined task, the previously viewed stimuli were presented one at a time, and children were instructed to sort them as quickly as possible using the two response buttons. In one condition, *math* and *boy* stimuli shared one response key, with *reading* and *girl* stimuli sharing the other. After completing the combined task, the response buttons associated with the *math* and *reading* categories were reversed and children were asked to sort only *math* and *reading* stimuli in another single-discrimination task (16 trials). Then participants completed the second combined task, in which *math* and *girl* stimuli shared one response key, with *reading* and *boy* stimuli sharing the other. Positive scores indicated stronger association of *math* with *own gender* than with *opposite gender* (which, given the IAT methodology, is also an association of *reading* with *opposite gender* more than with *own gender*).

In the math–gender stereotype Child IAT, we used the categories of female versus male and reading versus math. Reading is a natural contrast to math because (a) reading and math education are mandated from the first grade onward and (b) standardized tests across many countries have reading and math portions.

Gender identity Child IAT

During the gender identity Child IAT, children classified the stimuli representing the categories *me, not-me, boy,* and *girl.* In one combined task, *me* and *boy* stimuli shared one response key, with *not-me* and *girl* stimuli sharing the other. In the other combined task, two of the response assignments were reversed, such that *me* and *girl* stimuli shared one key while *not-me* and *boy* stimuli shared the other. Positive scores indicated stronger association of *me* with *boy* than with *girl.*

Math self-concept Child IAT

During the math self-concept Child IAT, children classified the stimuli representing the categories *me, not-me, math,* and *reading.* In one combined task, *math* and *boy* stimuli shared one response key, as did *reading* and *girl* stimuli. In the other combined task, left versus right assignment of *me*/*not-me* stimuli was reversed. Positive scores indicated stronger association of *me* with *math* relative to *reading.*

Counterbalancing

For the implicit measures, there were 16 counterbalancing conditions: 2 (Order of Administration of Implicit and Explicit Measures) ×2 (Order of Child IATs) ×2 (Order of Combined Tasks Within Each Child IAT) ×2 (Left/Right Side Assignment of Categories in Each Combined Task). This means that within each Child IAT, the order of the two combined tasks was counterbalanced, the categories assigned to left and right were counterbalanced across participants and Child IATs, and the order of administration of implicit and explicit measures was also counterbalanced across participants in the current study. Following Cvencek, Meltzoff et al. (2011), the gender identity Child IAT and math self-concept Child IAT were in the first and third positions (counterbalanced), with the math–gender stereotype Child IAT being administered in the second position. Moreover, both gender of the experimenter (2 male and 2 female) and race of the experimenter (2 Caucasian and 2 Asian) were counterbalanced across participants. On average, the administration of implicit measures took 20 min.

Explicit self-report measures

To measure students' explicit gender identity, math–gender stereotype, and math self-concepts, we drew on the procedure used by Cvencek, Meltzoff et al. (2011). This procedure is based on six Likert scales adapted from Harter and Pike's (1984) Pictorial Scale of Perceived Competence and Acceptance for Young Children. Examples of the procedure for the three explicit measures are provided below.

Likert scales

Measures assessing each of the three constructs consisted of two questions each. For each question, children were shown a pair of line drawings of boy and girl characters and were asked to report (a) which of the two characters they believed possessed an attribute (e.g., liking math) to a greater degree and (b) whether each character possessed the attribute "a little" or "a lot." The latter was done by pointing to two different-sized circles to indicate less versus more possession of the attribute. The explicit measures were scored so that each measure had the computational lower and upper bounds of −2 and +2, respectively.

The gender identity measure asked children to select which character (boy or girl) was "more like you." Positive values indicated that the child picked the boy character as being more like the self. The math–gender stereotype measure asked children to select which character (boy or girl) "liked to do math more." Positive values indicated that the child picked the same-sex character as liking to do math more. The math self-concept measure consisted of a pair of pictures showing two characters of the same sex as the test child, one engaged in math and one engaged in reading, and children were asked to select which was "more like you." Positive values indicated that the child picked the same-sex character that was doing math as being more like him or her.

Counterbalancing

For the explicit measures, there were 24 counterbalancing conditions: 2 (Order of Administration of Implicit and Explicit Measures) ×6 (Order of Explicit Measures) ×2 (Left/Right Side Assignment of Male Characters/Characters Doing Math and Female Characters/Characters Doing Reading in Each Measure). The order of the three explicit constructs was counterbalanced across participants. The left–right assignment of gender of the characters and the names used for each character were also counterbalanced across participants. The order of administration of explicit and implicit measures was counterbalanced across participants. On average, the administration of explicit measures took 5 min.

Internal consistency

For implicit measures, Cronbach's α was calculated from two *D* measures computed for matched 24-trial subsets of each IAT. Cronbach's α coefficients for the math–gender stereotype, gender identity, and math self-concept IATs were .74, .87, and .80, respectively.

For the explicit measures, Cronbach's α coefficients for gender identity and math self-concept were .83 and .75, respectively. The two Likert items that comprised the explicit math–gender stereotype scale were (a) who likes to do math more and (b) who likes to read more. Thus, the expectation was for a low correlation between these two Likert items—and therefore a low internal consistency of the explicit math–gender stereotype measure—which was the case, Cronbach's $\alpha = .31$.

Data reduction

Implicit measures were analyzed after excluding participants who met any one of three exclusion criteria, as is commonly done in both the adult IAT and Child IAT literature (Cvencek, Meltzoff et al., 2011; Dunham, Baron, & Banaji, 2006; Greenwald et al., 2003): (a) 10% or more of their responses faster than 300 ms, (b) error rate of 35% or higher in at least one of the three IATs, or (c) average response latency 2 standard deviations above the mean response latency for the whole sample in at least one of the participant's three Child IATs. These criteria excluded 17 participants (9.9%), leaving 155 participants (71 boys and 84 girls) for analyses.

Explicit data were analyzed after excluding data from 5 participants (2.9%) due to excessively slow responding (either 30 s or longer to respond to three or more explicit items or 90 s or longer to respond to any item), leaving 167 participants (81 boys and 86 girls). The 5 excluded children did not seem to be "on task" or to understand what the questions were asking. This data reduction procedure was applied previously by Cvencek, Meltzoff et al. (2011) using the same three explicit measures. Critically, the data reduction for all of the factors noted above did not change the direction or pattern of significant results compared with analyses of the full sample, but it did provide increased power as indicated by larger *t* ratios for the statistically significant effects reported below.

Results

Preliminary analyses examined the effects of student background variables (race/ethnicity, school, school grade, and experimenter) and experimental design factors (order of administration of implicit vs. explicit measures, order of administration of the three Child IATs, order of administration of combined tasks within each Child IAT, left–right assignment of categories for each Child IAT combined task, order of administration of the three explicit measures, and left–right assignment of characters for each explicit scale item). The main conclusion from these preliminary analyses was that none significantly influenced implicit or explicit scores (all $ps > .14$); therefore, we collapsed across these factors for the main effects reported below.

Implicit and explicit measures

Fig. 1 displays the results for both the implicit and explicit measures separately for boys and girls, combined over the three school grades.

Gender identity

The results for gender identity were unsurprising but are assessed because they are used later as part of the statistical assessment of cognitive consistency. As expected, on the implicit measure, boys associated *me* with *boy* more strongly than did girls, $t(153) = 10.99$, $p < .001$. Follow-up one-sample *t* tests were conducted to test for the statistical difference from the value of 0, where 0 indicated that

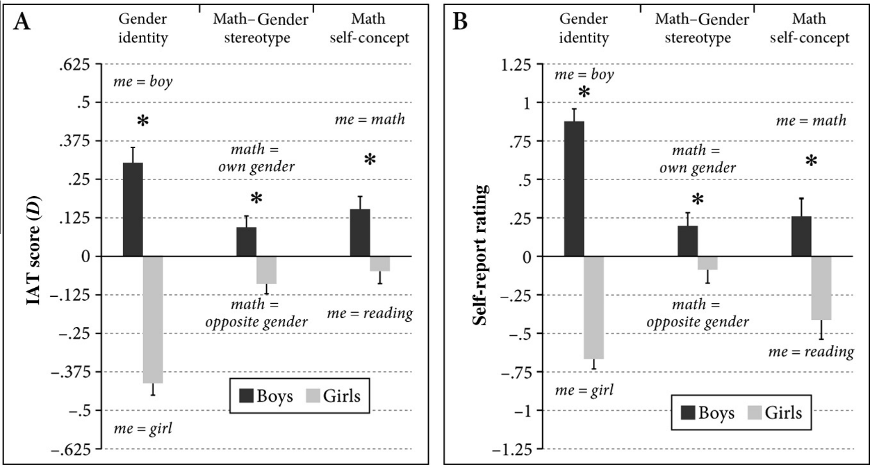

Fig. 1. Overall results for child implicit (A) and explicit (B) measures in Singaporean boys and girls. Asterisks (*) indicate significant sex differences. Error bars show standard errors.

the association of *me* with *boy* was as strong as the association of *me* with *girl.* On the implicit measure, results indicated that for boys the association of *me* with *boy* was statistically different from 0 in the male direction ($M = .30$, $SD = .43$), $t(70) = 5.92$, $p < .001$, and for girls it was statistically different from 0 in the female direction ($M = -.41$, $SD = .38$), $t(83) = -9.96$, $p < .001$.

On the explicit measure, boys also associated *me* with *boy* more strongly than did girls, $t(165) = 19.32$, $p < .001$. One-sample *t* tests indicated that the association of *me* with *boy* was statistically different from 0 in the male direction for boys ($M = .91$, $SD = .47$), $t(80) = 17.63$, $p < .001$, and also statistically different from 0 in the female direction for girls ($M = -.65$, $SD = .57$), $t(85) = -10.54$, $p < .001$.

Simply recoding the implicit and explicit gender identity measures to indicate *me = own gender* association allowed us to perform direct statistical tests to assess the magnitude differences between boys' and girls' gender identity (both boys and girls identified with their own gender, but did they do so to the same degree?). On the implicit measure, girls associated *me* with *own gender* to a higher degree than did boys, but this difference was not statistically significant, $t(153) = -1.74$, $p = .08$. On the explicit measure, boys associated *me* with *own gender* more strongly than did girls, $t(165) = 3.06$, $p = .003$.

Math–gender stereotype

On the implicit measure, boys associated *math* with *own gender* significantly more than did girls, $t(153) = 3.65$, $p < .001$. Follow-up one-sample *t* tests were conducted to test for the statistical difference from the value of 0, where 0 indicated that the association of *math* with *own gender* was as strong as the association of *math* with *opposite gender.* Results indicated that boys significantly associated *math* with their *own gender* ($M = .09$, $SD = .31$), $t(70) = 2.48$, $p = .015$. Girls significantly associated *math* with *opposite gender* ($M = -.09$, $SD = .31$), $t(83) = -2.70$, $p < .01$.

Similarly, on the explicit measure, boys were more likely to pick the same gender character as "liking to do math more" than were girls, $t(165) = 2.08$, $p < .05$. One-sample *t* tests indicated that the association of *math* with *own gender* was statistically different from 0 in the own-gender direction for boys ($M = .19$, $SD = .74$), $t(80) = 2.33$, $p < .05$, but not statistically different from 0 for girls ($M = -.06$, $SD = .84$), $p > .48$.

Math self-concept

On the implicit measure, boys associated *me* with *math* more than did girls, $t(153) = 3.34$, $p = .001$. Follow-up one-sample *t* tests were conducted to test for the statistical difference from the value of 0, where 0 indicated that the association of *me* with *math* was as strong as the association of *me* with *reading.* On the implicit measure, results indicated that the association of *me* with *math* was statistically different from 0 in the math direction for boys ($M = .15$, $SD = .38$), $t(70) = 3.36$, $p = .001$, but not statistically different from 0 for girls ($M = -.05$, $SD = .37$), $p > .20$.

Similarly, on the explicit measure, boys identified more with the same-gender character who was solving a math problem than did girls, $t(165) = 3.37$, $p < .001$. On the explicit measure, one-sample *t* tests indicated that the association of *me* with *math* was statistically different from 0 in the math direction for boys ($M = .26$, $SD = 1.07$), $t(80) = 2.18$, $p < .05$, and also statistically different from 0 in the reading direction for girls ($M = -.33$; $SD = 1.17$), $t(85) = -2.59$, $p < .05$.

Developmental changes in the three constructs

To examine age effects for each of the three constructs, a series of six hierarchical regressions was conducted. In each regression, age was entered as a predictor. For each of the regressions, the predictors were participants' implicit gender identity, explicit gender identity, implicit math–gender stereotype, explicit math–gender stereotype, implicit math self-concept, and explicit math self-concept. Only the analysis involving implicit math–gender stereotype revealed significant results; therefore, it is the only one discussed in detail below (all other *p*s > .51) (see Fig. 2).

In a follow-up regression analysis, the implicit math–gender stereotype measure was recorded so that positive scores indicated *math* = *boy* association. This measure was entered as a criterion and gender was entered as a predictor at Step 1. Age was added as a predictor at Step 2, and the Age × Gender product was added as a predictor at Step 3. The main effect of gender was not significant at regression Step 1, 2, or 3 (all *p*s > .25). The main effect of age was significant at Step 2 ($\Delta R^2 = .03$, $\beta = .19$), $t(152) = 2.36$, $p < .02$, showing that children's implicit math–gender stereotype was becoming stronger in the *math* = *boy* direction with increasing age. The Age × Gender interaction was not significant at Step 3 ($p > .19$), showing that the developmental increase in implicit math–gender stereotype was equally strong for boys as it was for girls.

Correspondence between implicit and explicit measures

Past research in adult social psychology has reported a lack of correspondence between implicit and explicit measures (Banaji & Greenwald, 1994; Banaji & Hardin, 1996; Bosson, Swann, & Pennebaker, 2000). However, a growing body of literature with children is providing evidence that implicit and explicit measures often correspond to one another. Zero-order correlations between the implicit and explicit measures are presented in Table 1.[1] The correspondence between implicit and explicit measures was strong for the gender identity measures, moderate for the math self-concept measures, and low for the math–gender stereotype measures. This pattern of implicit–explicit correspondence is of interest to developmental theory and is highly interpretable.

There was robust implicit–explicit correspondence for constructs involving the *self* (i.e., identity or self-concept constructs). That is, there were significant positive correlations between implicit and explicit gender identity and also between implicit and explicit math self-concepts.[2] In contrast, there

[1] The reader might wonder whether these correlations shown in Table 1 strengthen or weaken as a function of school grade. To examine this, we further conducted 45 possible comparisons (i.e., the 15 correlations shown in Table 1 in pairwise comparisons for each of the three school grades). Of these, only 4 were statistically significant, a number close to what would be expected by chance. More specifically, each correlation coefficient was first converted to a *z* score using Fisher's *r*-to-*z* transformation, and the resulting *z* scores were compared using Formula 2.8.5 from Cohen and Cohen (1983, p. 54). The four significant effects are the following. First, the correlation between implicit gender identity and implicit math–gender stereotype was stronger in Grade 5 than in Grade 1 ($p = .009$). Second, the correlation between implicit gender identity and implicit self-concept was stronger in Grade 5 than in Grade 3 ($p = .014$). Third, the correlation between implicit gender identity and explicit math–gender stereotype was stronger in Grade 3 than in Grade 1 ($p = .021$). Fourth, the correlation between explicit gender identity and implicit math–gender stereotype was stronger in Grade 5 than in Grade 1 ($p = .037$). If one chooses to give weight to these 4 of 45 comparisons, a likely interpretation might be that as children progress through elementary school, their gender identity becomes more multidimensional and gender becomes more central to their academic identities (math self-concepts) and their beliefs about social groups (math–gender stereotypes) (Egan & Perry, 2001; Ruble et al., 2004).

[2] It is also of interest that there is a significant positive correlation between *explicit* gender identity and *implicit* math self-concept. This effect fits with the idea of cognitive consistency; the stronger the association between self and one's social group (gender identity), the greater the individual's personal identification with the academic attribute that the culture stereotypically links to one's own social group (math self-concept).

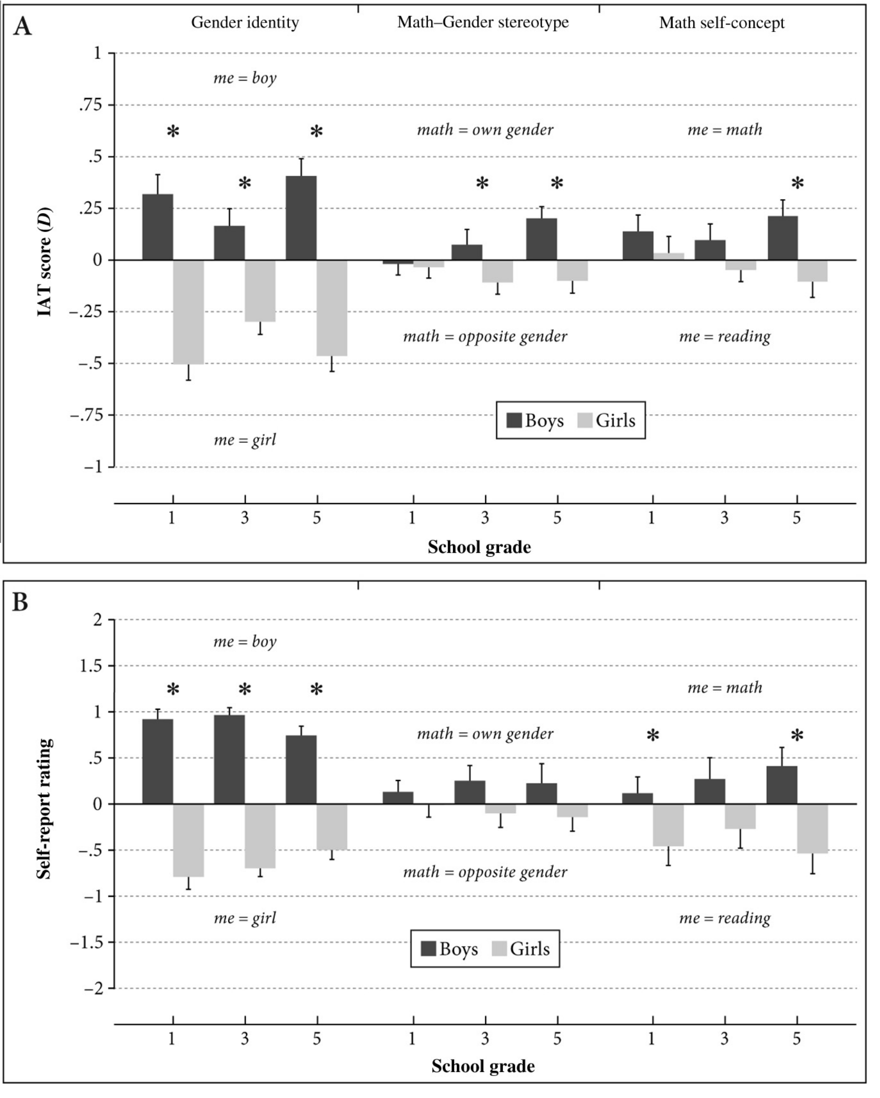

Fig. 2. Results for implicit (A) and explicit (B) measures in first-, third-, and fifth-grade Singaporean boys and girls. IAT, Implicit Association Test. Asterisks (*) indicate significant sex differences. $N = 155$ for the implicit measures, and $N = 167$ for the explicit measures. Error bars show standard errors.

was a low to nonexistent correlation between implicit and explicit measures of the cultural stereotype (see, math–gender stereotype column). This lack of a correlation between implicit and explicit stereotype measures is to be expected for socially sensitive domains such as stereotypes. One interpretation is that participants are regulating their verbal explicit answers to conform in part to "social desirability," which leads to a divergence in their verbal (explicit) responses versus their more nondeliberate automatic (implicit) responses. Impression management in verbal responses to an experimenter has been discussed previously as a source of dissociation in implicit/explicit measures in some domains in adults (Greenwald et al., 2002; Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005) and children (Steffens, Jelenec, & Noack, 2010).

Table 1
Correlations among implicit and explicit measures.

Measure	Implicit math–gender stereotype	Implicit math self-concept	Explicit gender identity	Explicit math–gender stereotype	Explicit math self-concept
Implicit gender identity	.24**	.25**	.61***	.03	.12
Implicit math–gender stereotype		.21**	.22**	−.02	.15
Implicit math self-concept			.25**	.15	.16*
Explicit gender identity				.14	.17*
Explicit math–gender stereotype					.33***

Note: The reported zero-order correlations collapse across participant gender and school grade, Ns = 151 to 167.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Cognitive consistency

We were interested in the relation or "consistency" among the constructs of gender identity, math–gender stereotype, and math self-concept. Greenwald and colleagues (2002) provided a mathematical procedure for statistically testing for *balanced identity* among constructs related to the self, the *4-test method.* The assumption underlying the 4-test method is that any one of the three constructs of gender identity, math–gender stereotype, and math self-concept can be predicted from the relationship between the values of the other two. That is, if a participant shows a strong *me* = *boy* association (male gender identity) and a strong *boy* = *math* association (math–gender stereotype), then the *me* = *math* association is expected to result (math self-concept). Statistically, this logic suggests the use of the two-way interaction term between any two constructs as the predictor of the third construct (Greenwald et al., 2002). This method has been applied successfully in adult social psychology (Aidman & Carroll, 2003), developmental psychology (Dunham et al., 2007), educational psychology (Devos & Cruz Torres, 2007), and ethnic minority psychology (Devos, Gavin, & Quintana, 2010). We used this 4-test method to examine whether the interrelations among gender identity, math–gender stereotype, and self-concept reflected the theorized balanced configuration.

Statistical tests

Statistical tests of the balanced identity involve a two-step hierarchical linear regression. In Step 1, the measure of each of three constructs is predicted solely from the multiplicative product of the other two measures. In Step 2, the two other variables are added individually. This method intentionally sidesteps the standard statistical procedure of first entering the component variables as predictors before testing a product term.

With three measures (gender identity, math–gender stereotype, and math self-concept), this analysis can be done with two of the three measures as multiplicative predictors in the two-step hierarchical regression and the third as a criterion. Each of these three regressions offers an opportunity to pass four tests. First, the multiple R at Step 1 should be statistically significant and the regression coefficient of the product term (b_1) should be numerically positive. Second, the value of b_1 at Step 2 should remain numerically positive. Third, the increase in variance explained in the criterion should not be statistically significant at Step 2. Fourth, neither of the regression coefficients associated with the two individual predictors at Step 2 (b_2 and b_3) should differ from zero. (Note that for these analyses, the math–gender stereotype measure was scored so that the association of *boy* with *math* was numerically positive.)

Table 2 shows results of the 4-test method applied to the regression analyses for the three implicit and three explicit measures (gender identity, math–gender stereotype, and math self-concept). For each type of measure (implicit or explicit), there are 12 possible tests to confirm the theoretically expected pattern (i.e., each of the three regressions provides an opportunity to pass 4 tests). Results obtained with the implicit measures passed all 12 tests, conforming to expectations from the pure

Table 2
Implicit and explicit measures provide strong evidence for cognitive consistency using Greenwald and colleagues' (2002) 4-test regression method.

Measure type	Boys (n)	Girls (n)	Criterion (Y)	Mean (Y) in *SD* units	Correlation between predictors (r)	Regression step 1 (interaction)		Regression step 2 (individual predictors)				Number tests passed
						Test 1 Beta[a]	p	Test 2 Partial r[b]	Test 3 R^2 gain[c]	Test 4a Partial r[d]	Test 4b Partial r[d]	
Implicit	71	84	Gender identity	−.16	−.078	**.231***	.004	**.142**	**.030**	**.034**	.176*	4
	71	84	Math–gender stereotype	.30	.249*	**.179***	.026	**.165***	**.003**	**.019**	−**.060**	4
	71	84	Math self–concept	.11	.025	**.226***	.005	**.137**	**.036**	−**.067**	.187*	4
Explicit	81	86	Gender identity	.12	−.031	**.246***	.001	**.204***	**.015**	**.061**	**.112**	4
	81	86	Math–gender stereotype	−.04	.174*	**.204***	.008	**.202***	**.004**	−**.054**	**.052**	4
	81	86	Math self–concept	.19	.063	**.248***	.001	**.218***	**.017**	**.132**	−**.016**	4

Note: The dependent variable indicates the criterion measure in each regression. *SD* = standard deviation. The two predictor variables for each regression are the measures indicated as dependent variables in the other two rows for the same measure type. Tests 1 to 4 are the 4 tests of Greenwald and colleagues' (2002) 4-test method, which uses three two-step hierarchical linear regressions. For Test 1, each measure is predicted only by the product of the other two measures at the first regression step (Step 1). For Tests 2 to 4, the two components of the product are added as predictors at the second step (Step 2). Each two-step regression provides opportunities to pass the 4 tests. Test 4 involves two effects identified as 4a and 4b (see last columns of Step 2 in the table). Bold font indicates tests that are "passed" by Greenwald and colleagues' (2002) criteria. The measure of math–gender stereotype used for these analyses is not scored as in Fig. 1 in the article itself (see text of the article for details).

[a] Should be statistically significant and numerically positive in order to pass the test.
[b] Should remain numerically positive in order to pass the test.
[c] Should not be statistically significant in order to pass the test.
[d] Should not differ from zero in order to pass the test.
* $p < .05$.

multiplicative model. Parallel results using the explicit measures also passed all 12 tests. The principles of cognitive balance are strongly demonstrated in Asian children.

Developmental increase

To investigate developmental changes in cognitive consistency, a set of three three-step regressions was conducted, where (a) Step 1 involved the regression of each criterion on school grade (first, third, or fifth), (b) Step 2 involved the addition of the multiplicative product of the other two predictors, and (c) Step 3 involved the addition of the product of grade with Step 2's product term. Table 3 shows results of the three-step hierarchical regression analyses.

Step 1 tested whether the criterion measure of each regression (i.e., gender identity, math–gender stereotype, or math self-concept) varied as a function of school grade. Although the only significant developmental trend found at Step 1 was that for the implicit math–gender stereotype (as discussed above), the signs of beta coefficients in Table 3 indicated that mean values of implicit and explicit measures of *me* = *boy* association (gender identity), *math* = *boy* association (math–gender stereotype), and *me* = *math* association (math self-concept) in Step 1 all increased slightly.

Step 2 tested whether a significant positive value of beta for Step 2's product term was evident when school grade was added as a preliminary predictor. The Step 2 product term was statistically significant in two of the three tests using each of the three measures as criterion for implicit measures, $t(153) > 2.91$, $p < .01$, as well as in all three tests using the explicit measures, $t(167) > 3.07$, $p < .001$, indicating that the balanced identity pattern was apparent when school grade was added as a preliminary predictor (see Table 3).

Step 3's three-component product term (including grade) tested the strength and direction of a linear developmental progression in cognitive consistency across school grades. Step 3's product term was positive for five of six measures and approached statistical significance for one of the three tests with implicit measures as criterion. Despite nonsignificance of the Step 3 explicit tests in Table 3, the near uniformity of the positive signs of implicit tests and their average beta coefficient value of .22 are suggestive of increasing cognitive consistency with increasing grade level, at least with the implicit measures.

Cross-cultural comparisons

Seizing an opportunity for a "first look" at cross-cultural aspects of math–gender stereotypes and math self-concept formation in elementary school children, we reanalyzed the published data from

Table 3
Developmental increase in cognitive consistency: Beta weights from hierarchical regressions predicting implicit and explicit gender identity, math–gender stereotype, and math self-concept.

Measure type	N	Criterion (Y)	R	Regression step 1 (grade)			Regression step 2 (product of the two predictors)			Regression step 3 (grade × product)		
				Beta	t	p	Beta	t	p	Beta	t	p
Implicit	155	Gender identity	.275	.038	0.47	.64	.230*	2.91	.004	.467[a]	1.88	.06
	155	Math–gender stereotype	.236	.178*	2.24	.03	.150[a]	1.87	.063	.111	0.58	.57
	155	Math self-concept	.233	−.033	0.40	.69	.230*	2.91	.004	.090	0.36	.72
Explicit	167	Gender identity	.264	−.048	0.61	.54	.257*	3.39	.001	−.091	0.44	.66
	167	Math–gender stereotype	.223	.063	0.81	.42	.210*	2.74	.007	.084	0.52	.60
	167	Math self-concept	.269	.008	0.10	.92	.260*	3.42	.001	.152	0.94	.35

Note: The dependent variable indicates the criterion measure in each regression. The two predictor variables for each regression are the measures indicated as dependent variables in the other two rows for the same measure type. The measure of math–gender stereotype used for the analyses in this Table were coded so that positive scores indicated *math* = *boy* association. The *R* values come from the third regression step at which the three-component product term (including grade) is added. At each of the three regression steps, the *t* values reported are absolute values.

* $p < .05$.

[a] $p < .10$.

Cvencek, Meltzoff et al. (2011) in conjunction with the data reported here. More specifically, the data for Grades 1, 3, and 5 from the study of Cvencek, Meltzoff et al. (2011) were used in combined analyses involving both Singaporean and American samples.

These cross-cultural contrasts approached significance in *expected* directions in two specific cases that are of theoretical interest and highly interpretable (the tests are reported as two-tailed assessments but clearly are in line with a priori predictions and arguably could be presented as significant one-tailed results). The first was the case of boys' explicit math self-concepts; Singaporean boys ($M = .69$, $SD = .92$) had stronger math self-concepts than did American boys ($M = .37$, $SD = 1.15$), $t(147) = 1.81$, $p = .06$. The second was the case of girls' implicit math–gender stereotypes; American girls ($M = -.18$, $SD = .36$) had stronger *math* = *male* stereotypes than did Singaporean girls ($M = -.09$, $SD = .31$), $t(152) = 1.73$, $p = .08$. In both of these cases, the effect sizes were moderate, supporting the idea that these marginally significant effects were nonetheless substantive. Although admittedly preliminary, these findings are both in the predicted direction and pave the way for cross-cultural tests using a larger *N*.

Discussion

We examined the operation and development of principles of cognitive consistency in a sample of children from a collectivist culture using implicit and explicit experimental methods. The current study goes beyond the existing findings with American elementary school children in three ways. First, it demonstrates that principles of cognitive consistency operate in an Asian culture and that cognitive consistency increases with age. Second, it shows that the math–gender stereotype is prevalent among elementary school children from Singapore, a country in which girls excel in math. Third, the developmental analyses demonstrated for the first time an increase in the strength of children's implicit math–gender stereotypes during the elementary school years.

Cognitive consistency is a culturally universal principle in social cognition

Implicit and explicit measures

Evidence for cognitive consistency was strongly demonstrated using both implicit and explicit measures of gender identity, math–gender stereotype, and math self-concept. One interesting finding is that the explicit measures (as well as the implicit ones) yielded a strong fit with the cognitive consistency pattern (Tables 2 and 3). In the available adult data, cognitive consistency pattern is found *only* using implicit measures (Cvencek, Greenwald, & Meltzoff, 2012; Greenwald, Rudman, Nosek, & Zayas, 2006; Greenwald et al., 2002). The lack of evidence for cognitive consistency with *explicit* measures in adults has been attributed to interference by "impression management" by the participants (Greenwald et al., 2002). The evidence for cognitive consistency with explicit measure data in the current sample of elementary school children suggests that such response factors that obscure cognitive consistency on explicit measures in adults operate more weakly in children.

Individualistic versus collectivist cultures and ontogenesis

According to Markus and Kitayama (1991), people in Asian cultures place a relatively larger emphasis (relative to Westerners) on roles, statuses, and societal obligations in contrast to internal cognitions such as private beliefs and personal opinions. These cultural variations can stand side by side with a set of core psychological principles that are culturally universal. The current demonstration of cognitive consistency in children in Singapore bolsters the speculation that the principle of cognitive consistency is one such cultural universal. Cultures may differ on the content of their cultural stereotypes and interpersonal norms, but the motivation for cognitive consistency may apply regardless of the content of the beliefs. How early in ontogeny the push toward cognitive consistency takes hold has implications for specifying mechanisms of change in social cognition (Meltzoff, 2013). For example, Meltzoff (2007; see also Meltzoff & Gopnik, 2013) argued that the rudiments of the process may exist preverbally; children have a fundamental drive to organize their social world by projecting "like-me" qualities onto others and incorporating attributes of "like-me" others into the self system.

Further empirical work investigating the ontogenesis of cognitive consistency promises to inform theories of social psychology and developmental science alike.

Singaporean math–gender stereotypes

The math–gender stereotype that math is a male domain was found previously in American elementary school boys and girls (Cvencek, Meltzoff et al., 2011) and German elementary school girls (Steffens et al., 2010). What the current study adds is that even in Singapore, where boys and girls both *excel* in this domain compared with their peers in other cultures, children associate *math* with *boys*. Based on what is known about school grades and standardized tests of math achievement (Mullis et al., 2008), Singaporean boys and girls are not developing math–gender stereotypes based on differences in actual achievement. Why would Singaporean children hold the stereotype that math is for boys?

Possible sources of the stereotype include parents/family members, peers, teachers, the Internet, and media messages, and some speculations are in order. Singapore is a cosmopolitan country well connected to the world. During the past two decades, the circulation of Singaporean daily newspapers in English has exceeded the circulation of Singaporean newspapers in any other language (Ang, 2007). Effectively all Singaporean school children read and write English, and 32% of all resident Singaporeans age 5 years and older speak English as the most frequent language at home (Singapore Department of Statistics, 2010). Western print media are also widely available (Abhijit, 2006), and Western radio and television are widespread, with American soap operas and daytime television shows among the most viewed television programs in Singapore (IMDb, 2013). According to the latest available information, 98% of 7- to 14-year-old children have access to the Internet at least once in 12 months, and 76% of Singapore households have regular access to the Internet (Infocomm Development Authority of Singapore, 2009). It is possible that American cultural stereotypes reach Singaporean children, in part, through the Web and electronic and print media. Moreover, Singaporean adults espouse stereotypical views about gender and academic subjects (Nosek et al., 2009), which may be an important source of stereotypes for children regardless of where adults get their ideas.

In this Singaporean elementary school sample, implicit math–gender stereotypes emerged during Grade 3 and persisted through Grade 5 (see Fig. 2). This general time frame is consistent with our research with American children (Cvencek, Meltzoff et al., 2011). However, the current results also show that Singaporean children's implicit math–gender stereotypes significantly increase during the elementary school years (the stereotype stayed relatively stable in the American sample). Such a developmental increase in Singaporean children's implicit math–gender stereotypes is consistent with the speculation that Singaporean children may assimilate messages about math–gender stereotypes somewhat later than American children, perhaps as they begin to encounter Western messages in the media and on the Web.

The observed developmental change in an implicit stereotype is directly relevant to emerging issues at the juncture of developmental and social psychology. Past research with children has prompted researchers to argue that children's implicit racial attitudes form early and remain strikingly stable over development (Baron & Banaji, 2006; Dunham et al., 2006; Newheiser & Olson, 2012; Rutland, Cameron, Milne, & McGeorge, 2005). Such reports of stability and the current findings of change can be reconciled. It is possible that more *affective* aspects of social cognition (e.g., implicit attitudes and preferences) form quickly and remain stable, whereas more *cognitive* aspects of social representations (e.g., implicit stereotypes and beliefs about gender and which social group is associated with math), form more gradually and are more malleable based on input over a protracted period of time (see also Halim, Ruble, & Amodio, 2011). A fertile area of future research on implicit (and explicit) cognition will be to carefully compare developmental changes in attitudes (likes/dislikes on valenced measures) versus stereotypes (beliefs about a social group) (Bosak & Diekman, 2010).

Singaporean children's math self-concepts

Singaporean boys had a stronger identification with math than did girls on both the implicit and explicit measures. These findings of stronger math self-concepts for boys than for girls present something of a puzzle. It is not readily apparent why, in the absence of any superiority in math achievement, Singaporean boys would identify with math more strongly than would girls. Here is where the concept of cognitive consistency is particularly informative. We argue that children's self-concepts about math emerge developmentally from an integration of the cultural stereotypes that bathe the children and their identification with their own gender. It could be that Singaporean boys develop stronger math self-concepts because they have already assimilated the cultural stereotype about math being a male domain (deriving from stereotyped media, adults, or peers). According to principles of balanced identity, boys, who strongly identify with male gender (gender identity), would then associate math with *self* in order to keep their cognition in balance. More speculatively, this could also account for the observed effects in Singaporean girls. The stereotype associating math with males would make it more difficult for female students to associate math with themselves (despite being high achieving in math) in order to stay in a balanced psychological configuration. For girls, developing a strong math self-concept would require opposing or resisting the societally stereotypical association of *math* with *boy* (and not *girl*). The current evidence for cognitive balance in Singaporean children suggests that a societal stereotype that connects boys (more than girls) with mathematics can potentially affect girls' self-concepts and identification with an academic discipline as early as elementary school.

It is also worth noting that math self-concepts were present but more weakly so than either of the other constructs tested here, that is, gender identity and math–gender stereotypes. Significant math self-concepts emerged only in Grade 5. Thus, we believe that math self-concept develops later than both gender identity and math–gender stereotype (see also Fig. 2), which can be tested through a longitudinal design in the future. This is consistent with our idea that children's math self-concepts arise from the combination of cultural influences and individual cognitive pressure for a balanced cognitive organization (see also Cvencek, Meltzoff et al., 2011, and Eccles, 2005). The current findings suggest that this pressure exists within both implicit and explicit cognition.

This discussion about children's developing academic self-concepts has been phrased in terms of mathematics. It must be acknowledged, however, that it is possible that our results are also informative about reading. Singaporean girls outperform Singaporean boys in reading (Mullis, Martin, Foy, & Drucker, 2012). A closer look at our implicit self-concept data for girls (Fig. 1A) reveals that the self-concepts of Singaporean girls are "discipline neutral"; girls associate *me* with *math* to a similar degree that they associate *me* with *reading,* not favoring one over the other. Given the relative nature of the IAT measures, it is difficult to untangle whether such discipline neutral academic self-concepts result from identifying equally strongly with both school subjects (i.e., math and reading) or from disidentifying equally strongly with both subjects. We hypothesize that Singaporean girls are identifying equally strongly with math and reading (two school subjects in which they excel) and that our implicit math and self-concept results tap the fact that girls have equally strong implicit math and reading self-concepts.

Conclusion

Singaporean elementary school children demonstrated the operation of cognitive consistency principles among their gender identity, math–gender stereotypes, and math self-concepts. This result is important because it establishes that, even in a collectivist culture such as Singapore, children's social cognition during elementary school years is already organized in a ways that reflect cognitive balance. We hypothesize that cognitive balance is a culturally universal and ontogenetically early psychological mechanism that drives important aspects of children's social–cognitive development.

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Appendix .

Words. for Child IATs

Me: my, mine, I, myself
Not-me: they, them, theirs, other
Boy: Ben, John, Peter, Tom
Girl: Alice, Jane, Mary, Wendy
Math: addition, numbers, graph, math
Reading: read, books, story, letters

Words. for explicit measures

Boy: Ali, Ben, Bryan, David, John, Peter, Samuel, Tom
Girl: Alice, Chloe, Jane, Jerica, Mary, Sally, Sarah, Wendy

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