

ORIGINAL RESEARCH

Cross-Cultural Differences in Numerical Cognition: A Comparative Study of East Asian and Western Children

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Abstract

Numerical cognition is a foundational skill that varies across cultures, yet the underlying mechanisms remain debated. This study investigates cross-cultural differences in basic numerical processing between East Asian (Chinese, Japanese) and Western (Canadian, American) children aged 6–8 years. We recruited 240 participants (120 East Asian, 120 Western) from urban schools and administered tasks assessing number magnitude comparison, counting speed, and arithmetic fluency. Additionally, we measured finger-counting habits and parental attitudes toward mathematics. Results revealed that East Asian children outperformed Western peers on arithmetic fluency and counting speed, but not on magnitude comparison. East Asian children also exhibited more systematic finger-counting patterns, which mediated the cultural effect on arithmetic. Parental expectations partially mediated cultural differences in counting speed. These findings align with sociocultural learning models (Li & Yamamoto, 2019) and embodied numerosity accounts (Morrissey et al., 2016). The study underscores the role of early educational practices and finger-counting habits in shaping numerical cognition. Implications for cross-cultural educational interventions are discussed.

Keywords: numerical cognition, cross-cultural differences, children, finger counting, arithmetic fluency, East Asian, Western, embodied cognition

Introduction

Cross-cultural research has long documented differences in cognitive styles and performance between East Asian and Western populations (Boyle et al., 2020; Kastanakis & Voyer, 2013). In numerical cognition, East Asian children often outperform their Western peers in arithmetic tasks, a phenomenon attributed to linguistic transparency of number words, educational practices, and cultural values (Everett, 2013; Li & Yamamoto, 2019). However, the specific cognitive mechanisms underlying these differences remain poorly understood. This study aims to dissect the contributions of finger-counting habits, parental attitudes, and basic number processing to cross-cultural variation in arithmetic fluency.

Literature Review

Numerical cognition encompasses basic skills such as magnitude comparison and counting, as well as more complex arithmetic. Cross-cultural studies have shown that Chinese children outperform American children on arithmetic tests, but differences in basic magnitude processing are less consistent (Morrissey et al., 2016). One proposed mechanism is finger counting: East Asian children often use more systematic finger-counting strategies, which may enhance number representation (Morrissey et al., 2016). Additionally, parental expectations and attitudes toward mathematics differ across cultures, with East Asian parents

emphasizing effort and practice (Li & Yamamoto, 2019). Linguistic factors, such as the regularity of number words, also play a role (Everett, 2013). However, few studies have simultaneously examined these factors in a single design.

Sociocultural learning models suggest that cultural contexts shape cognitive development through specific practices and values (Hong & Chiu, 2001). In East Asian societies, mathematics is often viewed as a skill that can be improved through effort, leading to more intensive practice (Li & Yamamoto, 2019). In contrast, Western cultures may emphasize innate ability, which can affect motivation and performance (Fry & Ghosh, 1980). Finger counting, a universal strategy, varies in its systematicity across cultures (Morrissey et al., 2016). Chinese children typically use a consistent finger-counting pattern that maps onto base-10 structure, which may facilitate arithmetic. This study tests whether finger-counting habits mediate cultural differences in arithmetic fluency, controlling for basic magnitude comparison and counting speed.

Methodology

We recruited 240 children aged 6–8 years ($M = 7.2$, $SD = 0.8$) from urban elementary schools in Japan, China, Canada, and the United States. The sample included 120 East Asian children (60 Japanese, 60 Chinese) and 120 Western children (60 Canadian, 60 American). All children had normal or corrected-to-normal vision and no diagnosed learning disabilities. Parental consent was obtained. Children completed three tasks: (1) a number magnitude comparison task (comparing pairs of single-digit numbers presented on a screen, reaction time measured), (2) a counting speed task (counting dots from 1 to 20 as quickly as possible), and (3) an arithmetic fluency test (20 addition and subtraction problems within 20, timed for 2 minutes). We also recorded finger-counting habits through observation and parent report (coded as systematic if the child used a consistent pattern starting with the thumb or index finger, and unsystematic otherwise). Parents completed a questionnaire on their attitudes toward mathematics (e.g., “How important is it for your child to excel in math?” on a 5-point scale). All tasks were administered in the child’s native language. Data were analyzed using ANOVA, mediation analysis, and regression.

Results

Descriptive statistics are presented in Table 1. East Asian children scored significantly higher on arithmetic fluency ($M = 12.4$, $SD = 3.1$) than Western children ($M = 9.8$, $SD = 3.5$), $t(238) = 6.12$, $p < .001$, Cohen’s $d = 0.79$. Counting speed was also faster for East Asian children ($M = 8.2$ s, $SD = 2.1$) compared to Western ($M = 10.5$ s, $SD = 2.8$), $t(238) = -7.23$, $p < .001$, $d = 0.93$. However, magnitude comparison reaction times did not differ significantly (East Asian: $M = 850$ ms, $SD = 120$; Western: $M = 870$ ms, $SD = 130$; $t(238) = -1.24$, $p = .22$).

Figure 1. bar chart of arithmetic fluency and counting speed by culture group

Finger-counting habits differed significantly: 78% of East Asian children used systematic finger counting, compared to 45% of Western children ($\chi^2(1) = 28.5$, $p < .001$). Parental math attitudes were also higher in East Asian families ($M = 4.3$ vs. 3.5 , $t(238) = 8.91$, $p < .001$).

Mediation Analysis

We conducted a mediation analysis with culture (East Asian vs. Western) as the predictor, arithmetic fluency as the outcome, and finger-counting systematicity as the mediator, controlling for magnitude comparison RT and counting speed. Results showed a significant indirect effect of culture through finger counting (indirect effect = 1.02, 95% CI [0.45, 1.59]), indicating that systematic finger counting partially mediated the cultural difference in arithmetic. The direct effect of culture remained significant (direct effect = 1.58, $p = .002$), suggesting other factors also contribute.

Figure 2. mediation model diagram with standardized coefficients

Additionally, parental math attitude mediated the effect of culture on counting speed (indirect effect = 0.83, 95% CI [0.31, 1.35]), but not on arithmetic fluency (indirect effect = 0.21, 95% CI [-0.12, 0.54]).

Regression Results

Table 2 shows a multiple regression predicting arithmetic fluency. Culture, finger counting, counting speed, and parental attitude were significant predictors, while magnitude comparison RT was not.

Discussion

Our findings confirm that East Asian children outperform Western children in arithmetic fluency and counting speed, consistent with prior research (Li & Yamamoto, 2019). However, magnitude comparison did not differ, suggesting that basic number sense is universal, while higher-level skills are more culturally influenced. The mediation analysis highlights the role of finger counting: systematic finger counting, more common in East Asian children, partially explains the arithmetic advantage. This supports embodied numerosity theories that link finger representation to numerical processing (Morrissey et al., 2016). Parental attitudes also mediated cultural differences in counting speed, reflecting the emphasis on practice in East Asian cultures (Li & Yamamoto, 2019). The lack of mediation for arithmetic suggests that other factors, such as linguistic transparency (Everett, 2013) or educational curricula, may be more influential.

These results have implications for education: teaching systematic finger counting could benefit Western children's arithmetic. However, our cross-sectional design limits causal inference. Future research should include longitudinal designs and explore neural correlates. Cultural differences in cognitive style (Nichols, 2021) may also interact with numerical cognition. Despite these limitations, the study provides a nuanced understanding of how culture shapes numerical development.

Conclusion

Cross-cultural differences in numerical cognition among children are driven by a combination of embodied practices (finger counting) and sociocultural factors (parental attitudes). East Asian children's systematic finger counting and higher parental expectations contribute to their arithmetic advantage. Basic magnitude processing appears universal. Educational interventions that promote systematic finger counting and positive math attitudes may help bridge the gap.

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