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Culture-Independent Prerequisites for Early Arithmetic

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Abstract
In numerate societies, early arithmetic development is associated with visuospatial working memory, executive functions, nonverbal intelligence, and magnitude-comparison abilities. To what extent do these associations arise from cultural practices or general cognitive prerequisites? Here, we administered tests of these cognitive abilities (Corsi Blocks, Raven's Colored Progressive Matrices, Porteus Maze) to indigenous children in remote northern Australia, whose culture contains few counting words or counting practices, and to nonindigenous children from an Australian city. The indigenous children completed a standard nonverbal addition task; the nonindigenous children completed a comparable single-digit addition task. The correlation matrices among variables in the indigenous and nonindigenous children showed similar patterns of relationships, and parallel regression analyses showed that visuospatial working memory was the main predictor of addition performance in both groups. Our findings support the hypothesis that the same cognitive capacities promote competence for learners in both numerate and nonnumerate societies.

Keywords
visuospatial ability, numerical cognition, indigenous children who lack number words, predictors of arithmetic ability

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It is widely claimed that a good working memory is a cognitive prerequisite for competent arithmetic development (Raghubar, Barnes, & Hecht, 2010), especially good visuospatial working memory (VSWM; Ashkenazi, Rosenberg-Lee, Metcalfe, Swigart, & Menon, 2013). Research shows that young children's arithmetic competence is associated with their VSWM and older children's with verbal working memory. For example, visuospatial interference disrupted 6-year-olds' arithmetic more that verbal interference, whereas the reverse was true of 8-year-olds (Holmes & Adams, 2006). These findings are consistent with the claim that nonverbal, spatial representations support early arithmetic (Lauer & Lourenco, 2016; Tosto et al., 2014). Measures of intelligence have also been associated with arithmetic ability (De Smedt et al., 2009). They often tap spatial capacities (Raven's Colored Progressive Matrices) as well as verbal capacities (Wechsler Intelligence Scale for Children) and are thought to reflect executive functions (Alloway & Passolunghi, 2011) that may be important in manipulating the contents of working memory (Cragg & Gilmore, 2014; Iuculano, Moro, & Butterworth, 2011). While these associations have been challenged, it is worth asking if they are the result of intrinsic cognitive capacities independent of cultural factors.

Here, we asked whether the contribution of VSWM and nonverbal intelligence to arithmetic ability depends on cultural factors or if they are general cognitive prerequisites independent of culture. To do this, we studied arithmetic abilities in two very different communities. The first comprises mainstream English-speaking 5- to 6-year-olds in urban Australian schools. The second are Anindilyakwa-speaking 5- to 6-year-olds from an island off the coast of Arnhem Land, northern Australia (see Fig. 1). The latter children have little experience of counting because their language contains no count

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Fig. 1. Map of Australia showing flight distances between Darwin and Melbourne (full map) and between Darwin and Groote Eylandt, Northern Territory (detail). The location of Groote Eylandt is marked by a red oval on the full map. (Darwin was chosen as the city from which to show distance.)

words (Butterworth & Reeve, 2008; Butterworth, Reeve, & Reynolds, 2011; Butterworth, Reeve, Reynolds, & Lloyd, 2008). Anindilyakwa is a classifier language that is claimed to have nine categories and is considered a very difficult language (Dixon, 2011). A classifier language comprises at least two classes of nouns with which other words (e.g., adjectives) must agree. The form of agreement varies depending on the class of the noun (Aikhenvald, 2017). This makes language comparisons between classifier and nonclassifier languages difficult (Lakoff, 1987).

Butterworth et al. (2011) found that Anindilyakwa-speaking children used a "pattern" strategy, producing organized spatial arrangements of counters in computing answers to an addition task, whereas urban-educated children counted out tokens, placing them in a line; moreover, the indigenous children were faster and more accurate. Indigenous children's ability to use spatial patterns may reflect better spatial abilities. Kearins (1981, 1986) reported that indigenous children, compared with their nonindigenous peers, had superior visuospatial memory.

In numerate cultures, counting is typically experienced in a spatial context when a parent or teacher points to to-be-counted objects while reciting counting words (Gelman & Gallistel, 1978). Children are often taught counting and simple arithmetic using a physical number line on which digits are arrayed, usually from left to right (Reeve, Paul, & Butterworth, 2015). Simple addition and subtraction are taught using spatially organized numerals (e.g., two addends are placed one above the other, in subtraction the subtrahend is placed below the minuend). Multidigit addition and subtraction may depend, at least partially, on a mental image of these arrangements.

By contrast, Anindilyakwa-speaking 5- to 6-year-olds have experienced little or no counting and, ipso facto, no spatially organized counting. Nevertheless, research on the numerical abilities of Anindilyakwa-speaking children who lack counting words suggests that both exact enumeration and simple exact nonverbal calculation are comparable with the numerical abilities of English-speaking children (Butterworth et al., 2008; Butterworth et al., 2011; Butterworth & Reeve, 2008). The interpretation of these findings depends primarily on failing to find a difference between indigenous and English-speaking children. The one exception is that indigenous children used a different strategy to remember the number of objects in a display. The English speakers remembered the word denoting the number of objects, whereas the indigenous children tended to employ a spatial enumeration strategy (Butterworth et al., 2011).

The importance of visuospatial abilities for early numerical cognition in North American and European cultures raises the question of whether individual differences in number abilities in Anindilyakwa-speaking and English-speaking children are driven by similar visuospatial factors. It should be noted that whereas many studies find a relationship between visuospatial abilities and early computation abilities (Paul & Reeve, 2016; Sella, Sader, Lolliot, & Cohen Kadosh, 2016), some do not (Mix & Cheng, 2012). If the same factors predict culturally appropriate arithmetic, this would support the hypothesis that the same cognitive representations are deployed by individuals with and without counting words.

The Present Study

To test our hypothesis, we assessed Anindilyakwa-speaking and English-speaking children on tasks known to correlate with emerging arithmetic abilities in English speaking children—a VSWM task (Corsi Blocks) and a nonsymbolic magnitude-comparison task (Halberda, Mazzocco, & Feigenson, 2008; Iuculano et al., 2011; Libertus, Feigenson, & Halberda, 2011)—as well as a nonverbal intelligence task (Raven's Colored Progressive Matrices) and a spatial reasoning task (Porteus Maze). While IQ has been linked to early math ability in nonindigenous cultures (see Alloway & Passolunghi, 2011), it remains to be seen whether nonverbal IQ is similarly linked to numerical abilities in an indigenous culture.

Raven's Colored Progressive Matrices is regarded as a culturally fair measure of general cognitive ability (Raven, Raven, & Court, 2004) and has been used with Australian indigenous children (Dingwall, Pinkerton, & Lindeman, 2013). The Porteus Maze is a measure of spatial executive functions and has also been used with Australian indigenous children (Dingwall et al., 2013). Porteus (1965) described his maze test as requiring an ability to (a) inhibit initial reactions, (b) follow rules, and (c) utilize error feedback.

We assessed the Anindilyakwa-speaking children's nonverbal addition (NVA) abilities, using a version of Levine, Jordan, and Huttenlocher's (1992) task, and English-speaking children's verbal single-digit addition (SDA) abilities. Our aim was to determine whether similar visuospatial factors predicted culturally appropriate computation abilities. Because the two computation tasks are superficially different, our focus was on similarities in the interitem correlational analyses rather than on comparisons of performance in the two groups directly. We refer to our approach as "parallel" analysis. Even though the NVA and SDA tasks are superficially different, they are computationally similar—their execution depends on similar arithmetic operations (Canobi & Bethune, 2008).

Method

Participants

Eighty-two 5- to 6-year-olds participated: 41 indigenous Anindilyakwa-speaking[1] children from Groote Eylandt, Northern Territory, Australia and 41 age-matched English-speaking children from Melbourne, Australia (see Fig. 1 for location of both communities). An age/gender automatic matching algorithm selected Melbourne children who had participated in a separate yet-to-be-published study and who were closest in age to the Northern Territory children. No other matching constrains were applied. The Northern Territory sample size (and ipso facto the Melbourne sample) was constrained by available participants in the remote Northern Territory community.

Tasks and procedure

All children completed four cognitive tasks and a computation test: (a) Raven's Colored Progressive Matrices; (b) the Corsi Blocks, a standard test of VSWM (Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000); (c) Porteus Maze, a test of spatial reasoning and executive functioning (Porteus, 1959, 1965); and (d) a magnitude-comparison task. The Northern Territory children completed an NVA task (Levine et al., 1992), and the Melbourne children completed a 30-item SDA task.

Raven's Colored Progressive Matrices is a matrix-completion task that requires the coordination of spatial relations. It consists of three 12-problem sets in which difficulty increases across problems: (a) Continuous Pattern (Set A), (b) Discrete Figure (Set AB), and (c) Analogical Pattern (Set B; Set A > AB > B). The task is to select one of six options that complete a matrix correctly. Error options include (a) close integration—one incorrect relation; (b) part integration—two incorrect relations, and (c) no integration—three or more incorrect relations.

The Corsi Blocks test is a spatial working memory task containing nine blocks on a board. Blocks are tapped one at a time, and participants attempt to tap blocks in the same order. Memory span is determined by the number of blocks tapped without error. (It should be noted that while the Corsi Blocks task is a commonly used measure of VSWM, its cognitive properties have yet to be fully determined. For example, the task requires sequential memory and motoric tracking capabilities that may or may not be independent of visuospatial processes.)

The Porteus Maze task consists of a series of mazes that require coordination of three rules (i.e., avoid dead ends, maintain continuous tracing, stay within maze bounds) to reach an exit point. Two trials are permitted for each maze level, which increases in difficulty as a function of maze-level complexity. Children were introduced to requirements using the simplest maze. The interviewer indicted the start location and informed children that they had to reach the maze exit following three rules: (a) do not go down dead ends; (b) do not lift your pencil, but stop and look ahead; and (c) do not trace across maze alleys. For the Northern Territory children, the task was presented by an indigenous assistant sitting next to the interviewer on the ground. A Perspex layout of a maze was used to convey task rules and errors. If an error occurred, rules were redescribed, and a second maze of the same level presented. This procedure assessed error-feedback utilization (Paul & Reeve, 2016). Following test procedures, we stopped testing after two unsuccessful trials on the same maze level.

All children completed a nonsymbolic magnitude-comparison task. In our version, children judged as quickly as possible which of two sets of squares "has the more blue squares." Stimuli consisted of blue squares on a yellow background. The number of squares in each set differed, but both sets had equivalent areas of "blueness." Children judged 72 stimuli, which consisted of all combinations of one to nine squares (excluding tied pairs). Children responded by pressing a colored right-shift key if the right side contained more blue squares and a colored left-shift key if the left side contained more blue squares. The larger number of squares appeared equally often on the right and left side of the screen.

Differences in stimuli relations were analyzed using ratio rather than numerical distances: Distances do not take into account absolute magnitude (e.g., 2 vs. 3 is regarded as equivalent to 7 vs. 8; see Brannon, 2006; Iuculano et al., 2011). Although the quantities 1 and 2 and 8 and 9 have numerical distances of 1, their ratio is different, and it takes longer to discriminate between 8 and 9 than between 1 and 2. Ratio was computed by dividing the smaller by the larger number of squares. The smaller the ratio, the "closer" the two sets of squares were in number.

Computation tasks

The Northern Territory children completed an NVA task, and the Melbourne children completed an SDA task. The SDA test comprised 30 two-term single-digit addition problems (see Paul & Reeve, 2016). Addends included a combination of all digits between 2 and 7 (excluding tied pairs; e.g., 2 + 2), in both orders (e.g., 2 + 7 and 7 + 2). Children's answers and enumeration strategies were recorded (i.e., whether answer outputs reflected a linear or a spatial pattern format); because children conveyed answers using counters, we did not collect information about computation strategies, and whereas some nonindigenous children used fingers to keep track (approximately 15%), no indigenous child did.

The NVA task was based on Levine et al.'s (1992) task. Two identical 24 cm × 35 cm mats and bowls containing 25 tokens were placed in front of a child and the interviewer. The interviewer sat beside the child—the appropriate practice in Australian indigenous communities (Kearins, 1981, 1986)—rather than opposite, as is typical in Western practice. The interviewer placed one token on her mat and, after 4 s, covered her mat. Next, the interviewer placed another token beside her mat and, while the child watched, slid the additional token under the cover and onto her mat (see Fig. 2). (Where the addend was more than one token, all tokens were swept under the mat in one movement.) Children were asked by the indigenous assistant to "make your mat like hers." Nine trials were used: 2 + 1, 3 + 1, 4 + 1, 1 + 2, 1 + 3, 1 + 4, 3 + 3, 4 + 2, and 5 + 3. Children's answers and behaviors were recorded.

Analysis

Because we were interested in the overlap in patterns of correlations among measures and the degree to which they predicted computation ability in the two groups, we do not report group differences in measures (i.e., we are interested in similarity in parallel patterns). Because of possible sample-size issues, we report robust estimation metrics for all tests (bias-corrected bootstrapping for bivariate correlations and 95% confidence intervals for Fisher's exact z-test comparisons

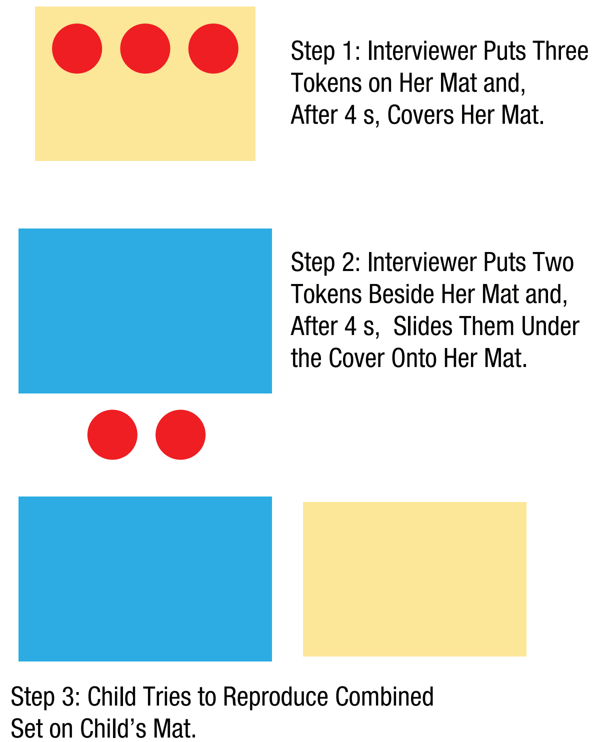

Fig. 2. Description of the steps in the nonverbal addition task administered to Northern Territory children.

for bivariate correlations). We also report η_p^2 statistics for multiple linear regression outcomes.

Results

Means and standard deviations for all measures are reported in Table 1, and Table 2 shows the zero-order correlations between measures. We used Fisher's exact z test (Fisher, 1925; Zou, 2007) to assess whether the pattern of correlations between the Northern Territory and Melbourne children was similar. Pairs of correlations were compared to determine whether the strength of association was significantly different between the two samples. Table 3 shows that no correlation pairs were significantly different between samples. For example, the correlation between Raven's Matrices and Corsi Blocks scores in the Northern Territory sample (r = .43) was not significantly different from the correlation between the Raven's and Corsi scores in the Melbourne sample (r = .36), as confirmed by a Fisher's exact z test (z = 0.35, 95% CI = [−0.31, 0.44]).

The similarity between the correlation matrices of each sample (Northern Territory, Melbourne) was also measured by the correlation matrix distance (Herdin, Czink, Özcelik, & Bonek, 2005),

$$d_{\text{corr}}(\text{Northern Territory, Melbourne}) = 1 - \frac{tr\{\text{Northern Territory} \times \text{Melbourne}\}}{||\text{Northern Territory}||_f \times ||\text{Melbourne}||_f} \in [0, 1],$$

where $tr\{\times\}$ is the matrix trace and $||\times||_f$ is the Frobenius norm. Distance scores (d_{corr}) range from 0, if the correlation matrices are equivalent, to 1 if they are orthogonal. The distance between the correlation matrices for the Northern Territory and Melbourne children was low (i.e., high similarity), d_{corr} = 0.021. Together, these findings suggest a high similarity in the pattern of correlations between measures, independently of location.

To determine whether similar or different measures predicted NVA (Northern Territory children) and SDA (Melbourne children) abilities, we conducted multiple linear regression analyses (see Table 4). The overall regression model predicting NVA (Northern Territory children) was significant, $F(4, 40) = 4.20$, $p = .007$, R^2 = .32, adjusted R^2 = .25, root-mean-square error (RMSE) = 21.70; however, only the Corsi Blocks measure was identified as an individual predictor in the overall model ($p < .05$). The overall linear regression model predicting SDA abilities (Melbourne children) was

Table 1. Means for All Measures, Separately for Northern Territory and Melbourne Children

Measure	Northern Territory	Melbourne
Age (in months)	82.02 (8.11)	81.90 (10.25)
Raven's Colored Progressive Matrices score	75.98 (17.04)	60.37 (29.29)
Corsi Blocks score	3.35 (0.59)	2.63 (0.73)
Porteus Maze score	7.10 (1.96)	7.17 (1.65)
Magnitude comparison (response time in ms)	2,711.78 (765.15)	1,722.79 (962.09)
Nonverbal addition (% correct)	56.10 (24.93)	
Single-digit addition (% correct)		75.69 (33.86)

Note: Standard deviations are given in parentheses.

Table 2. Bivariate Correlations Between Measures for Northern Territory and Melbourne Children

Measure	1	2	3	4
Northern Territory				
1. Raven's Matrices	—			
2. Corsi Blocks	.43**	—		
3. Porteus Maze	.28	.62**	—	
4. Magnitude comparison	−.31*	−.35*	−.24	—
5. Nonverbal addition	.30	.52**	.33*	−.38*
Melbourne				
1. Raven's Matrices	—			
2. Corsi Blocks	.36*	—		
3. Porteus Maze	.36*	.33*	—	
4. Magnitude comparison	−.46**	−.32*	−.36*	—
5. Single-digit addition	.39*	.53**	.50**	−.42**

Note: Bias-corrected bootstrapping (1,000 samples) was conducted to ensure robust estimates of correlation coefficients and significance.
*$p < .05$. **$p < .01$.

significant, $F(4, 40) = 7.01$, $p < .001$, $R^2 = .44$, adjusted $R^2 = .38$, RMSE = 26.77; the Porteus Maze ($p = .04$) and Corsi Blocks ($p = .02$) measures contributed to the model predicting SDA abilities (*p*s < .05).

Why did Porteus Maze performance differentially predict computation ability in the two groups? The answer may lie in differences in children's ability to benefit from feedback. The task procedure involved providing feedback if children made an error on the first trial at a maze level. We evaluated whether children either benefited from feedback (e.g., avoided an error on the next trial after feedback) or did not benefit (e.g., making an error on the same maze after being given feedback). Melbourne children tended to benefit from feedback ($n = 41$, benefit = 30, no benefit = 11), $\chi^2(1) = 8.81$, $p < .01$, whereas Northern Territory children tended not to benefit from feedback ($n = 41$, benefit = 24, no benefit = 17), $\chi^2(1) = 1.20$, $p = .27$. These findings suggest that Melbourne and Northern Territory children may have approached the maze task differently, even though their overall mean performance was similar (see Table 1).

Differences in the patterns of magnitude-comparison judgments for Northern Territory and Melbourne children are reported in Figure 3. These show that the response times for adjacent ratio-judgment differences were similar for both Northern Territory and Melbourne children.

Discussion

We found that individual differences in computation abilities were driven by similar visuospatial factors in Anindilyakwa-speaking and English-speaking children. We interpret this finding as supporting the hypothesis that the same cognitive abilities are deployed by individuals with and without counting words. Specifically, the finding shows that similar spatial capabilities support the calculation abilities of indigenous children with few number words and the calculation abilities of nonindigenous children. This finding highlights the importance of visuospatial abilities for emergent numerical cognition. Verbal abilities may extend basic numerical abilities but may not be the basis of numerical cognition (Butterworth et al., 2008).

The finding that differences in VSWM in indigenous and nonindigenous children predict culturally appropriate computation ability is consistent with the growing body of research showing that spatial abilities (VSWM in particular) predict early math ability. The difference between earlier findings and our own is that previous research compared spatial memory abilities using gamelike tasks (Kearins, 1981, 1986), whereas we employed a commonly used VSWM task (Corsi Blocks, as well as other nonverbal tasks). Nevertheless, the

Table 3. Results of Fisher's Exact *z*-Test Comparison of Bivariate Correlations Between Northern Territory and Melbourne Children

Measure	1	2	3	4
1. Raven's Matrices	—			
2. Corsi Blocks	0.35 [−0.31, 0.44]	—		
3. Porteus Maze	−0.38 [−0.47, 0.32]	1.69 [−0.05, 0.64]	—	
4. Magnitude comparison	0.76 [−0.23, 0.52]	−0.15 [−0.42, 0.36]	0.60 [−0.28, 0.52]	—
5. Single-digit addition/nonverbal addition	−0.48 [−0.48, 0.30]	−0.07 [−0.34, 0.32]	−0.88 [−0.53, 0.20]	0.22 [−0.33, 0.42]

Note: Values in brackets are 95% confidence intervals.

Table 4. Results of the Multiple Linear Regression Predicting Computation in Northern Territory and Melbourne Children

Measure	β	*SE*	*b*	*t*	*p*	η_p^2
Northern Territory						
Intercept	10.64	29.63		0.36	.72	.00
Magnitude comparison	–0.01	0.01	–0.22	–1.43	.16	.05
Porteus Maze	0.08	2.16	0.01	0.04	.97	.00
Raven's Matrices	0.06	0.20	0.05	0.31	.76	.00
Corsi Blocks	17.71	8.03	0.42	2.21	.03	.12
Melbourne						
Intercept	–6.34	28.38		–0.22	.83	.00
Magnitude comparison	–0.01	0.01	–0.16	–1.12	.27	.03
Porteus Maze	6.02	2.88	0.29	2.09	.04	.11
Raven's Matrices	0.10	0.17	0.09	0.58	.57	.01
Corsi Blocks	16.29	6.45	0.35	2.53	.02	.15

patterns of correlations among the measures were statistically similar for nonindigenous and indigenous children.

Our claims are based on interpreting the meaning of statistically similar correlation matrices and parallel regression analyses. Because of cultural-specific number experiences, we were unable to use the same computation tasks in both cultural settings. SDA using the familiar numerals (e.g., 3 + 5 = ?) is introduced in the early school years in Australia and worldwide (Organisation for Economic Co-operation and Development,

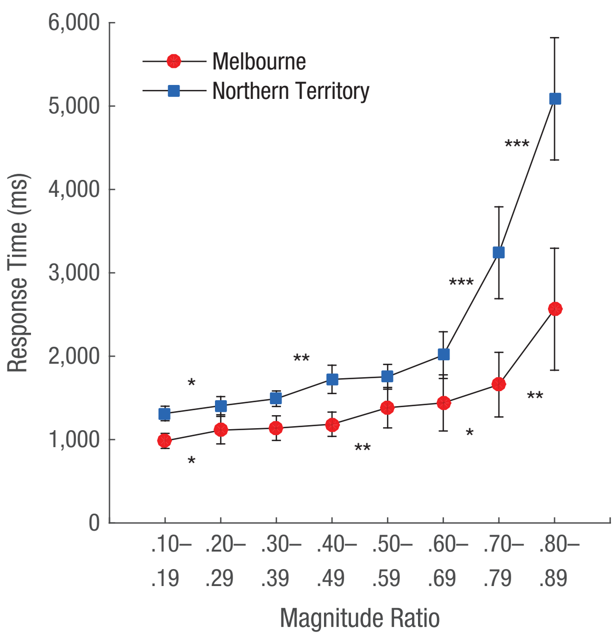

Fig. 3. Means of median judgment response time as a function of magnitude ratio and sample. Asterisks indicate significance of adjacent pairwise comparisons (*$p < .05$, **$p < .01$, ***$p < .001$). Error bars represent ±2 *SEM*.

2014). It is a learned math skill, with acquisition likely depending on various cognitive functions. For example, the finding that the Porteus Maze and Corsi Blocks measures are associated with SDA abilities is unsurprising. The Porteus procedure involves providing feedback following an error on the first trial of a maze level.

The Porteus performance contributed to predicting nonindigenous children's math ability but did not contribute to predicting indigenous children's math ability. There are several possible reasons for this. Although administration of the Porteus was similar in the two contexts, it was not identical. Melbourne children received standardized verbal instructions, whereas the Anindilyakwa-speaking indigenous assistant explained the task to the Northern Territory children. Melbourne children appeared to benefit from feedback, whereas the Northern Territory children did not. If an error was made on the first trial of a maze level, the instructions were repeated. If an error was made on the second trial, the task was terminated. Some Melbourne children benefited from this feedback and performed better on the subsequent maze trial. As far as we could tell, the Northern Territory children showed no propensity to benefit from feedback. While caution should be exercised in interpreting the meaning and significance of similarities and differences in Porteus Maze performance in the two cultures, we may have underestimated Anindilyakwa-speaking children's maze performance because they did not appear to attend to feedback.

While the SDA task was familiar to the Melbourne children, the NVA task was an unfamiliar task for the Anindilyakwa-speaking children. Perhaps more practice should have been given with the NVA task. Nevertheless, we stress that the same visuospatial measures predicted differences in computation in Melbourne and the Northern Territory.

The performance of the Anindilyakwa-speaking children on the nonverbal magnitude-comparison task is impressive for several reasons. As far as we are aware, the Anindilyakwa-speaking children had never used a computer. Although the Anindilyakwa-speaking children were slower overall, their pattern of response times for the different ratios was similar to that of the Melbourne children. Even though magnitude-comparison abilities were correlated with other measures in the expected fashion, magnitude comparison did not contribute to the equation predicting computation abilities in either culture. While some researchers find a relationship between magnitude-comparison ability and early math ability (Schneider et al., 2017), not all do (De Smedt, Noël, Gilmore, & Ansari, 2013).

Many reasons have been suggested for indigenous children's poor school performance. Some researchers suggest that indigenous children are unaccustomed to self-monitoring learning activities (Kearins, 1986). Observational learning or watching, rather than listening, seems to be an important learning method for indigenous children. In addition to sociocultural differences in learning practices, language undoubtedly plays a part in nonindigenous children's math—the exact role of which has yet to be determined.

On the weight of evidence, it seems that similar visuospatial factors underlie young children's math abilities (addition in the current context), independently of culture. The degree to which visuospatial abilities underlie other mathematical competencies is a matter for further research. Our findings contribute to the growing body of evidence supporting the hypothesis that the same cognitive abilities are deployed by individuals with and without counting words.

Action Editor

John Jonides served as action editor for this article.

Author Contributions

R. A. Reeve and B. L. Butterworth developed the study concept and designed the study. F. Reynolds collected the data. J. Paul and R. A. Reeve analyzed the data. R. A. Reeve and B. L. Butterworth wrote the manuscript. All the authors approved the final manuscript for submission.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Open Practices

Data and materials for this study have not been made publicly available, and the design and analysis plans were not preregistered.

Note

1. Anindilyakwa is the indigenous language of Groote Eylandt, off the east coast of Arnhem Land. It is a classifier language with a very limited number vocabulary with a singular marker (*awilyaba*), a dual (*ambilyuma* or *ambambuwa*), a trial (which may in practice include 4: *abiyakarbiya*), and a plural meaning more than 3 (*abiyarbuwa*). It also has words for 5 (*amangbala*), 10 (*ememberrkwa*), 15 (*amaburrkwakbala*), and 20 (*wurrakiriyabulangwa*), likely derived from Macassan traders. The number system is not formally introduced to community members until adolescence. In traditional indigenous society, nothing was counted that was outside normal everyday experience. When asked for what purpose counting was used in the old days, the old women who know the number names say it was used for turtle eggs (30). Although Anindilyakwa contain quantifiers for countable nouns, such as "some" (*akwala*), a "few" (*ambawura*), and "many" (*ababurna*), and for uncountable nouns, including a "little" (*thile ayukwujiya*) and "much" (*adirrungwarna*), these are not number words. Ordinals, such as "first," "second," and "third," would be more problematic but do not exist in Anindilyakwa (Gilmore, 2015).

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