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BRIEF REPORT

An Exploratory Analysis of American Indian Children's Cultural Engagement, Fluid Cognitive Skills, and Standardized Verbal IQ Scores

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This exploratory cross-sectional study examined fluid cognitive skills and standardized verbal IQ scores in relation to cultural engagement amongst Tohono O'odham children ($N = 99$; ages 7 to 12 years). Guardians with higher socioeconomic status engaged their children in more cultural activities, and participation in more cultural activities contributed to higher standardized verbal IQ scores. Mean cognitive skill scores varied as a function of age and Tohono O'odham language knowledge. Children who understood and/or spoke Tohono O'odham started out with lower average scores than did children with no language knowledge, but mean scores generally increased in the older age groups such that they were equal to or higher than those of nonspeakers by age 9. Children with higher fluid cognitive skill scores had higher standardized verbal IQ scores than did children with lower scores.

Keywords: American Indian, culture, fluid cognitive skills, working memory, inhibition, verbal IQ

Many American Indian and Alaska Native leaders today support the idea that education is the key to strengthening the sovereignty and self-determination of their nations, but they also stress that maintaining traditional ways, their language, and their culture must not be sacrificed in the pursuit of education (Inglebret, Jones, & Pavel, 2008; Rivera & Tharp, 2006; Tohono O'odham Nation Education Department, 2004). Very little research has been done in support of this goal. Historically, federal educational policy from the 1870s and well into the 1970s emphasized assimilation and the destruction of American Indian and Alaska Native cultures as the goal of education (as cited in Lipka, 2002). In part due to this policy, as well as other detrimental factors such as high rates of poverty in American Indian and Alaska Native communities, in 2006, American Indian and Alaska Native students represented only 1% of the total enrollment in colleges and universities, with this 1% representing a doubling of enrollment over the past 30 years (DeVoe, Darling-Churchill, & Snyder, 2008).

There is very little research on normative cognitive development in American Indian and Alaska Native children despite the fact that American Indians and Alaska Natives typically have poor educational outcomes in comparison to other groups within the United States (National Indian Education Association, 2008). In fact, only Hispanics have a higher drop-out rate at 21% compared with 15% for American Indian and Alaska Native youth (National Indian Education Association, 2008). The elementary school years are fundamental in setting the stage for future academic success in high school and college. According to Cooper, Chavira, and Mena (2005), as ethnic minority youths progress from elementary school to middle school and then to high school, their numbers shrink dramatically. Additionally, the elementary school years represent a key period in the development of children's basic cognitive skills particularly in relation to their mastery of more complex tasks (Diamond, 2006).

Some researchers have theorized that one of the reasons for the high rate of school failure for American Indian and Alaska Native children is that American Indian and Alaska Native cultural values and mainstream educational values are incompatible (e.g., Bachtold, 1982; Westby & Roman, 1995; Westby & Rouse, 1985). Others have theorized that culture shapes cognition; children learn how to think by engaging in the daily activities of their community (e.g., Rogoff et al., 2007; Serpell & Hatano, 1997). For children in communities where attending school is not the social norm, this often leads to the development of skills not valued in Western-style school settings (for a discussion of Western-style schooling, see Cole, 2005, or Rogoff, Correa-Chávez, & Cotuc, 2005). Although children who are not exposed to Western-style schooling were generally found to have less advanced cognitive skills than children who engaged in Western-style schooling, nonschooled children have demonstrated superior cognitive skills when the tested skills had meaningful purposes in their communities (e.g., Mishra, Singh, & Dasen, 2009; Rogoff & Waddell, 1982).

A more complex view of school success in relation to cognitive development and culture for American Indian and Alaska Native

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children seems necessary today, as American Indian and Alaska Native nations have coexisted within the United States for well over 500 years. Tribal and community leaders have worked hard to make education meet the needs of their children, most notably through the Indian Education Act of 1972 and the Indian Education and Self-Determination Assistance Act of 1975. Moreover, American Indian and Alaska Native children do not grow up in communities where they are exposed only to the cultural values and practices of their communities, nor are all American Indian and Alaska Native children exposed to their traditional values (for an example of a counterculture, see Eckholm, 2009). As of 2005, a total of 624,000 American Indian and Alaska Native students were enrolled in the U.S. kindergarten—12th-grade education system; 93% attended public schools and 7% attended Bureau of Indian Education schools (National Indian Education Association, 2008).

Transactional or dynamic systems models seem more likely to capture the complex nature of American Indian and Alaska Native child development today. Transactional models emphasize the bidirectional effects between individuals and cultural contexts and underscore the impact of accumulated exposure to physical and social environments on development (Sameroff, 2009; Sameroff & MacKenzie, 2003). People actively shape their environments through the choices they make in engaging in some activities and refraining from others, and this selective engagement influences their development over time. Thus, culture is defined as engagement in traditional practices, that is, culture is not viewed as fixed, nor is it viewed as shared equally by all members of a community. It is through engaging in cultural activities that the cultural values and goals of the community are transmitted to the next generation.

There is some evidence that cultural engagement improves cognitive development in American Indian and Alaska Native communities. In particular, immersion in tribal language schools has led to improvements in verbal skills in English (Renker & Arnold, 1988) and including cultural knowledge in a mathematics lesson enhanced Yup'ik children's understanding of the concepts of area and perimeter (Lipka & Adams, 2004). A growing body of research has shown that bilingual children demonstrate an advantage over monolingual children on inhibitory control (the ability to control attention such that irrelevant information is suppressed or a dominant response is prevented) and other executive control functions (Bialystok, 2010; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008). Additionally, there is evidence that working memory (the mental work space where information can be stored and processed for brief periods of time during demanding cognitive activities) and inhibition are cognitive skills that are not influenced by socioeconomic status (SES) factors (Engel, Santos, & Gathercole, 2008; Gathercole, Pickering, Knight, & Stegmann, 2004).

Conversely, studies examining verbal ability have shown that these tests tap into crystallized knowledge, which is highly dependent upon culture and the SES of the family (Bigelow, 2006; Hoff, 2003, 2006; Hoff & Tian, 2005). Research in American Indian and Alaska Native communities supports these findings with American Indian and Alaska Native children typically doing well on performance test items and performing poorly on verbal items (Mueller, Mulcahy, Wilgosh, & Walters, 1986; Salois, as cited in Bigelow, 2006). Bigelow (2006) proposed that these results were not due to a failure to allow American Indian and Alaska Native children to capitalize on their strengths, but instead they were due to the fact that assessments of verbal ability are most affected by poverty.

Exploring the interrelations among fluid cognitive skills, standardized verbal IQ scores, and cultural engagement has implications for academic achievement in American Indian and Alaska Native communities, as better fluid cognitive skills and higher standardized verbal IQ scores have been linked to enhanced academic outcomes. For example, St. Clair-Thompson and Gathercole (2006) found that working memory and inhibition were closely linked to achievement in English and mathematics, with inhibition also associated with success in science in middle school. These findings appear to be strong across cultural groups, as similar results have been reported with samples from the United States (Blair & Diamond, 2008), Mexico (Aguirre-Pérez, Otero-Ojeda, Pliego-Rivero, & Ferreira-Martínez, 2007), and Singapore (Lee, Ng, & Ng, 2009). With regard to verbal ability, according to Neisser et al. (1998), standardized verbal IQ scores predict as much as 25% of the variance in school performance. Although standardized verbal IQ scores are widely criticized as being culturally biased, verbal ability in the English language is an important indicator of school achievement for American Indian and Alaska Native students (Beiser, Sack, Manson, Redshirt, & Dion, 1998).

The Tohono O'odham Nation was selected as a good place to conduct this study, as a community-wide survey in 2004 revealed that both parents and children believed that success in school and the incorporation of their culture in school were important (Tohono O'odham Nation Education Department, 2004). The traditional way of life on the Tohono O'odham Nation is Himdag. Himdag includes the values of respect, responsibility to the community, and spiritual connectivity with the earth and one another. Cultural values are transmitted through the use of storytelling, songs, and religious practices. According to Zepeda, a Tohono O'odham linguist, the Tohono O'odham language is the primary means for the transmission of the spiritual and cultural values of the community and is viewed as fundamental to cognition (Zepeda, 1990, 1995). Thus, participation in cultural activities and knowledge of the Tohono O'odham language were used as indicators of cultural engagement.

Because of the exploratory nature of this study, and the fact that none of the assessments have established validity and reliability in testing Tohono O'odham children, the first objective was to explore Tohono O'odham children's average scores in comparison with previously published scores. The second goal was to test for significant differences between children who were culturally engaged and children who were not culturally engaged on the cognitive assessments. In keeping with the transactional model of development, differences between age groups were tested in order to include an analysis of how cultural engagement might lead to significant differences in fluid cognitive skills and verbal ability over time. Because of the cross-sectional study design, examining differences by age group can only provide preliminary evidence of significant differences in fluid cognitive skills and verbal ability as a function of accumulated cultural engagement.

The final goal was to model the associations between the two measures of cultural engagement (Tohono O'odham language knowledge and cultural participation), fluid cognitive skills, and verbal ability such that the direct and indirect effects of each indicator of cultural engagement could be examined in relation to

the measures of fluid cognitive skills and verbal ability as latent constructs. By using the partial least squares latent modeling technique, it was also possible to examine whether SES was differentially associated with fluid cognitive skills and verbal ability within the same model. Additionally, partial least squares modeling allowed for an examination of age as a potential moderator of the effect of Tohono O'odham language knowledge and cultural participation such that the accumulated effects of both variables within the older children (again, assumed rather than verified as a result of the cross-sectional nature of the data) would have differential effects over time on fluid cognitive skills and/or verbal ability. In addition, the two measures of cultural engagement were tested as mediators of the effect of SES on fluid cognitive skills and verbal ability. Partial least squares modeling is ideal for examining all of the possible associations between the variables of interest as it can be used with small data sets and is recommended for exploratory purposes, as it does not have the strict measurement and distributional requirements of other modeling procedures (Chin, 1998; Chin & Newsted, 1999).

Method

Participants

Tohono O'odham children living on their reservation in the southwestern part of the United States were recruited after permission was given by the Tohono O'odham tribal council and approval was obtained from the Bureau of Indian Education and the local public school district. A total of 99 children—55 girls and 44 boys ($M = 9.94$ years; $SD = 1.40$)—who self-identified as Tohono O'odham were included in the final sample, with eight children not included because they identified themselves as nontribal members. The average annual income was $25, 455; however, the mode was $5,000 per year ($n = 23$), with 52.5% percent of the guardians reporting that they received food stamps. The majority of the guardians had a 12th- grade education (47.5%) or higher (22.2%), with 3% completing bachelor's degrees. All of the guardians were fluent in the English language. Tohono O'odham language knowledge was almost evenly split between children who had no knowledge of their native language (children who did not speak or understand their native language [$n = 47$]) and children who had some knowledge of their native language (children who understood but did not speak their native language [$n = 40$] and children who understood and spoke their native language fluently [$n = 12$]).

Procedure

The children were recruited through elementary schools and recreation centers located on the reservation by handing out packets with a flier describing the study and a contact information form. The children were asked to give the packets to their guardians and then return the completed form to their teacher or the recreation center director if they agreed to participate. After the contact forms were received, the consent forms and guardian questionnaires were sent home with participating children. As a result of the sampling method, only 50% of the distributed packets were returned. Because of the size of the reservation, it was not possible to make contact with all of the parents and guardians directly.

The children were interviewed by a researcher who is an enrolled member of a different American Indian tribe but who has a long history of living among and working with the Tohono O'odham people. The children participated at school or at the district recreation center and received $10 and some small gifts (e.g., balls, stickers, bracelets) for participating, along with fruit punch, water, and fruit roll-ups during the testing session. All were actively engaged throughout the 2-hr testing session, with many stating that they enjoyed participating. Guardians also received $10 with the money sent home with the children in a sealed envelope.

Demographic, Cultural, and Cognitive Assessments

The means, standard deviations, and ranges for all of the assessments are reported in Table 1.

SES. Guardians were asked to fill out a short survey assessing their economic status. Family yearly income was assessed on a scale ranging from *less than $5,000* and to *over $200,000,* with the highest number in the circled range recorded as the family's income. Guardians were also asked about their occupation and educational attainment.

Tohono O'odham language. A respected Tohono O'odham tribal member was hired to assist with designing the language and cultural assessments. Cultural engagement questions asked the guardian to rate their child's language knowledge on the following scale: 0 = *does not speak,* 1 = *understands, but doesn't speak well,* and 2 = *understands and speaks fluently.* This variable was dichotomized such that 0 = *does not speak* and 1 = *understands, but doesn't speak well or speaks fluently.*

Cultural participation. The guardians were asked to list all of the cultural activities their children participated in on a regular

Table 1
Means and Standard Deviations for Socioeconomic Status, Cultural Participation, Fluid Cognitive Skills, and Verbal IQ

Variable	*M*	*SD*	Range
Annual income ($)	25,455	17,463	5,000 to 80,000
Guardian education (years)	11.91	1.61	8 to 16
Cultural participation	2.02	1.75	0 to 8
Reading span	10.93	6.34	2 to 32
Digit span	4.62	1.52	1 to 8
Stroop inhibition	−19.31	7.31	−43 to −3
Recall inhibition	3.92	2.56	−3 to 9
Verbal IQ	87.32	11.76	58 to 119

basis. Given the exploratory nature of the study, this question was intentionally broad, as the cultural activities tribal groups practice vary widely, with some groups sharing common traditions and others having very different traditions. Thus, it did not seem appropriate to place limits on what Tohono O'odham guardians viewed as their traditional religious and cultural activities. Nonetheless, enrolled community members were consulted to verify the authenticity of the activities listed. The total number of activities listed (e.g., saguaro fruit harvesting, Waila music, Toka—a traditional stick game) was used as an indicator of cultural participation.

Working memory capacity. Two tests of working memory capacity were administered: the Sentence Completion and Recall Test (Towse, Hitch, & Hutton, 1998) and a Backward Digit Span Test. The Sentence Completion and Recall Test asked the children to read a series of short sentences with the last word missing. The total number of correctly recalled words was counted as the child's Reading Span, with a total of 42 possible points. The Backward Digit Span Test is a commonly used test of working memory capacity that requires the participant to repeat a sequence of digits backward (e.g., Alloway, Gathercole, Willis, & Adams, 2004). Correctly reported numbers were counted with a total of 14 possible points.

Inhibition. Two tests of inhibitory control were administered to tap into two potentially separable aspects of inhibition: prepotent response inhibition and intentional inhibition (Wilson, Kipp, & Daniels, 2003). We used the Stroop Color and Word Test: Children's Version to measure prepotent response inhibition (Golden, Freshwater, & Golden, 2003). This test was developed for children between the ages of 5 and 14 years. The final score was calculated by subtracting the raw Color score from the raw Color–Word score (Stroop Inhibition).

A categorized block-cued directed-forgetting task was used as a measure of intentional inhibition (Wilson, Kipp, & Daniels, 2003). The children were told to remember a list of words categorized as fruits and vegetables for a memory test later. After all of the words in the Fruits and Vegetables list had been read, the children were told to forget them as they were just for practice and to only remember a second list of words categorized as furniture. After a 30-s delay, the children were asked to recall only the words they were told to remember. The incorrectly reported number of recalled fruits and vegetable words was subtracted from the number of correctly reported furniture words; thus, negative scores were possible (Recall Inhibition). A forced-choice recognition task was administered after the recall task in order to assess the encoding status of both lists of words. In keeping with prior research, the difference between the children's recognition of the words on the fruits and vegetables and the words on the furniture list was not significant, indicating that the children had encoded both sets of words in memory, $t(98) = -0.27$, $p = .79$.

Standardized verbal IQ. The Vocabulary and Similarities subtests of the Wechsler Abbreviated Scale of Intelligence (WASI) were administered to assess the children's verbal IQ (WASI; Wechsler, 1999). The test administrator received extensive training in administering and scoring the WASI for children between the ages of 7 and 12 years as a research assistant for the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development. Raw scores on the Vocabulary subtest and the Similarities subtest were converted to standardized scores and combined to provide a standardized indicator of verbal IQ.

Results

Preliminary Analyses

The data were screened for univariate and multivariate outliers as well as for other violations of assumptions, such as extreme deviations from normality, with only one child's score on cultural participation flagged as an outlier because the parent listed 14 cultural activities; the score was brought within three standard deviations of the mean for the analyses. One participant failed to complete the Stroop Inhibition task, and another participant's score on the Recall Inhibition task was dropped as it was not clear that he or she understood the directions.

Comparison of Tohono O'odham Children's Scores to Previously Published Scores

Because of the lack of normative data on American Indian children in general, and Tohono O'odham children specifically, Table 2 provides the means and standard deviations for the Tohono O'odham children by age group. As a result of the small number of 7- and 12-year-olds, children of ages 7 ($n = 8$) and 8 ($n = 15$) were combined into one group, and children of ages 11 ($n = 17$) and 12 ($n = 7$) were combined into another group, resulting in four age groups: 7- and 8-year-olds, 9-year-olds, 10-year-olds, and 11- and 12-year-olds. Data published in the WASI manual (Wechsler, 1999) and the Children's Stroop Test manual (Golden, Freshwater, & Golden, 2003) were used to test for differences between the Tohono O'odham children and the children who participated in the standardization of these tests by age group. Comparison data for the measures of Reading Span, Digit Span, and Recall Inhibition were obtained from previously published studies. On the measure of recall inhibition, comparison data were only available for 8-year-olds (Wilson, Kipp, & Daniels, 2003).

The means and standard deviations for the comparison groups and the single sample *t*-test results are provided in Table 2. A Bonferroni correction was applied in order to adjust the Type II error rate; thus, only tests with significance level of less than .003 were counted as significant differences. The Tohono O'odham children had significantly lower scores in each age group than did the mainstream children on the reading span assessment of working memory. They had significantly lower verbal ability scores in the three older age groups, but they started out approximately equivalent to their peers who were not of American Indian or Native Alaskan ethnicity. On the Digit Span assessment of working memory, only the 10-year-olds had significantly lower scores than their mainstream peers. Interestingly, the 7- and 8-year-olds had significantly better Stroop inhibition scores than did their peers in the normative sample. However, by the age of 10, their inhibitory control scores were not as good as the scores of the comparison group. The difference between the Tohono O'odham children and the comparison group on the recall inhibition task was not significant.

Table 2
Means (and Standard Deviations) by Age Group With Comparison Data From Normative Samples or Previously Published Research for the Measures of Fluid Cognitive Skills and Verbal IQ

			Single-sample *t* test		
Cognitive test/age (years)	Tohono O'odham	Comparison data	*t*	*df*	*p*
Reading span					
Age 7 and 8 ($n = 23$)	7.26 (3.89)				
Age 9 ($n = 23$)	10.48 (7.62)	18.92 (9.87)	−5.31**	22	<.003**
Age 10 ($n = 29$)	12.97 (6.20)	20.45 (9.93)	−6.50**	28	<.003**
Age 11 and 12 ($n = 24$)	12.42 (5.95)	19.71 (11.54)	−6.01**	23	<.003**
Digit span					
Age 7 and 8 ($n = 23$)	3.91 (1.41)				
Age 9 ($n = 23$)	4.83 (1.27)	5.64 (1.58)	−3.08	22	.005
Age 10 ($n = 29$)	4.69 (1.63)	5.92 (1.91)	−4.07**	28	<.003**
Age 11 and 12 ($n = 24$)	5.00 (1.59)	5.76 (2.68)	−2.34	23	.03
Stroop inhibition					
Age 7 and 8 ($n = 22$)	−17.43 (6.81)	−10.98 (11.14)	−4.55**	22	<.003**
Age 9 ($n = 23$)	−17.87 (6.12)	−18.66 (8.14)	0.62	22	.54
Age 10 ($n = 28$)	−18.93 (5.89)	−23.10 (13.54)	3.74**	27	.001**
Age 11 and 12 ($n = 24$)	−22.92 (9.21)	−22.80 (9.55)	−0.06	23	.95
Recall inhibition					
Age 7 and 8 ($n = 23$)	3.04 (1.99)	4.00 (2.02)	−2.31	22	.03
Age 9 ($n = 23$)	3.43 (3.16)				
Age 10 ($n = 29$)	4.24 (2.76)				
Age 11 and 12 ($n = 23$)	4.87 (1.77)				
Verbal IQ					
Age 7 and 8 ($n = 23$)	91.91 (10.84)	98.90 (17.40)	−3.09	22	.005
Age 9 ($n = 23$)	90.96 (10.01)	100.90 (19.20)	−4.76**	22	<.003**
Age 10 ($n = 29$)	86.37 (9.79)	101.60 (18.80)	−8.38**	28	<.003**
Age 11 and 12 ($n = 24$)	80.58 (13.48)	99.20 (19.30)	−6.76**	23	<.003**

** $p < .003$, with a Bonferroni correction.

Comparison of Tohono O'odham Children's Scores by Age Group and Cultural Engagement

Significant differences between groups were examined by age group—with Tohono O'odham language knowledge (see Table 3) as the first between-groups variable and cultural participation (see Table 4) as the second between-groups variable—using a median split, with children who participated in three or more activities in the first group and children who participated in two or fewer cultural activities in the second group. For the most part, there were no significant differences between the language and cultural activity groups, but there were three exceptions. The children in the youngest age group who understood or spoke the Tohono O'odham language had significantly lower Recall Inhibition scores, $t(21) = 3.10$, $p = .005$, $SE = 0.70$, $CI_{95\%} = 0.72, 3.64$, and significantly lower verbal IQ scores, $t(21) = 2.32$, $p = .03$, $SE = 4.13$, $CI_{95\%} = 0.98, 18.17$, on average, than children who did not speak or understand Tohono O'odham. Finally, 10-year-olds who participated in three or more cultural activities had significantly higher verbal IQ scores, on average, than 10-year-olds who participated in two or fewer activities ($M = –1.66$), $t(27) = –2.54$, $p = .02$, $SE = 3.38$, $CI_{95\%} = −15.52, –1.66$. It should be noted that the power to detect significant differences was low because of small sample sizes in each group.

Interrelations Among Age, Gender, SES, Tohono O'odham Language Knowledge, Cultural Participation, Fluid Cognitive Skills, and Verbal IQ Scores

To increase power, all of the statistical tests described here included age and cultural participation as continuous variables. The correlations among all of the variables of interest were examined first (listed in Table 5). To examine the unique sources of variance associated with fluid cognitive skills and verbal IQ scores, a series of models were tested using partial least squares analysis (Chin & Newsted, 1999; Falk & Miller, 1992).

Data-analytic strategy. Partial least squares analysis is recommended for situations in which mediation or moderation effects are suggested, but not significant, with traditional techniques such as analysis of variance (ANOVA) and multiple regression, as partial least squares analysis increases the power to detect these effects by using product indicators that reflect the shared variance of the manifest variables (Chin, Marcolin, & Newsted, 2003). The partial least squares analysis algorithm simultaneously models the structural paths and the measurement paths and allows each indicator to vary in how much it contributes to the latent variable composite score such that indicators with stronger relationships to the related indicators and the latent construct are given higher weightings. Partial least squares is preferable to techniques such as

Table 3
Means (and Standard Deviations) by Age Group and Tohono O'odham Language Knowledge for the Measures of Fluid Cognitive Skills and Verbal IQ

Cognitive test/age (years)	Understands or speaks Tohono O'odham		Does not speak Tohono O'odham	
	M (*SD*)	*n*	*M* (*SD*)	*n*
Reading span				
Ages 7 and 8	6.83 (4.19)	12	7.73 (3.63)	11
Age 9	11.44 (7.47)	9	9.86 (7.93)	14
Age 10	12.94 (5.96)	17	13.00 (6.79)	12
Ages 11 and 12	11.43 (5.93)	14	13.80 (6.00)	10
Digit span				
Ages 7 and 8	3.50 (1.24)	12	4.36 (1.50)	11
Age 9	4.89 (1.45)	9	4.78 (1.19)	14
Age 10	4.82 (1.78)	17	4.50 (1.45)	12
Ages 11 and 12	5.21 (1.48)	14	4.70 (1.77)	10
Stroop inhibition				
Ages 7 and 8	−17.17 (8.48)	12	−17.72 (4.76)	11
Age 9	−15.78 (7.46)	9	−19.21 (4.92)	14
Age 10	−19.41 (6.77)	17	−18.18 (4.40)	11
Ages 11 and 12	−21.43 (10.47)	14	−25.00 (7.07)	10
Recall inhibition				
Ages 7 and 8	2.00 (1.54)	12	4.18** (1.83)	11
Age 9	3.11 (2.80)	9	3.64 (3.45)	14
Age 10	4.47 (2.72)	13	3.92 (2.91)	12
Ages 11 and 12	4.85 (1.46)	14	4.90 (2.18)	10
Verbal IQ				
Ages 7 and 8	87.33 (8.66)	12	96.91* (11.10)	11
Age 9	93.11 (11.35)	9	89.57 (9.23)	14
Age 10	86.59 (9.43)	17	86.08 (10.71)	12
Ages 11 and 12	80.07 (12.55)	14	81.30 (15.36)	10

* $p < .05$. ** $p < .01$.

regression, because it does not assume error free measurement (Lohmöller, as cited in Chin, Marcolin, & Newsted, 2003).

In partial least squares analysis, single indicators can be included when the measurement is simple and direct, as in age or gender. To establish discriminant validity, factor loadings should be above .707 (Chin, 1998). Bootstrap resampling is used to establish the stability of the estimates. The average variance extracted (*AVE*) scores measure the amount of variance that a latent variable component captures from its indicators relative to measurement error and should be higher than .50 (Chin, 1998). After the validity of the latent factors is established, the pathways among the latent variables and the single indicators are estimated by means of ordinary least squares regression. Adequate model fit is demonstrated by high R^2s and standardized path weights of at least .20 and ideally above .30.

Model specification. The factor loadings for each of the measured variables on the latent constructs were examined first. The Stroop inhibition and reading span assessments were dropped as indicators of fluid cognitive skills, as the factor loadings were below the recommend loading of .707. With these two variables dropped, the remaining factor loadings were acceptable (see Table 6 for loadings and cross-loadings). Bootstrapping established the validity of the latent constructs with AVE scores of .85 for verbal IQ, .67 for fluid cognitive skills, and .68 for SES.

Using the steps outlined by Baron and Kenny (1986) a series of models were run to examine possible mediation and moderation effects. First, tests of moderation were conducted by including interaction variables for Age × Cultural Participation (both centered) and Age (centered) × Tohono O'odham language knowledge (coded as 0 = *no language knowledge* and 1 = *some language knowledge or fluent*). The low path weights indicated that the effect of cultural participation on verbal IQ and fluid cognitive skills was not moderated by age. Age was a significant moderator of the effect of Tohono O'odham language knowledge on fluid cognitive skills. Next, a series of models were run to determine whether cultural participation mediated the effect of SES on verbal IQ. SES was significantly related to cultural participation, *pw* = .37, and verbal IQ, *pw* = .23, and cultural participation was significantly related to verbal IQ, *pw* = .29. With all of the pathways included, the pathway between SES and verbal IQ dropped to .16, illustrating that cultural participation played a mediating role in the association between SES and verbal IQ, as this pathway remained significant, *pw* = .20.

The final model with all significant pathways (see Figure 1) revealed that older children had lower standardized verbal IQ scores than younger children, explaining 18% of the variance in verbal IQ scores. Importantly, fluid cognitive skills explained an additional 15% of the variance in verbal IQ scores, with children with better cognitive skills demonstrating higher verbal IQ scores than children with poorer cognitive skills. Cultural participation accounted for the remaining 5% of the variance in verbal IQ scores. Interestingly, cultural participation mediated the effect of SES on standardized verbal IQ scores. High SES was associated with more involvement in cultural activities, and children who

Table 4
Means (and Standard Deviations) by Age Group and Culture With a Median Split for the Measures of Fluid Cognitive Skills and Verbal IQ

Cognitive test/age (years)	3+ Cultural activities		0 to 2 Cultural activities	
	M (*SD*)	*n*	*M* (*SD*)	*n*
Reading span				
Ages 7 and 8	5.14 (3.45)	7	8.19 (3.78)	16
Age 9	8.50 (6.45)	10	12.00 (8.34)	13
Age 10	14.00 (6.91)	12	12.24 (5.75)	17
Ages 11 and 12	8.80 (8.41)	5	13.37 (4.99)	19
Digit span				
Ages 7 and 8	3.43 (0.79)	7	4.12 (1.59)	16
Age 9	4.70 (1.49)	10	4.92 (1.11)	13
Age 10	4.92 (1.31)	12	4.53 (1.84)	17
Ages 11 and 12	5.80 (1.64)	5	4.79 (1.55)	19
Stroop inhibition				
Ages 7 and 8	−17.57 (7.96)	7	−17.37 (6.53)	16
Age 9	−18.10 (5.76)	10	−17.69 (6.61)	13
Age 10	−19.00 (4.71)	12	−18.87 (6.80)	16
Ages 11 and 12	−26.60 (5.37)	5	−21.95 (9.86)	19
Recall inhibition				
Ages 7 and 8	2.57 (2.30)	7	3.25 (1.89)	16
Age 9	3.80 (3.08)	10	3.15 (3.31)	13
Age 10	4.50 (2.84)	12	4.05 (2.77)	17
Ages 11 and 12	4.60 (1.34)	5	4.94 (1.89)	18
Verbal IQ				
Ages 7 and 8	91.57 (15.43)	7	92.06 (8.77)	16
Age 9	93.80 (11.88)	10	88.77 (8.14)	13
Age 10	91.42 (9.61)	12	82.82* (8.47)	17
Ages 11 and 12	83.80 (12.19)	5	79.74 (13.98)	19

* $p < .05$. ** $p < .01$.

participated in more cultural activities had higher standardized verbal IQ scores than children who participated in fewer activities. Tohono O'odham language knowledge was not directly related to verbal IQ, but age significantly moderated the effect of Tohono O'odham language knowledge on fluid cognitive skills, with children who understood or spoke the language, demonstrating that mean scores on the digit span and recall inhibition assessments increased by age group.

Discussion

The results of this study are important not only because it is the first study to examine fluid cognitive skills and verbal ability in Tohono O'odham children in comparison with mainstream samples but also because it is the first study to explore differences in cognitive development in relation to cultural engagement within one ethnic minority community. As noted by García Coll et al.

Table 5
Intercorrelations Among Age, Gender, Income, Guardian Education, Tohono O'odham Language, Cultural Participation, Reading Span, Digit Span, Stroop Inhibition, Recall Inhibition, and Verbal IQ

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Age	—										
2. Gender	.07	—									
3. Income	−.18	.04	—								
4. Guardian education	−.02	−.08	.37*	—							
5. Tohono O'odham language	.13	.07	−.02	.00	—						
6. Cultural participation	−.09	−.08	.23*	.36**	.19	—					
7. Reading span	.31*	.13	−.10	−.09	−.01	−.18	—				
8. Digit span	.24*	.03	.04	.03	.00	.03	.41**	—			
9. Stroop inhibition	−.21*	−.12	.17	.06	.05	.06	−.17	−.14	—		
10. Recall inhibition	.27*	.17	−.13	−.03	−.03	−.05	.25*	.34**	−.33**	—	
11. Verbal IQ	−.36**	.05	.21*	.22*	−.15	.25*	.18	.32**	−.10	.22*	—

* $p < .05$. ** $p < .01$.

Table 6
Final Loadings and Cross-Loadings for Relations Among Verbal IQ Scores, Fluid Cognitive Skills, Cultural Participation, Tohono O'odham Language, Socioeconomic Status, Centered Child Age, and Centered Child Age by Tohono O'odham Language

	Latent variable						
Manifest variable	Verbal IQ	Cognitive skills	Tohono O'odham language	Cultural participation	Socioeconomic status	Age	Age by Tohono O'odham language
Vocabulary	**.91**	.27	−.11	.33	.23	−.28	−.16
Similarities	**.93**	.33	−.08	.13	.20	−.39	−.20
Digit span	.31	**.83**	.01	.03	.04	.24	.30
Recall inhibition	.22	**.80**	−.07	−.05	−.08	.27	.32
Tohono O'odham language	−.10	−.03	**1.00**	.17	.06	.13	.08
Cultural participation	.24	−.01	.17	**1.00**	.37	−.09	−.04
Guardian education	.19	−.003	.03	.36	**.90**	−.02	−.11
Annual Income	.19	−.05	.07	.23	**.73**	−.18	−.12
Centered child age	−.36	.31	.13	−.09	−.09	**1.00**	.78
Centered child age by Tohono O'odham language	−.20	.37	.08	−.04	−.13	.78	**1.00**

Note. Boldface represents the factor loadings of the manifest variables included as indicators of the latent variable; regular typeface represents the cross-loadings of the manifest variables not included as indicators of the latent variable.

(1996), there is a critical shortage of research that examines the normative development of ethnic minority children; moreover, there is a lack of attention to variability within ethnic minority groups. The current study demonstrated that examining age differences in average scores on the cognitive assessments by level of cultural engagement revealed important differences within Tohono O'odham children in their developmental trajectories that would have been obscured if the data had only been explored by looking at the average scores for the group as a whole.

The Tohono O'odham children generally had lower scores than mainstream children on the tests of fluid cognitive skills. However, the pattern of significant differences indicated that the reading span test of working memory capacity might not be the best assessment of fluid cognitive skills in this community, as there were significant differences across all age groups. One possible reason for this result is that the reading span assessment requires the children to read a sentence and generate the last word, which they must then keep in working memory so that they can recall all

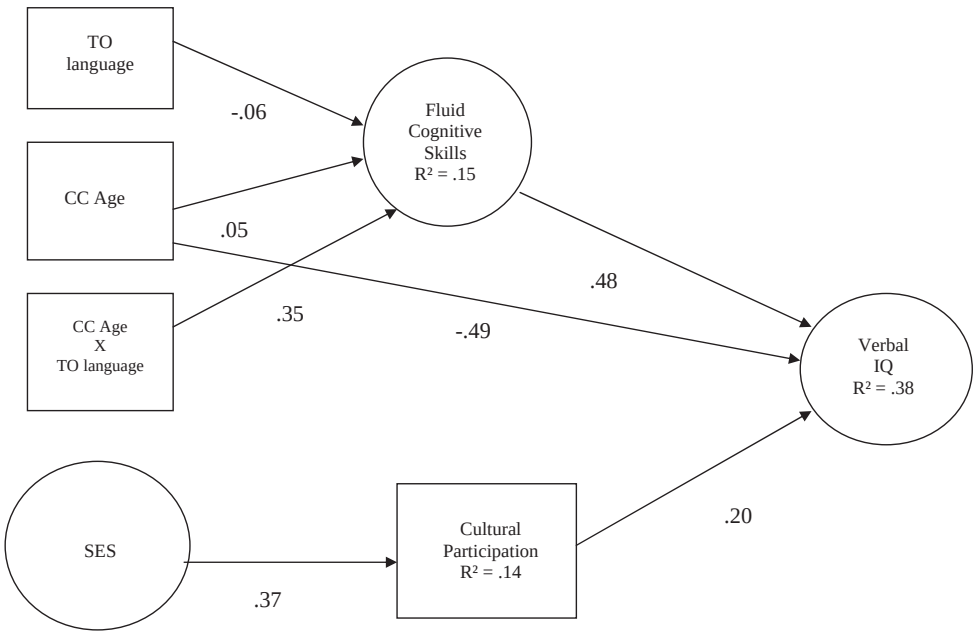

Figure 1. Latent variable path weights and R^2 values for the relations among verbal IQ, fluid cognitive skills, cultural participation, Tohono O'odham Nation language, socioeconomic status (SES), centered child age, and centered child age by TO language. TO language = knowledge of the Tohono O'odham language coded as 0 = no language knowledge and 1 = some language knowledge; CC age = centered child age.

of the words they produced after reading through the set of sentences (set sizes start with two sentences and increase by one, with each successful completion of a series of three sets to a maximum of six sentences). As a result, this test taps into verbal abilities as well as working memory capacity. The other tests of fluid cognitive abilities also rely on verbal skills, but to a much lesser extent. Given that the Tohono O'odham children did not have significantly lower test scores in each age group and even did better than their mainstream peers in one age group on the Stroop task, these assessments are potentially useful as indicators of fluid cognitive development in American Indian and Alaska Native children.

The partial least squares model provided insight into some of the processes that might be underlying differences in fluid cognitive skills and verbal IQ scores in relation to age, SES, and cultural engagement. Guardians with more education and higher incomes participated in more cultural activities with their children, which then predicted higher standardized verbal IQ scores. This result challenges the view that American Indian and Alaska Native cultures are incompatible with education (e.g., Bachtold, 1982; Deyhle, 1992). This is not to say that these earlier reports were in error, as viewing the current results with a transactional framework lends itself to a different interpretation. It could be that current values of the Tohono O'odham people, which stress the importance of education for self-determination and sovereignty (as cited by the Tohono O'odham Nation Education Department, 2004), created a cohort effect in which the current generation of educated parents and guardians modeled these values to their children, making education a meaningful pursuit embedded within cultural activities. In support of this view, a community survey conducted by the Tohono O'odham Nation Education Department (2004) found that higher education levels among members of the community were associated with an increased ability to read and write their tribal language. Such results support the need to view American Indian and Alaska Native communities as actively engaged in organizing and structuring the communities in which they live rather than as static representations of cultures defined ethnographically over a century ago.

It is also possible that engagement in cultural activities provided Tohono O'odham children with a more enriched environment by exposing them to more people with whom to interact, thus contributing to higher verbal IQ scores indirectly through increased social interaction. Given that 10-year-olds who engaged in three or more cultural activities had significantly better verbal IQ scores than the 10-year-olds with low cultural engagement, and the fact that this significant difference was not maintained in next oldest age group, with a corresponding drop in the number of children who were active in three or more cultural activities (from 12 to five), the benefit of increased social interaction seems plausible. Given the potential cognitive benefits of cultural participation, the low percentage (21%) of children who were engaged in three or more cultural activities in the 11- and 12-year-old age group is a concern. Longitudinal research is needed to explore this decline in cultural participation and to more meaningfully examine the ways in which cultural engagement is facilitating verbal development.

The partial least squares model also revealed that age moderated the influence of Tohono O'odham language knowledge on fluid cognitive skills as measured by the digit span and recall inhibition tasks. It is tempting to interpret this finding as showing that children who are growing up with their language have better fluid cognitive skills than do children who are not being exposed to their language, thus conferring a bilingual advantage (e.g., Bialystok, 2010) in this community. However, examination of the means by age group reveals that what is really happening is that children who are exposed to their language start out with lower scores in comparison with the non–Tohono O'odham speakers, but the average scores by age group are sequentially higher for the Tohono O'odham language speakers, whereas the non–Tohono O'odham speakers are not showing any meaningful differences in their average scores by age group. Of course, this interpretation assumes that the children in the older age groups have always been exposed to their language, and longitudinal research is needed to confirm this assumption.

Longitudinal research might also reveal that a bilingual advantage exists, as the higher average mean scores in the older age groups indicate that it could be that over time, children who speak Tohono O'odham, or at least are exposed to their language, will develop significantly better fluid cognitive skills in comparison with children who do not speak Tohono O'odham. The fact that different developmental trajectories existed on the basis of whether Tohono O'odham children were being exposed to their native language is quite interesting. Given the potential for a cognitive advantage over time, the rapid loss of the Tohono O'odham language in the younger generations documented by the Tohono O'odham Nation Education Department (2004) is a matter that must be addressed more aggressively through the efforts of not only the Tohono O'odham community but also through the public school system.

Importantly, children with better fluid cognitive skills had higher verbal IQ scores than children with poorer fluid cognitive skills. Some researchers have suggested that developmental improvements in executive function depend on developmental increases in language ability and cannot be studied separately (e.g., Hughes & Ensor, 2007; Zelazo, 1999). Others have argued that language depends on domain general cognitive processes, such as memory, processing speed, attention, and representational competence (Bloom, 1993; Hollich et al., 2000; Rose, Feldman, & Jankowski, 2009). Although exploratory and not causal, the results presented here might be interpreted as support for language as a domain-general process.

However, it is important to remember that partial least squares modeling assesses the strengths of the relationships between the manifest variables and the latent constructs simultaneously on the basis of the direction of the pathways in the model. Therefore, the path weights might change if the cultural engagement variables were not included in the model. Thus, it must be specifically stated that for the Tohono O'odham children who were exposed to their native language and who were engaged in more cultural activities, increased working memory capacity and better recall inhibition skills were associated with higher verbal IQ scores. This finding provides some support for the view that language development is tied to fluid cognitive processes, at least in this community. This result is of particular significance on account of the fact that the development of language is highly dependent on SES with children who grow up in poverty demonstrating developmental delays in language acquisition (Bigelow, 2006; Hoff, 2003, 2006). When you consider that the modal income reported by the participating

guardians was less than $5,000 in income annually, the implications of this finding become even more meaningful.

That said, the generalizability of the results to other American Indian and Alaska Native communities is not known. However, it is promising that studies examining fluid cognitive skills in many different countries have been consistent in demonstrating that better fluid cognitive skills are related to improved cognitive outcomes (e.g., Aguirre-Pérez et al., 2007; Lee, Ng, & Ng, 2009; Oakhill, Cain, & Bryant, 2003). Thus, it is highly likely that the findings concerning fluid cognitive skills in this community will generalize to children in other American Indian and Alaska Native communities. Moreover, given the robust empirical support for associations between fluid cognitive skills and standardized verbal IQ scores with academic outcomes, the results of this study give some insight into how to improve the educational outcomes of American Indian and Alaska Native children.

Conclusion

In 2004 former President Bush acknowledged the importance of cultural preservation for American Indian and Alaska Native tribes by issuing Executive Order No. 13336, which was designed to assist American Indian and Alaska Native students in meeting the challenging academic standards of the No Child Left Behind Act in a manner consistent with tribal traditions, languages, and cultures (National Indian Education Association, 2008). The results presented here provide some preliminary support for the idea that the maintenance of tribal cultures and the pursuit of higher education can coexist and indeed might even be mutually beneficial of one another. Moreover, these findings suggest that educators in tribal communities should embrace teaching tribal languages and encourage cultural participation in their schools, as both yielded cognitive benefits, but through very different pathways. As such, cultural engagement potentially augments—rather than detracts from—academic achievement.

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