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Trajectories of Cognitive Development among American Indian Young Children

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Abstract

Children who begin kindergarten with stronger skills learn faster than did those who enter with lower skills. Minority children tend to enter kindergarten already at a disadvantage and the gap widens across time. However, little is known about cognitive development among American Indian young children. In this study, 110 American Indian infants from one Northern Plains reservation community were assessed 4 times between ages 6 months through 36 months, using the Mullen Scales of Early Learning. At 6 months of age, scores were near the national norms; a drop occurred between 6 and 15 months. Scores then tended to level off below the norms through 36 months. In each domain, we observed a crucial decline over the first year of life and relatively little change in the second and third years of life, highlighting the importance of developing culturally syntonetic interventions to facilitate cognitive development during the first year of life.

Keywords

Cognitive development; American Indian; trajectories; early childhood

Families, educators, health care professionals, researchers, and policymakers all strive to ensure that infants and toddlers gain skills so that, as they enter kindergarten, they can benefit from the educational system and become competent adolescents and young adults (Black, Hess, & Berenson-Howard, 2000; Duncan et al., 2007; E. L. Marks, Moyer, Roche, & Graham, 2003). Nowhere is the concern with skills development and school readiness more pressing than among ethnic minority children, who have consistently been reported to enter school with cognitive skill levels that lag behind those of White children (Demmert, 2005; A. K. Marks & García Coll, 2007). Using the nationally representative Early Childhood Longitudinal Study data set, Marks and García Coll (A. K. Marks & García Coll, 2007) found that skill levels at kindergarten were strongly related to gains in both reading and mathematics through third grade: Children who began kindergarten with stronger skills learned faster than did those who entered with lower skills. This association was considerably more pronounced among Hispanic, African American, and American Indian children than among White children. Thus, the long-lasting influence of lower skill levels at kindergarten is even more powerful among minority children; they tend to enter kindergarten already at a disadvantage and the gap widens across time.

To truly understand early cognitive development among minority children, however, longitudinal studies are required. García Coll and colleagues (García Coll et al., 1996) noted over a decade ago that longitudinal studies of normative development among ethnic

minority children were scarce; since then, new studies have been launched to fill this gap. However, most of these studies have focused on African American and Hispanic children, while studies of American Indian children remain virtually nonexistent. The limited research available on development among American Indian children has focused on school-aged children, with little or no attention paid to children younger than 5 (Canivez & Bohan, 2006; Pewewardy, 2002). Those studies of older children paint a disturbing situation for American Indian children in public schools, with evidence of higher levels of both internalizing (e.g., depression) and externalizing (e.g., acting-out) problem behaviors; lower achievement test scores; and more problematic educational outcomes such as suspensions and dropping out (Day & Jamieson, 2003; Fisher, Gacon, & Storck, 1998; Germaine, 1996; Manson, Bechtold, Novins, & Beals, 1997; A. K. Marks & García Coll, 2007; Wolfe, Schwartz, & Petersen, 1996).

Two problems attend many developmental studies. First, studies in non-majority ethnic groups have used standardized assessments, such as the Bayley Scales of Infant Development (BSID, Bayley, 1993) or the Mullen Scales of Early Learning (MSEL, Mullen, 1995), that draw on national norms. However, these designs—almost without exception—have relied on cross-sectional data (e.g., Black, et al., 2000; Eisert & Lamorey, 1996; Gagnon & Nagle, 2000; McConachie, LeCouteur, & Honey, 2005; Mirrett, Bailey, Roberts, & Hatton, 2004). Second, in the few instances where repeated measurements have been used, data have usually been analyzed without examining intra-individual change and variation across ages—in effect, treating repeated-measures data as sequential but independent observations (e.g., Harris, Megens, Backman, & Hayes; McConachie, et al., 2005; Mirrett, et al., 2004). Emphasis on these designs arises from the tradition in infant developmental assessment of focusing on the relationship of an individual child to a normative reference sample at specified time points (Deter, Karmel, Gardner, & Flory, 2001). In such assessments, scores are typically adjusted to attempt to eliminate the age effect by creating cross-sectional standards at different ages—that is, standards are derived from different children in each age group. Yet while below-normal *performance* can be documented using such age-specific norms, patterns of problematic *development* require not only measurements of the same children across time but also appropriate analyses created to address issues such as auto-correlation and differing trajectories of development across individuals (Deter, et al., 2001).

Research Question

This study addressed these two concerns of reliance on cross-sectional data and the lack of intra-individual change across ages. Based on longitudinal data and latent growth curve modeling, our research question was what are the shapes of the developmental trajectories of cognitive development among 110 American Indian young children from a Northern Plains reservation community between ages 6 months through 36 months. With a few notable exceptions (e.g., Deter, et al., 2001; Mayes, Cicchetti, Acharyya, & Zhang, 2003), no studies have examined development trajectories of young children in this way.

Method

Sample

This study was funded under the Science and Ecology of Early Development (SEED) initiative, sponsored by the National Institute of Child Health and Human Development, and was approved by the participating tribal council and the university's Institutional Review Board. The sample of infants was recruited from parents who had been participants in two previous studies conducted in a single Northern Plains reservation-based tribe. (In order to protect the confidentiality of the tribal communities involved in this research (Norton &

Manson, 1996), we refer to the tribes using a general descriptor of “Northern Plains” rather than the specific tribal name.) One was a cross-sectional psychiatric epidemiology project conducted with individuals between ages 15 and 54 (Beals, Manson, Mitchell, Spicer, & AI-SUPERPFP Team, 2003). The other project was a seven-year longitudinal study of adolescent development with high school students (Mitchell & Beals, 1997). We focused on these parents so that, in the larger SEED project, we would eventually be able to link child development data with information provided by the parents at earlier points in their lives. For this initial report, though, we concentrated on the data from the SEED child assessments.

Parents with babies born in the two-year window between July 1, 2003 and June 30, 2005 were eligible to participate in this study. A cohort of 733 potential participants was identified. Of this larger group, 102 (14%) individuals could not be located; 123 (17%) did not return to the reservation or the surrounding area at any time during the study; 26 (4%) were ineligible because they were incarcerated; 18 (2%) were deceased; and 5 (1%) chose not to participate. A total of 122 live births (71 females and 51 males) occurred in the remainder of the parent cohort ($n = 459$). In the final sample of mothers at the first wave of data collection, the mean age was 26.3 (range, 19 – 43); 83.6% lived with their spouse or partner; 18.6% were married. The median household income range in the previous year was \$10,000 – \$14,999; 23% had received a degree from an institution of higher education. Of the entire sample, 17% of the infants were born premature, which is consistent with the prematurity rates of American Indians in this state (Dimes, 2007).

Measure

The MSEL measures early cognitive and motor abilities, assessing visual and language abilities at both the receptive and expressive levels (Briggs-Gowan & Carter, 2007; Mullen, 1995). Appropriate for children 0 – 69 months of age, the MSEL consists of one gross motor scale (assessed only up to 34 months) and four cognitive scales (Fine Motor, Visual Reception, Receptive Language, and Expressive Language). A summary score—the Early Learning Composite—based on the four cognitive scales describes overall cognitive development in terms of a standard score (mean = 100, SD = 15).

Using norms by age group, raw scores can be converted to T scores (mean = 50 and SD = 10). In the norming sample, median split-half internal consistency coefficients ranged from .75 – .83 for the scales; the coefficient for the composite was .91. Validity (e.g., comparisons with similar measures such as the Bayley Scales of Infant Development) was reported to be consistent and at satisfactory levels. Although the MSEL has most commonly been used in cross-sectional designs, as noted above, it has also proved appropriate for longitudinal designs as well (e.g., Humphrey, Williams, Pinto, & Bolton, 2004; Jacobs, Miller, & Tirella, 2010; Jeste, Mustafa, Bolton, Ploubidis, & Humphrey, 2008; Landa & Garrett-Mayer, 2006). We chose the MSEL because it purports to measure verbal and non-verbal domains of cognitive development; the possible differential importance of these two aspects in the raising of American Indian children was of specific interest. Because of this interest, we used the individual scales as well as the composite score. Within wave, the scales were correlated, on average, .47, .46, .53, and .58.

Procedure

All data collection was done in the home, following explanation of the study and obtaining informed consent by trained field-based research staff. Recruitment to the study emphasized our interest in learning about the development of young children in the tribal community. The MSEL was administered to 110 children (46 males, 64 females) at four waves, focused on a 3-month window beginning at various target ages: Wave 1, target age of 6 months;

Wave 2, 15 months; Wave 3, 27 months; and Wave 4, 36 months. In all, 3 children had 1 wave of data; 25 had 2 waves; 34 had 3 waves, and 48 had 4 waves (average, 3.1 waves). Table 1 shows target and actual ages and assessment intervals. Parents received \$20 per hour for allowing their children to participate in each data collection.

Community members serving as MSEL assessors were trained by two faculty members who were experienced MSEL assessors, reviewing basic concepts of child development such as infant mental health and fetal alcohol spectrum disorders for each age range of the four waves of data collection. As recommended, MSEL items were taught to standardization level for each age range by having assessors watch the MSEL training video; read, review, and practice items with each other; and administer and score assessments with “practice” children. Assessors also received training on calculating ages and later were provided with an electronic age calculator. When staff changed, this training process was implemented with new staff members as well. Ten interviewers conducted assessments across the four waves; the average number of assessments per interviewer was 41 (range, 2 – 194). Following initial training, the two faculty members reviewed the videos of staff administering the MSEL as they became available, monitoring for compliance with the standard administration procedure and to resolve any issues.

Analyses

We used latent growth curve modeling (LGCM) to examine the trajectories of the MSEL scores from ages 6 months to 36 months. (Although each age represented a three-month window for location and assessment, we refer to the lowest age of each window here.) Recognizing that plots of raw mean scores across time may poorly represent the trajectories of individual people, we elected to study the children’s MSEL scores by LGCM. With typical ordinary least squares (OLS) regression analyses, coefficients that estimate change across time can have unnecessarily large standard error since residuals are often correlated and have unequal variance across time (Singer & Willett, 2003).

Both multilevel (i.e., random effects) modeling and LGCM provide an improvement over more familiar OLS approaches. However, we preferred LGCM because of the ease with which one can explore nonlinear trajectories. Using Mplus Version 5 (Muthén & Muthén, 1998–2007) for the LGCM, we estimated trajectories of the MSEL scores across Waves 1 – 4 (6 months, 15 months, 27 months, and 36 months). Missing data were handled using Full Information Maximum Likelihood (Muthén & Muthén, 1998–2007). The Gross Motor scale is relevant only through 34 months; thus that trajectory covered only Waves 1 – 3. To maintain a linear trajectory across these unequally spaced time points (lapsed times of 9 months, 12 months, and 9 months respectively), we used time scores of 0, 0.75, 1.75, 2.50 (rather than the typical 0, 1, 2, 3 time scores representing equally spaced time periods). The MSEL values were represented by their corresponding *T* scores in the MSEL national normative sample (standard scores for the Early Learning Composite) in order to model changes in the developmental status of the SEED children relative to that among children across the U.S. We initially constrained all parameters to be equal across gender, testing both a linear and a quadratic model. Neither fit well for any MSEL score, with comparative fit indices (CFIs) < .90.

In the face of the consistently unsatisfactory fit, we tested a systematic series of nonlinear models by allowing the time scores for, first, the oldest and, second, the two oldest ages to be estimated freely rather than constrained to fixed values, as usually done in LGCM. Since these models were all nested, we used the χ^2 difference test to compare fit; a statistically significant χ^2 suggested a significant improvement in the fit of the model with the smaller χ^2 . Once the best model was determined, we freed all parameters to be estimated separately by gender and compared that model to the previous model, using the χ^2 difference test. A

significant χ^2 difference here indicated significantly different trajectory parameters for boys and girls. All models discussed here were statistically significant improvements ($p < .05$) over the previously tested models.

It should be noted that an alternative modeling strategy might have been to use piecewise curves, where one set of parameters is estimated for one part of the curve (e.g., 6–15 months) and another set of parameters is estimated for the second part of the curve (e.g., 27–36 months). However, such an approach would require at least 6 data points—3 for each of the 2 curves. With at most 4 data points, we could not estimate such a model.

Results

As noted above, the linear and quadratic models did not fit well for any variable. Three scales (Visual Reception, Fine Motor, and Gross Motor) were linear across all but Wave 4; CFIs were .96, 1.00, and 1.00, respectively (where a CFI of $>.90$ reflects a satisfactory fit). On average, Visual Reception scores (Figure 1) were above the norm at 6 months and at the norm at 15 months; however, by 27 months, scores fell below the norm and remained there at 36 months. Fine Motor (Figure 2) showed a much flatter, although still negative, slope. At both 6 months and 15 months, the infants were near the norm but they fell below the norm at 27 and 36 months. In contrast, Gross Motor scores (Figure 3) were below the norm at all 3 ages, although quite close to the norm at 15 months.

For the ELC (Figure 4), the model with the last two time scores freely estimated fit best (CFI = 1.00). Again, infants at 6 months were at the norm; however, they dropped well below the norm at age 15 months and remained below at subsequent ages. Only two scales (Receptive Language and Expressive Language) had trajectories that differed significantly (using a χ^2 difference test; $p < .05$) by gender, both using models with the final two time scores estimated freely (CFI = .94 and .96). The patterns for these two scales were quite similar, although infants scored near the norm at 6 months for Receptive Language (Figure 5) while they were below the norm at 6 months on Expressive Language (Figure 6). At subsequent ages, boys dropped to approximately one SD below the norm and remained there through 36 months. For girls, a similar drop appeared at 15 months although they evidenced a slight increase in T scores at 27 months, followed by a drop again at 36 months.

In summary, we found that at 6 months, scores were near the national norms—and for Visual Reception, above the norms. However, a drop occurred between 6 and 15 months. Scores then tended to level off below the norms through 36 months. We uncovered few significant differences in trajectories by gender; the exceptions were in receptive and expressive language. For these two constructs, the differences were small, although statistically significant: Girls performed at higher levels than boys did, although still below norms. In each domain, we observed a crucial decline over the first year of life and relatively little change in the second and third years of life.

Discussion

This study is the first report of American Indian early childhood development using a standardized assessment—the MSEL. Very few longitudinal data sets in any population using the MSEL have been reported and such longitudinal data have been nonexistent for American Indian children prior to this study. Examining the four scales separately permitted us to explore possible differential changes in young children's development, although we found the patterns to be quite similar across the scales—performance at 6 months within the range of the norms followed by a drop at age 15 months that was maintained through 36 months.

A growing body of research on children in poverty in the U.S., where formal education is expected, underscores the negative impact that these patterns may have on the kinds of cognitive skills necessary for success in school. A number of longitudinal studies with families in the U.S. have demonstrated a decline in developmental performance among toddlers from low-income families even though few utilized appropriate longitudinal analyses such as LGCM in coming to these conclusions (Black, et al., 2000; Hurt et al., 1995; Hurt et al., 1997; Schuler, Nair, & Harrington, 2003). As we found here, scores have been comparable to national norms during infancy but have fallen below national norms in toddlerhood. This drop is often explained by the different environmental requirements for infants and toddlers. For infants, development may be a bit more physiologically based—more “hard-wired”—where above a certain level of adequacy, most infants develop similarly. For toddlers, however, the environment may begin to play a more important role in enhancing or hindering growth. Differences likely exist in the items at the two ages as well. In the MSEL, the items for infants were more biologically based (e.g., tracking a ball, babbling). For toddlers, though, the environment may exert a greater influence on their performance on the less biologically based items.

Since so little research has been conducted on early childhood development among American Indian children, one has to turn to other settings and ethnicities for a larger context. Evidence drawn primarily from research in urban settings has suggested that toddlers in low-income families have less access to developmentally stimulating environments and therefore may exhibit delays in cognitive development compared to those in higher-income families (Black, et al., 2000). For example, compared with mothers at higher socioeconomic levels, mothers at lower socioeconomic level have been reported to speak to their children less frequently and to do less facilitation of their children’s conversations (Hart & Risley, 1995, 2003; Huttenlocher, Vasilyeva, Waterfall, & Veven, 2007). Often living in more dangerous and stressful environments, low-income parents may use language to prohibit the toddler’s activities more often, rather than using more questions, repetitions, and elaborations of the child’s speech (Black, et al., 2000; Hart & Risley, 1992). When health and subsistence are comfortable realities, parents have the luxury of stressing exploration and self-expression. Where health and survival are more tenuous, parents tend to be more protective of their children’s activities and movements (Gagnon & Nagle, 2000).

Limitations

This study was the first examination of early childhood development among American Indian children and one of only a handful of studies to examine this development using longitudinal data and an analytic approach appropriate for understanding developmental trajectories. However, concerns exist with LGCM analyses here as well. For instance, the norms on which the age-adjusted MSEL *T* scores are based were drawn from discrete groups of children at different ages rather than from repeated assessments of a single group of children across age. As a result, the norms do not necessarily capture the true *patterns* of normative development. Actual developmental trajectories in normal infants simply may not follow the shape of population percentile lines. Until norms are developed by following children through early childhood, the interpretation of developmental trajectories using these normed scores must be done cautiously (Deter, et al., 2001).

Issues can also be raised about the appropriateness of the MSEL norms and the sample on which they were based. For example, while the norm sample of 1,849 included American Indians, American Indians and Asians were combined into an “Other” category. Even combined, though, only 55 children fell into this “Other” category (Mullen, 1995). Despite possible problems with the norms, we relied on *T* scores in order to place our findings within the context of the norming sample. Raw scores were not available for the norming sample; lacking such data, we could say nothing about developmental patterns of our sample

compared to the national sample using the unadjusted scores. In addition, we conducted individual LGCMs for each scale, despite their moderate correlations (average correlation, .51). Since this average correlation indicates a shared variance of .25, the overlap is not dramatic. However, a parallel-process LGCM, where the most highly correlated scales could be modeled together, would provide information on performance on each scale when taking the trajectories of the other scales into account. Our sample was too small for these models to converge; however, this approach would be very informative for future research.

Concerns arise about the design of this study as well. We worked with a relatively modest number ($N = 110$) of children in one American Indian tribe living on a rural reservation. Thus, generalizations to other ethnic groups or even to other tribes can only be made with utmost caution, if at all. Similarly, we cannot generalize the findings here to American Indian children living in more urban settings or to children of young adult American Indian young adults who have moved from their reservation communities—who, in an earlier study, were to be more invested in obtaining higher education and used alcohol to a lesser extent than those who remained on the reservation after high school (Croy, Bezdek, Mitchell, & Spicer, 2009).

This study was not designed to directly address the cultural appropriateness of the MSEL; yet issues with the measure itself must be raised. Due to the complexities of determining internal consistency with scales using basal and ceiling scores (Mullen, 1995), we were unable to directly assess this aspect in this sample. However, two faculty members experienced with training on the MSEL reviewed all tapes and resolved any discrepancies. Furthermore, issues of validity should be considered. The MSEL requires activities that are important for school readiness but that may be less familiar to American Indian toddlers (e.g., doing activities while seated at a table, a strong emphasis on compliance) and thus may have affected their performance in ways reflective of their culture more than of their cognitive development. Additionally, the MSEL may not adequately capture aspects of competence that are most relevant to children in these families (Black, et al., 2000).

Implications

The longitudinal data presented here and analyzed using LGCM help to advance the field by moving beyond simple documentation of cross-sectional group trends in cognitive development in early childhood. Modeling initial status and change across time for individual children better captures patterns of underlying developmental processes and is an important step beyond the more traditional exploration of developmental performance as a series of snapshots at various ages.

The desire for children to do well in school is nearly universal among parents, educators, service providers, and policymakers; this is the case in American Indian communities as in many others. The connection between cognitive development in early childhood and subsequent school readiness has been demonstrated in the literature. Thus, it is critical that we understand both the challenges and the successes of young children.

Although found consistently, it is possible that drops in scores such as we found here might not be considered serious enough to reach the threshold that automatically triggers the provision of services to these children. However, once this drop occurred, it remained in place through 36 months—and possibly beyond. Given others' findings (A. K. Marks & García Coll, 2007), difficulties that accompany minority children as they enter public school systems are likely to only increase. Our findings highlight the importance of developing interventions to facilitate cognitive development beginning during the first year of life among these Northern Plains and possibly other American Indian infants and toddlers. For example, this team has received funding to develop an intervention that provides parents in

this community with opportunities to be more engaged with their children. The continuing challenge will be to work to advance early child development in a variety of ways that both are culturally syntonetic and sensible to parents and families.

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Figure 1.
MSEL Visual Reception scale scores, at ages 6, 15, 27, and 36 months.

Figure 2.
MSEL Fine Motor scale scores, at ages 6, 15, 27, and 36 months.

Figure 3.
MSEL Gross Motor scale scores, at ages 6, 15, and 27months.

Figure 4.
MSEL Early Learning Composite scores, at ages 6, 15, 27, and 36 months.

Figure 5.
MSEL Receptive Language scale scores, at ages 6, 15, 27, and 36 months.

Figure 6.
MSEL Expressive Language scale scores, at ages 6, 15, 27, and 36 months.

Table 1

Age of infants at each wave of data collection and assessment intervals, in months.

Wave	Age in months			Assessment interval in months		
	Actual		Target	Assessment interval in months		Range
	Mean	Range		Mean	Range	
1	6 months	7.8	6 – 11	n.a.		
2	15 months	17.2	15 – 20	9	9.4	4.7 – 12.1
3	27 months	28.8	26.5 – 31.5	12	11.8	9.4 – 15.7
4	36 months	37.5	35.8 – 40.3	9	8.7	5.5 – 11.6