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Structure and continuity of intellectual development in early childhood ☆

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ABSTRACT

We evaluated over 200 participants semiannually from 12 to 48 months of age on measures of intellectual (Bayley Scales, Stanford–Binet Scale) and verbal (MacArthur–Bates Inventory, Peabody Picture Vocabulary Test) status. Structural equation modeling and hierarchical linear (growth curve) analyses were applied to address the nature of development and individual differences during this time. Structural analyses showed a strong and robust simplex model from infancy to the preschool period, with no evidence of qualitative reorganizations or discontinuities. Growth-curve modeling revealed significant associations between level factors across the early and later measures of cognition, providing further evidence of continuity; the growth trajectory from the Bayley through 24 months predicted growth in a nonverbal factor, but not in a verbal factor. Altogether, the findings reveal continuous and stable development in intellectual function from late infancy through the preschool years. Additionally, the high level of continuity demonstrated across these ages was observed to be largely independent of growth in vocabulary.

The study of intellect and its development continues to be a primary focus in the area of psychology (e.g., Bornstein, Slater, Brown, Roberts, & Barrett, 1997; Craik & Bialystock, 2006; Lewis, 1976). The traditional view of early intellectual development (see Bayley, 1940; Honzik, 1976; Hunt, 1967; Hunt & Bayley, 1971) has long championed the view that early measures of developmental status were unrelated to later intelligence. A modified view of this position emerged in the 1970s and 1980s, suggesting that the first two years of life featured periods of discontinuous development due to reorganizations of cognitive function that eventually settled into more stable, mature forms of intelligence (see McCall, 1976, 1983; McCall, Eichhorn, & Hogarty, 1977; McCall, Hogarty, & Hurlburt, 1972; Lewis, 1973).

The view of discontinuity and reorganization was initially challenged during the 1980s and 1990s, with repeated findings showing that discrete indices of attention, memory, and speed of encoding or processing were modestly but significantly correlated with more mature forms of intelligence (see reviews by Bornstein & Sigman, 1986; Colombo, 1993; Colombo & Frick, 1999; McCall, 1994; McCall & Carriger, 1993; McCall & Mash, 1995; Rose, 1989), and were sensitive to other markers or manipulations of cognitive risk (e.g., Jacobson, Jacobson, Sokol, Marter, & Ager, 1993) or benefit (e.g., Colombo et al., 2004a). Initial speculation (e.g., Fagan & Singer, 1983) regarding this phenomenon implied that these early measures might tap into a general intelligence factor that was relatively constant throughout the lifespan. Adoption and twins studies lend support to this speculation by providing support for a genetic influence on general intellectual development (Johnson et al., 2007; Segal, McGuire, Havlena, Gill, & Hershberger, 2007). Subsequent hypotheses emphasized the contribution of multiple and independent information processing components to overall cognitive

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function (Colombo, 1993), and more recent work has elucidated a more heterotypic path, in which developmental cascades of lower-order components contribute to later intellectual function (Bornstein et al., 2006; Rose, Feldman, Jankowski, & Van Rossem, 2005).

Although our understanding of the manner in which cognition during the first year of life contributes to later intelligence has become clearer in recent years, the transition between the first year of life to the preschool period is not as understood as well. Despite the ready availability of standardized tests that are appropriate for the toddler and preschooler (e.g., Lichtenberger, 2005), the development of intellectual function during this period remains relatively understudied (Reznick, Corley, & Robinson, 1997). Furthermore, the available data on the relative continuity and stability of performance on intellectual measures during this period is equivocal. A number of studies and conceptual analyses suggest that the second and third years of life represent periods of major discontinuity and reorganization in cognitive or intellectual function (Birns & Golden, 1972; Dunst & Rheingrover, 1981; Lewis, Jaskir, & Enright, 1986; Roe, 1977); several reports in this category present data supporting qualitative transition(s) at or just before the second year of age (Reznick et al., 1997; McCall et al., 1977; Molfese & Acheson, 1997). Other studies, however, report relatively smooth change with significant prediction from standardized measures of intellectual performance during the second and third years to preschool IQ (Aylward, 2004; Humphreys & Davey, 1988; Ramey, Campbell, & Nicholson, 1973; Siegel, 1981; Wilson, 1983). Findings of good continuity from late infancy through the preschool period appear to be especially robust or frequent in studies of at-risk samples (e.g., Dezoete, MacArthur, & Tuck, 2003; Keogh, Bernheimer, & Guthrie, 1997; Wildin, Smith, Anderson, & Swank, 1997).

There might be some disagreement about the degree of intellectual continuity shown in late infancy and toddlerhood, but proponents from both positions would agree that measures of cognitive and intellectual function tend to become more stable as the preschool period approaches. The mechanisms responsible for this are not well understood; passing references have been made to a more integrated cognitive structure in the second year (Reznick et al., 1997), and events in brain development certainly are consistent with this (see, e.g., Colombo & Cheatham, 2006). Theories (Vygotsky, 1962) have implied, and investigators have otherwise speculated (e.g., Colombo, 1993; Reznick et al., 1997) that the emergence and establishment of language skills in the second year of life drives the improved prediction that one routinely observes from the latter part of infancy into early childhood. Colombo (1993) noted that infant and childhood IQ tests do not correlate until vocabulary becomes a common and relatively dominant feature of each; Reznick et al. (1997) report that the plurality of variance accounted for in both contemporaneous and developmental models predicting Bayley Mental Development Index (MDI) scores during the second year is verbal in nature, and that this increases across the second year.

We were able to capitalize on an extensive database of standardized test measures taken during infancy through the preschool period to evaluate these various issues with respect to early intelligence. A follow-up of the sample of infants recruited for the Kansas Early Cognition Project (Colombo, Shaddy, Richman, Maikranz, & Blaga, 2004b), was conducted using semiannual assessments on the Bayley Scales of Infant Development (2nd Edition; BSID II) and the MacArthur–Bates Communicative Development Inventory (MBCDI) from 12 to 24 months of age, and then the Stanford–Binet (4th Edition; SB4E) and Peabody Picture Vocabulary Test (3rd Edition; PPVT III) from 30 to 48 months of age. This intensive measurement strategy allowed for a more rigorous and comprehensive examination of the nature of intellectual development (e.g., its nature and the degree to which measures are stable) during this understudied period. Furthermore, longitudinal data analytic techniques not available to earlier investigators were applied to address questions about the structural aspects of these measures (e.g., whether language skills cohere with more global developmental measures, and the degree to which continuity is mediated by language), as well as the degree and nature of continuity manifest within intellectual functioning at these ages. Aside from the general interest of our discipline in the nature of the development of intellectual function in early childhood, such analyses expand our current understanding in the context of increased societal emphasis on early childhood and the transition to school age.

1. Method

1.1. Participants

The primary sample consisted of 226 healthy children from the metropolitan and suburban areas of Kansas City, KS (see Colombo et al., 2004b). The recruitment area included cities and towns that featured populations with a relatively diverse range of backgrounds, including upper-middle to lower SES (see demographics reported in Frick, Colombo & Saxon, 1999). The primary sample was Caucasian (91%), but included Asian–American (3%), Hispanic (4%), and African–American (2%) participants in proportion to the population sampled.

1.2. Standardized assessments

At 12, 18, and 24 months of age, children were administered the BSID II (Bayley, 1993) and the MBCDI (Fenson, Dale, Reznick, Bates, Thal & Pethick, 1994). The BSID II is an individually administered scale, which assesses a number of aspects of mental and motor development in children from birth to 42 months of age; from this assessment both motor and mental index scores are derived. For the purpose of the current study only the mental index scores (BSID II MDI) will be utilized in the analyses. The MBCDI is a parent-reported language assessment for children ages 8 to 30 months of age. There are four distinct inventories that comprise the MBCDI: Words and Gestures, Actions and Gestures, Words and Sentences, and Sentences and Grammar; the inventory used is dependent upon the age of the child (i.e., a different inventory was administered at the different ages). The aspect that each inventory in the MBCDI has in common across the 12- to 24-month age range is Words Produced, and because of this commonality, we used this score for the MBCDI measurement in the current study.

At 30, 36, 42, and 48 months of age children were administered the SB4E (Thorndike, Hagen, & Sattler, 1986) and the PPVT III (Dunn, Dunn, Williams, & Wang, 1997). The SB4E is an individually administered cognitive scale for children aged 2 through adulthood. The SB4E provides composite scores for both general intelligence and modular factors. The factors (i.e., subscales) are Verbal Reasoning, Abstract-Visual Reasoning, Quantitative Reasoning, and Short-Term Memory. These factors are further divided into 15 subtests; however, not all subtests are administered at each age. For the 30- to 48-month age group, the subtests that are administered for the Verbal Reasoning factor are Vocabulary, Comprehension, and Absurdities, for the Abstract-Visual Reasoning factor the subtests are Pattern Analysis and Copying, for the Quantitative Factor the subtest is Quantitative, and for the Short-Term Memory factor the subtests are Bead Memory and Memory for Sentences. The PPVT III is an individually administered receptive language measure that provides one total score. Preliminary analyses of the structure of these subscales revealed two factors: (a) a Verbal factor consisting of the PPVT III scores and the SB4E subscales of Vocabulary, Comprehension, Absurdities, and Memory for sentences and (b) a Nonverbal factor consisting of the SB4E subscales of Pattern Analysis, Copying, Quantitative, and Bead memory.

1.3. Procedure

Children were assessed longitudinally at 6-month intervals beginning at 12 months of age and continuing through 48 months of age, typically within one week (plus or minus) of their semiannual "birthday." At each 12- to 24-month testing session, we administered the BSID II, and parents were asked to complete the MBCDI. Between 30 to 48 months, we administered both the SB4E and PPVT III according to standardization instructions specified in the manuals. After each session, tests were scored and the results were mailed to the parents. Previous research (Haskins, 1978) indicates that repeated testing on the Bayley and Stanford–Binet does not influence performance on the scales.

For the current analyses, we used the BSID II MDI and the raw MBCDI Words Produced score to reflect Early Cognition for the 12- to 24-month range, and the SB4E subtest raw scores and PPVT III total raw scores to represent two constructs of intellectual functioning (Verbal and Nonverbal) across the 30- to 48-month range. Because these variables are on different scales, we performed a longitudinal standardization ($M=10$, SD = 1) across both the 12-, 18-, and 24-month assessments as well as across the 30-, 36-, 42-, and 48-month assessments. This monotonic transformation allowed us to create unit-weighted construct scores for the growth models that are not biased by differences in variances and yet retain the information about mean-level changes over time; it also facilitated convergence in the SEM models. The longitudinally standardized means and standard deviations at each assessment are presented in Table 1.

As is typical in longitudinal studies, not all children had scores for all assessments at each age. We imputed missing data using a single EM imputation with the MCMC algorithm (Proc MI; www.sas.com) rather than use FIML estimation because we wanted to include a number of additional variables on the data set to inform the missing data estimation process. To ensure coverage across the early to late period, we imputed only for subjects who provided at least one assessment during the early period (12–24 months) and one assessment during the later period (30–48 months). With this constraint, 166 participants were included in the analysis. A total of 12.1% of the data points were imputed, which is a reasonable amount for longitudinal studies (Hofer & Hoffman, 2007). Using the LISREL software package (version 8.72; www.ssicentral.com), we conducted a longitudinal confirmatory factor analysis to evaluate the measurement invariance and latent structure of the constructs across the 12- to 48-month interval. We also fit a longitudinal SEM model that specified only auto-regressive relations to examine the stability across time. We then fit latent growth curve models to examine the dynamic relations among the levels and rates of change in each construct. All models were evaluated for fit using the Root Mean Squared Error of Approximation (RMSEA), for which values of about 0.08 and less are deemed acceptable, and both the Non-Normed Fit Index (NNFI) and the Comparative Fit Index (CFI), for which values of about 0.90 and greater are deemed acceptable.

Table 1
Mean, standard deviation, skewness, and kurtosis of each study constructs

Variable	Mean	SD	Skew	Kurtosis	r_{xx}
Early Cognition 12	9.52	0.41	−0.30	−0.62	0.27
Early Cognition 18	9.86	0.66	0.08	1.15	0.58
Early Cognition 24	10.62	0.94	−0.27	−0.17	0.67
Verbal Composite 30	8.96	0.48	0.19	1.09	0.81
Verbal Composite 36	9.75	0.60	−0.27	−0.04	0.83
Verbal Composite 42	10.43	0.54	−0.57	0.38	0.84
Verbal Composite 48	10.86	0.45	−0.66	1.55	0.74
Nonverbal Composite 30	9.12	0.34	0.41	0.63	0.63
Nonverbal Composite 36	9.79	0.42	0.26	0.27	0.60
Nonverbal Composite 42	10.23	0.53	0.63	1.72	0.56
Nonverbal Composite 48	10.86	0.70	0.51	0.99	0.64

Note. Variables were standardized longitudinally to have a mean of 10 and a standard deviation of 1. r_{xx} is the internal consistency reliability estimate. In the SEM analyses, the variance of a latent construct is determined by the common variance among the indicators of the construct and thereby corrects the latent relationships for the degree of unreliability reflected here.

2. Results

2.1. Confirmatory factor analysis (CFA)

Our first analytic goal was to fit a longitudinal CFA across ages for all constructs. The observed variables of BSID II MDI and MBCDI Word Production loaded on the latent construct of Early Cognition (measured at 12, 18, and 24 months). The scores from the PPVT III and four subtests of the SB4E (Vocabulary, Comprehension, Absurdities, and Memory for sentences) loaded on the Verbal construct and the remaining four subtests of the SB4E (Bead Memory, Pattern Analysis, Copying, and Quantitative) loaded on the Non-Verbal construct (measured at 30, 36, 42 and 48 months). With 42 indicators of 11 constructs, we specified loading invariance across time and allowed the specific component of each indicator to correlate with itself at each measurement occasion (see Little, Preacher, Selig, & Card, 2007). This model fits the data very well ($\chi^2_{(727,\ n=166)}=1102.6$; RMSEA = $0.049_{(.042|.056)}$; NNFI = 0.965; CFI = 0.970); however, the modification indices and residuals indicated that the MBCDI production scale was not invariant due to the very low levels of variability on the scale at 12 months relative to its variances at 18 and 24 months. We allowed this loading to vary freely and model fit improved ($\chi^2_{(726,\ n=166)}=1078.1$; RMSEA = $0.048_{(.040|.055)}$; NNFI = 0.967; CFI = 0.972). Table 2

Table 2
Loadings, standard errors, and communality from the longitudinal CFA

Variable	Construct	Loading information			Residual information		
		Estimate	SE	Standardized	Estimate	SE	h^2
MBCDI Production	Early Cognition 12	0.03	0.01	0.21	0.01	0.00	0.05
BSID II MDI	Early Cognition 12	0.75	0.15	0.95	0.07	0.22	0.90
MBCDI Production	Early Cognition 18	0.18	0.05	0.44	0.19	0.02	0.19
BSID II MDI	Early Cognition 18	0.75	0.15	0.89	0.21	0.45	0.80
MBCDI Production	Early Cognition 24	0.18	0.05	0.24	1.02	0.11	0.06
BSID II MDI	Early Cognition 24	0.75	0.15	1.00	0.00	0.29	1.00
Vocabulary	Verbal 30	0.41	0.04	0.53	0.44	0.05	0.28
Comprehension	Verbal 30	0.38	0.03	0.78	0.09	0.01	0.60
Absurdities	Verbal 30	0.35	0.03	0.71	0.13	0.02	0.50
PPVT III	Verbal 30	0.45	0.04	0.69	0.22	0.03	0.48
Memory For Sentences	Verbal 30	0.43	0.04	0.58	0.37	0.04	0.34
Bead Memory	Nonverbal 30	0.24	0.03	0.41	0.29	0.03	0.17
Pattern Analysis	Nonverbal 30	0.28	0.03	0.52	0.21	0.03	0.27
Copying	Nonverbal 30	0.22	0.03	0.61	0.08	0.01	0.38
Quantitative	Nonverbal 30	0.25	0.03	0.55	0.14	0.02	0.31
Vocabulary	Verbal 36	0.41	0.04	0.66	0.36	0.04	0.43
Comprehension	Verbal 36	0.38	0.03	0.65	0.31	0.04	0.43
Absurdities	Verbal 36	0.35	0.03	0.60	0.37	0.04	0.36
PPVT III	Verbal 36	0.45	0.04	0.78	0.22	0.03	0.60
Memory For Sentences	Verbal 36	0.43	0.04	0.71	0.29	0.04	0.51
Bead Memory	Nonverbal 36	0.24	0.03	0.43	0.48	0.06	0.18
Pattern Analysis	Nonverbal 36	0.28	0.03	0.58	0.28	0.04	0.34
Copying	Nonverbal 36	0.22	0.03	0.56	0.19	0.02	0.32
Quantitative	Nonverbal 36	0.25	0.03	0.56	0.23	0.03	0.32
Vocabulary	Verbal 42	0.41	0.04	0.71	0.23	0.03	0.50
Comprehension	Verbal 42	0.38	0.03	0.63	0.30	0.04	0.40
Absurdities	Verbal 42	0.35	0.03	0.68	0.20	0.02	0.47
PPVT III	Verbal 42	0.45	0.04	0.75	0.22	0.03	0.56
Memory For Sentences	Verbal 42	0.43	0.04	0.75	0.31	0.03	0.56
Bead Memory	Nonverbal 42	0.24	0.03	0.39	0.66	0.08	0.15
Pattern Analysis	Nonverbal 42	0.28	0.03	0.53	0.41	0.05	0.28
Copying	Nonverbal 42	0.22	0.03	0.32	0.85	0.10	0.10
Quantitative	Nonverbal 42	0.25	0.03	0.47	0.42	0.05	0.22
Vocabulary	Verbal 48	0.41	0.04	0.56	0.34	0.04	0.31
Comprehension	Verbal 48	0.38	0.03	0.56	0.28	0.03	0.32
Absurdities	Verbal 48	0.35	0.03	0.61	0.19	0.02	0.38
PPVT III	Verbal 48	0.45	0.04	0.64	0.26	0.03	0.41
Memory For Sentences	Verbal 48	0.43	0.04	0.63	0.27	0.03	0.39
Bead Memory	Nonverbal 48	0.24	0.03	0.48	0.93	0.11	0.23
Pattern Analysis	Nonverbal 48	0.28	0.03	0.62	0.62	0.08	0.38
Copying	Nonverbal 48	0.22	0.03	0.49	0.74	0.09	0.24
Quantitative	Nonverbal 48	0.25	0.03	0.61	0.50	0.07	0.37

displays the summary of the measurement parameters from this best-fitting CFA.

Although this CFA sets the stage for the structural and growth curve analyses that follow, it is instructive in its own right. First, it provides information regarding the coherence of early cognition (as indicated by the BSID II MDI and the MBCDI Word Production measure). Essentially, verbal production, as indicated by the MBCDI Word Production, did not cohere with BSID II MDI performance during the second year of life. This finding was surprising, because the BSID II MDI includes a number of language-based items, although not a comprehensive measure of production. The finding that MBCDI Word Production was not strongly related to the MDI scores from the BSID II suggests that either the word production measure is not a sensitive gauge of language or that individual differences in performance on the BSID II MDI are not driven or dominated by language growth during the second year.

Second, the CFA strongly confirmed the presence of Verbal and Nonverbal constructs derived from the preschool tests beginning as early as 30 months of age, and continuing through to 48 months. To our knowledge, this is the first structural confirmation of intellectual function at these early ages, and certainly represents the first application of the CFA approach to these kinds of data in the realm of developmental science. The magnitudes of the loadings (Table 2) are generally lower than comparable loadings at older ages, suggesting that verbal and nonverbal cognition are less reliably measured at these early ages than they are at older ages. However, the measurement invariant loadings clearly support the validity of these two constructs.

2.2. Structural analysis

Given the acceptable fit of the CFA model, we conducted a longitudinal structural analysis to examine the ability of the measures taken during early childhood to predict later standardized measures of intellectual functioning. For this model, we specified only between time (auto-regressive) pathways. Because of the very high stability between the three early cognition constructs, we equated the unstandardized paths between

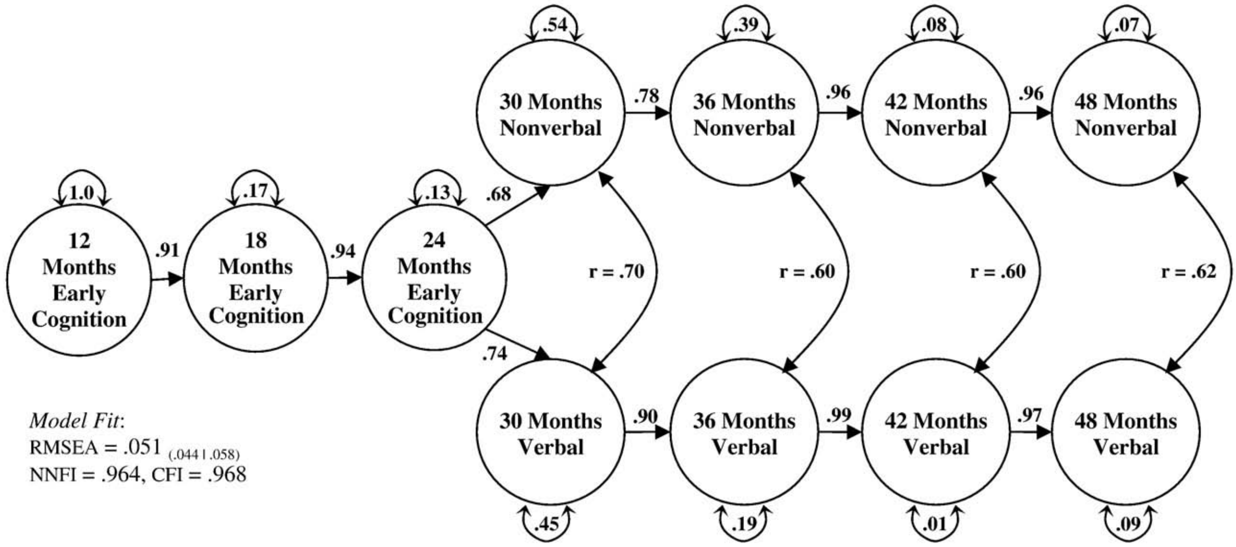

Fig. 1. Traditional longitudinal SEM model of the stability in individual differences of intellectual functioning.

12 to 18 and 18 to 24 months. The final structural model also had a very good fit ($\chi^2_{(767,\ n=166)}=1166.7$; RMSEA $=0.051_{(.044|.058)}$; NNFI = 0.965, CFI = 0.968). The standardized parameters are depicted in Fig. 1. In this figure, the coefficients are roughly interpretable as standardized regression coefficients (as in traditional regression analysis). The variance explained in the constructs would be 1 minus the residual variance depicted in Fig. 1 for each construct. As shown in Fig. 1, all of the direct longitudinal relations were quite strong. These are disattentuated effects given the levels of reliable variance among the indicators, and thus may appear higher than typically reported in the literature; however, these effects are accurate estimates of the true population values (see Little, Lindenberger, & Nesselroade, 1999). In terms of the indirect pathways implied in this model, even the indirect effect of Early Cognition at 12 months had a significant relation to both constructs representing intellective function at 48 months. Specifically, early cognition at 12 months had a standardized indirect effect of 0.55 ($z=4.17$, $p<0.01$) on Verbal 48 and a 0.42 ($z=3.65$, $p<0.01$) on Nonverbal 48.

The findings from the structural model connote strong continuity across the entire period of measurement. In keeping with Humphreys and Davey (1988), we saw clear and elegant evidence of a true simplex process (i.e., the simplex model only holds under conditions of steady and consistent change processes over the time span measured). While we generally expected continuity in the constructs measured with the same instruments, even the transition from the BSID II MDI factor to the later factors derived from the SB4E and PPVT was surprisingly smooth and robust, with little evidence of any discontinuity.

2.3. Latent growth curve analysis

We also examined the structural relations among these constructs by way of growth curve analysis. In addition to providing another means of examining the continuity of the level of performance across ages, this approach also assesses the continuity of the developmental trajectory across the age intervals in terms of intra-individual change relations.

For this analysis, we simultaneously specified three level and shape growth curves and examined the structural relations among the three intercept (or level) constructs and the three change (or shape) constructs (see Little, Bovaird, & Slegers, 2006). Because the MBCDI production measure showed very low levels of communality with the Early Cognition factor (see Table 2), we chose to remove it as an indicator and to represent the early cognitive capabilities of these children using only the BSID II MDI.[1] For the Verbal and Nonverbal factors, we constructed unit-weighted factor scores for use in the growth curve model. These analyses assess the degree to which the level and shape of change in early intellect correspondingly predicts the level and shape of change in later intellectual functioning. That is, we used the intercept and change constructs representing the BSID II MDI to predict the intercept and change information in both verbal and nonverbal factors derived from the SB4E and PPVT III.

The initial level and shape model with all constructs allowed to correlate revealed a significant residual correlation between the Nonverbal 36 and Nonverbal 42 indicators. After allowing this intercorrelation, the model fit was adequate ($\chi^2_{(37,\ n=166)}=115.4$; RMSEA $=0.093_{(.069|.118)}$; NNFI = 0.947; CFI = 0.960). When estimating the predictive relations among the constructs, we estimated the covariance between the level and shape of early cognition and used these constructs to predict the level and shape of the Verbal and Nonverbal constructs. As shown in Fig. 2, non-significant parameters among the latent constructs were removed. The final model for this analysis had a good fit ($\chi^2_{(48,\ n=166)}=132.8$; RMSEA $=0.088_{(.066|.110)}$; NNFI = 0.956; CFI = 0.962). The raw and estimated (i.e., model implied) means and the variance explained in each indicator are presented in Table 3.

[1] We note here that the results were minimally different when we used the combined BSID II and MBCDI factor scores. Thus, the MBCDI added little to the robustness of the model.

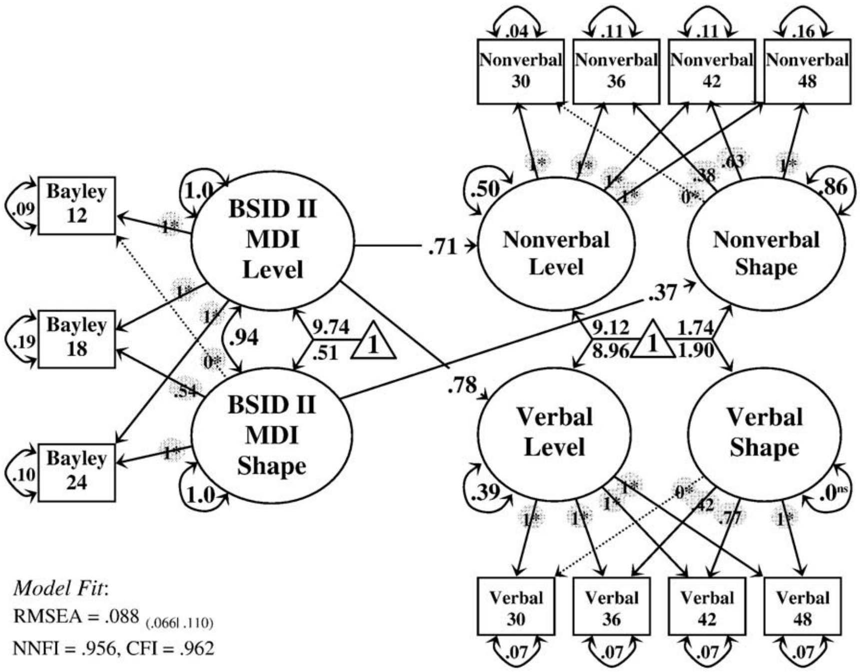

Fig. 2. Multivariate growth curve models relating early and later intellectual development.

As seen in Fig. 2, the high degree of stability in cognitive and intellectual functioning is found mostly in the relationships among the level factors. However, the rate of change in early cognition was also positively related to the rate of change in the Nonverbal factor. This pattern of dynamic influence suggests that young children who make more rapid gains in early cognition also show more rapid growth in the Nonverbal factor across the early childhood years; this pattern was not evidenced for the Verbal factor. For the Verbal factor, mean levels did change over time, but there was no significant variability in the rates of change (consistent with the higher levels of stability for this construct depicted in Fig. 1). Here, the individual differences in the intra-individual change patterns for verbal ability are restricted to the initial levels of verbal ability measured at 30 months of age.

Table 3
Raw and estimated means and variance explained by the Level and Shape Growth Curve Factors

Variable	Raw mean	Estimated mean	r^2
BSID II MDI 12	9.75	9.74	0.45
BSID II MDI 18	9.98	10.01	0.53
BSID II MDI 24	10.27	10.25	0.68
Verbal Composite 30	8.96	8.96	0.75
Verbal Composite 36	9.75	9.76	0.75
Verbal Composite 42	10.43	10.42	0.75
Verbal Composite 48	10.86	10.86	0.74
Nonverbal Composite 30	9.12	9.12	0.60
Nonverbal Composite 36	9.79	9.78	0.50
Nonverbal Composite 42	10.23	10.22	0.60
Nonverbal Composite 48	10.86	10.86	0.63

Note. Variables were standardized longitudinally to have a mean of 10 and a standard deviation of 1.

3. Discussion

The current analyses provide a rigorous and summary examination of this rich and extensive database. The fundamental message to emerge from this endeavor is that intellectual function shows striking continuity from 12 through 48 months of age. Like infancy, the period from toddlerhood through preschool age has been suspected to be a period of discontinuity and reorganization. Although a careful look at the extant data provide some hints that continuity exists, both the structural analyses and the level analyses from growth curve modeling reported in this paper show clear and strong evidence of continuity within and between instruments. The transition from the BSID II MDI to the factors gleaned from the SB4E and the PPVT III shows no evidence of tumult or reorganization, and the findings are quite consistent with the conclusions of Humphreys and Davey (1988) in their first examination of this age period nearly two decades ago; a simplex model featuring a high level of continuity is quite adequate to describe intellectual development from the end of infancy forward.

A second finding of interest from the growth curve modeling is that the trajectory of change for the early-cognition factor computed from the BSID II MDI during the second year is related to growth in nonverbal – but not verbal – abilities during the second and third years. Thus, the trajectory of growth in the MDI is predictive of the trajectory of nonverbal skills during the preschool period. We would reiterate here that the MDI level of performance during year 2 was highly predictive of the level of performance in both Verbal and Nonverbal factors in years 3 and 4.

A final contribution of the current data set is the observation that early vocabulary production (as measured by the MBCDI), did not cohere strongly with the early cognition factor during the second year, and contributed relatively little to the continuity that we observed here. We very much suspected that early vocabulary growth during the second year would carry much of the continuity we expected to see in the preschool period, but this was not the case. This finding implies that early expressive word acquisition is not the sole factor, and is probably not the predominant factor, in driving the development of intellectual function in the second year of life (see also Reznick et al., 1997), Indeed, even though the structural model shows significant prediction of the verbal factor in the 3rd and 4th years of life, the latter two findings together imply the stable and continuous emergence of an intellectual skill set that is relatively independent of these early individual differences in expressive vocabulary. These findings do not detract in any way from the probable importance of early language in cognitive development. However, it has long been suspected that the emergence of continuity on mental tests (like the BSID) during the period of later infancy and early toddlerhood has been largely attributable to the emergence of productive vocabulary, particularly the vocabulary "burst" during the second year (Colombo, 1993). The emphasis on vocabulary during this time is reflected in the shifting of items on most infant tests at and shortly after the first birthday to represent it fully in the assessment domains. Not coincidentally, that is when age-to-age correlations for infant tests and the predictive validity of infant tests to later childhood (McCall, 1979, 1983) show dramatic improvement. Thus, we presumed that we would find some reorganization and discontinuity in these models, and that this discontinuity would be resolved by the emergence of vocabulary. These observed models, however, instead show considerable stability in individual scores from the earliest ages tested that are apparently independent of the contribution of early vocabulary growth.

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