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Parent–Infant Resemblance for General and Specific Cognitive Abilities in the Colorado Adoption Project*

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Previous publications emanating from the Colorado Adoption Project have reported significant relationships between parental general cognitive ability (*g*) and infant Bayley MDI scores. The present study compared infant Bayley factor scores representing separable dimensions of infant cognition with parental general and specific cognitive abilities for 182 adoptive families and 164 nonadoptive families. Parent/offspring correlations between 12-month Bayley factors and parental cognitive abilities suggest only minimal relationships for both parental *g* and specific abilities. At 24 months, more parent/offspring resemblance was present; moreover, Bayley factors that were related to parental cognition tended to be related to parental *g*, not to specific abilities. The finding of significant parent/offspring relationships at 24 months between biological parents and their adopted-away infants, as well as between nonadoptive parents and their infants, suggests some genetic continuity from infancy to adulthood.

INTRODUCTION

Explication of the nature of intelligence must consider both general cognitive ability (*g*) and specific cognitive abilities. Behavioral geneticists studying cognition have focused on *g* in the past but are currently incorporating specific cognitive abilities into their research designs (DeFries, Vandenberg, & McClearn, 1976; Scarr & Carter-Saltzman, 1983). Lagging behind, however, is the examination of specific cognitive abilities in infants. This delay can be partially attributed to the difficulty of measuring specific abilities in infants, given the many constraints inherent in infant testing, as well as a disagreement concerning the nature of infant intelligence. Some researchers believe that abilities measured

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during infancy change from age to age, thus making it difficult to obtain a measure of *g* (McCall, Hogarty, & Hurlburt, 1972). Others believe that infant intelligence can be measured as *g* and is predictive of general cognitive ability later in life (Fagan & McGrath, 1981). Still others feel that infant intelligence can best be characterized as a set of separable dimensions which go through transformations but remain somewhat related from age to age (Lewis, 1983).

An earlier report in this journal (DeFries, Plomin, Vandenberg, & Kuse, 1981) based on the Colorado Adoption Project indicated significant resemblance between Bayley Mental Development Index (MDI) scores of 12-month-old infants and general cognitive ability of their parents. This relationship was found for adoptive parents and their adopted children, biological parents and their adopted-way children, and nonadoptive parents and their children. This finding suggests that both heredity and common family environmental influences contribute to observed parent/offspring resemblance for infant Bayley MDI and parental general cognitive ability. No systematic pattern of parent/offspring resemblance emerged in comparisons between infants' Bayley MDI Scores and their parents' specific cognitive abilities. Similar results were found at 24 months (Plomin & DeFries, 1983). A subsequent analysis of Bayley items using the same Colorado Adoption Project sample suggested that those Bayley items which are related to parental cognitive ability are predictive of *g* but not of specific cognitive abilities (Rice, Plomin, & DeFries, 1984).

Before the nature of infant intelligence in relation to adult *g* and adult specific abilities can be further understood, measures of specific cognitive abilities in infants are needed. Short of designing a new test battery, there are limited alternatives for reaching this goal. One alternative involves factor analyzing items from an extant infant intelligence test such as the Bayley. Previous attempts at factor analyzing the Bayley, however, have failed to gain widespread use and acceptance (Stott & Ball, 1965). The fact that item dependencies influence the factor structure has been one obstacle inhibiting the construction of reasonable factors. Recently, Michael Lewis and Mary K. Enright (Lewis, 1983) applied to the Bayley items a factor analytic procedure involving an oblique rotation solution which controls for item dependencies. Reasonable and interpretable factors emerged from their analysis.

The present study compared infant specific cognitive abilities as measured by the Lewis–Enright Bayley factors to specific cognitive abilities and *g* in biological, adoptive, and control parents of the infants. A relationship between Lewis–Enright Bayley factors for adopted and nonadopted infants and parental specific cognitive abilities would indicate that these factors are tapping abilities present during infancy that are related to specific cognitive abilities in adulthood. More specifically, correlations between nonadoptive parents and their infants would suggest familial influence mediated genetically or environmentally; correlations between adoptive parents and their adopted infants would suggest the influence of family environment; and correlations between biological parents and their adopted-away infants would suggest genetic influence.

METHODS

The Colorado Adoption Project (CAP) is a longitudinal study of genetic and environmental influences on individual differences in behavioral development. A full adoption design is employed and allows the examination of genetic and environmental effects. Children and their parents in nonadoptive families share both genes and environment, whereas adopted children share only genes with their biological parents and only family environment with their adoptive parents. Therefore, in the absence of selective placement, relationships found between adopted children and their biological parents can be attributed to genetic effects and relationships between adopted children and their adoptive parents can be traced to the effect of family environment. Nonadoptive families can provide replication of these genetic and environmental effects.

Biological and adoptive parents are contacted through two Denver adoption agencies. Adoptive mothers and fathers, biological mothers, and about 20% of the biological fathers have participated. The CAP sample consists of 182 adoptive families and 164 nonadoptive (control) families. Control families are from the Denver metropolitan area and are matched to the adoptive families on the basis of sex of child, total number of children in the family, father's age, occupational status of the father, and the number of years of the father's education. Details about these procedures have been reported by DeFries et al. (1981). The CAP sample appears to be representative of the Denver area, and selective placement is negligible (Plomin & DeFries, 1983).

Parent Measures

Each parent participating in the study is administered a 3½- hour test battery which includes 16 tests of specific cognitive abilities. The 13 scores derived from these tests yield four rotated factors: Spatial Ability, Verbal Ability, Perceptual Speed, and Memory. The first unrotated principal component is used as a measure of general cognitive ability, or *g*. The median test–retest reliability for the 13 scores is .80. For details, see DeFries et al. (1981).

When comparing the infant Bayley clusters to parental general and specific cognitive abilities, it is important that the reliabilities of the parental first principal component score and specific factor scores be comparable. Although these reliabilities have not been calculated for the CAP sample, data from the Hawaii Family Study of Cognition (HFSC), which utilized the same adult cognitive test battery, address this issue. Kuse (1977) reports that reliabilities are similar for the first principal component and for the Spatial, Verbal, and Perceptual-Speed factors—.87, .84, .83, and .86, respectively. The reliability of the Memory factor is slightly lower at .60. Thus, data from the HFSC indicate that the reliabilities of the first principal component score and specific factor scores are sufficiently similar and will not differentially influence results obtained in parent/offspring comparisons.

Infant Measures

The adopted and control children in the CAP are tested in their homes by trained testers. The Bayley Scales of Infant Development (Bayley, 1969) are administered as part of 2-hour home visits at 12 and at 24 months of age.

To go beyond the general Bayley MDI score and examine infant specific cognitive abilities, a factor structure developed by Michael Lewis and Mary K. Enright (Lewis, 1983; Lewis & Enright, 1982) was utilized. Because many of the Bayley items are dependent upon each other, Lewis and Enright used a resistant-fitting technique which involves oblique factor rotation and controls for item dependencies. At 12 months, three factors emerged—Means-End, Imitation, and Verbal Skill; at 24 months, there were four factors—Spatial, Lexical, Verbal, and Imitation. The Bayley clusters used in the present analysis were constructed using unit weights based on the Lewis–Enright factor analysis and summing the items in each cluster. Parent/offspring correlations were calculated between each of the Lewis-Enright clusters at 12 and 24 months and the CAP parental general and specific cognitive ability scores for the biological, adoptive, and control parents and the adopted and control children.

Before a decision was made to use the Lewis–Enright Bayley clusters, a principal component analysis was performed on the CAP data. The resulting factor structure was similar to the structure obtained by Lewis and Enright for both ages, with three factors for the 12-month Bayley and four factors for the 24-month Bayley. If the use of the Bayley clusters is to be informative and comparable across studies, it is important to arrive at a generally acceptable approach for grouping the Bayley items. Therefore, the decision was made to construct Bayley clusters in accordance with the factors obtained by Lewis and Enright.

RESULTS

Table 1 presents correlations of control parent general and specific cognitive abilities with control infant scores on Lewis–Enright factors derived from the Bayley items and with the Bayley MDI.[1] We begin with the control families, who share both heredity and family environment with their offspring, because analyses of these data are most likely to detect parent/offspring correlations. The present sample size yields 80% power to detect parent/offspring correlations of .20 or higher; correlations of .10 can be detected with 33% power (Cohen,

[1]Full intercorrelation tables for both control and adoptive families are available from the authors upon request.

TABLE 1

Correlations of Control Parent General and Specific Cognitive Abilities with Control Infant Bayley Factors and the Bayley MDI

	Parental Cognitive Abilities									
	General		Spatial		Verbal		Perceptual Speed		Memory	
Bayley Factors	Mother	Father	Mother	Father	Mother	Father	Mother	Father	Mother	Father
12 Months										
Means–End	.05	.13*	.03	.03	.00	.04	−.03	.06	.17*	.18*
Imitation	.03	.06	.06	.06	.03	.03	−.10	−.03	.12	.08
Verbal Skill	.01	.07	.11	.08	.10	−.01	−.16*	.05	−.09	.01
24 Months										
Spatial	.23*	.14*	.24*	.07	.14*	.00	.00	−.15*	−.03	.08
Lexical	.12	.17*	.08	.01	.04	.10	.14*	.24**	−.13	−.08
Verbal	.07	.11	.08	.03	.07	.02	.00	.18*	−.04	−.06
Imitation	.21*	.03	.13*	−.09	.05	−.05	.15*	.12	.03	.14*
12-Month MDI	.04	.09	.09	.05	.05	−.03	.06	−.09	−.02	.14*
24-Month MDI	.22**	.21**	.22**	.06	.10	.09	.05	.19**	−.05	.09

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

1977). Familial influences suggested by control parent/offspring correlations can be attributed to genetic factors, if the correlations are replicated for the biological parents and their adopted-away offspring; similarly, the familial resemblance can be ascribed to family environment when the control parent/offspring correlations are replicated for the adoptive parents and their adopted infants.

Control Families

General Cognitive Ability. For control infants, the Lewis–Enright factors at 12 months suggest only minimal relationships with general cognitive ability of their parents. Only one of the six correlations is significant, and the median correlation is .06. At 24 months, more parent/offspring resemblance is seen: Half of the correlations are significant, and the median correlation is .16. For the Lewis–Enright Spatial factor at 24 months, both mother/infant and father/infant correlations are significant, and a similar pattern is apparent for the Lewis–Enright Lexical factor.

Specific Cognitive Abilities. In order to simplify the presentation of the results for specific cognitive abilities, we shall focus on the parent/offspring comparisons of greatest interest: Spatial scores of parents and Lewis-Enright infant spatial factors (Means–End at 12 months and Spatial at 24 months); and Verbal scores of parents and Lewis–Enright infant verbal factors (Verbal Skill at 12 months and Lexical and Verbal at 24 months). In general, control parents' specific cognitive abilities are not significantly related to their infants' Lewis–Enright scores at 12 months; the median correlations for parents' Spatial, Verbal, Perceptual Speed, and Memory scores are .06, .03, .03, and .10, respectively. Mothers' and fathers' Spatial scores correlate .09 and −.04, respectively, with infants' Means–End scores; parental Verbal scores correlate .02 and .09 with infants' Verbal Skill. One other comparison to be described later is noteworthy because it replicates for the biological parents and their adopted-away infants: The infants' Means–End scores are positively correlated with both mothers' and fathers' Memory scores. Furthermore, the correlations remain significant when parents' general cognitive ability is partialed out (control mother $r = .17$, control father $r = .15$).

At 24 months, parental specific cognitive abilities also yield low correlations with the Lewis–Enright factors. The median correlations for parents' Spatial, Verbal, Perceptual Speed, and Memory scores are .07, .04, .13, and −.04, respectively. The parent/offspring correlations for Spatial scores are .24 and .07 for mothers and fathers, respectively. The mother/infant correlation is statistically significant; however, when the control mothers' general cognitive ability is partialed out, the correlation is no longer significant ($r = .12$), suggesting that the correlation is to some extent a reflection of general cognitive ability rather than specific to spatial ability. Neither the Lewis–Enright Lexical scores nor the

Verbal scores yield significant correlations with control parents' Verbal scores (r = .04 and = .11 for Lexical; .07 and .02 for Verbal). Although the parents' Perceptual-Speed factor yields significant correlations with the Lewis–Enright Lexical and Imitation scores, we shall see that these parent/offspring correlations do not replicate in either the adoptive or biological parent comparisons; thus, we conclude that these relationships are due to chance.

In summary, the control family results indicate that the Lewis–Enright scales at 24 months are related to parental general cognitive ability. The median parent/offspring correlation is .16, and significant correlations are observed for both Spatial and Lexical scores of the infants. In contrast, parental specific cognitive abilities yielded lower correlations with the infant Lewis–Enright scores at 24 months. Although the differences between parent/offspring correlations for general cognitive ability and those for specific cognitive ability are not statistically significant, the pattern of results is suggestive of possibly important differences. Infant Lexical scores are correlated only .04 and .11 with Verbal scores of mothers and fathers, respectively. Infant Spatial scores are more highly correlated with mothers' Spatial scores (r = .24), but this relationship is greatly reduced when parental general cognitive ability is partialed out.

Although parent/offspring correlations in control families can be more readily detected because control parents share both heredity and family environment with their offspring, we employed adoptive parent/adoptee and biological parent/adoptee comparisons in an attempt to replicate the findings in the control families. As noted earlier, family resemblance can be attributed to family environment when the control parent/offspring correlations are replicated for adoptive parents and their adopted infants; genetic factors are implicated if the control parent/offspring correlations are replicated for biological parents and their adopted-away offspring.

Adoptive Parents and Their Adopted Infants

General Cognitive Ability. The adoptive parent/adopted infant correlations presented in Table 2 suggest that family environment has little effect on infants' Lewis–Enright factor scores. None of the 14 correlations is significant for adoptive parents' general cognitive ability and Lewis–Enright scores at 12 or 24 months. In the control families, parent/offspring relationships emerged for the Lewis–Enright Spatial and Lexical factors at 24 months. For adoptive mothers and fathers, respectively, these parent/offspring correlations are .02 and .09 for Spatial and .09 and .02 for Lexical.

Specific Cognitive Abilities. As in the control families, the adoptive parents' specific cognitive abilities show little relationship to the Lewis–Enright scores: Only 2 of the 56 correlations are significant. Also similar to the results for the control families are the adoptive parent/adoptee correlations for spatial and ver-

TABLE 2
Correlations of Adoptive Parent General and Specific Cognitive Abilities with Adopted Infant Bayley Factors and the Bayley MDI

	Parental Cognitive Abilities									
	General		Spatial		Verbal		Perceptual Speed		Memory	
Bayley Factors	Mother	Father	Mother	Father	Mother	Father	Mother	Father	Mother	Father
12 Months										
Means–End	−.02	−.01	−.06	.10	−.03	−.05	.03	−.06	.06	.02
Imitation	−.01	−.09	.00	−.07	−.07	−.01	−.01	−.03	.10	.00
Verbal Skill	.02	.06	.04	.09	−.04	.08	.06	.01	−.03	.04
24 Months										
Spatial	.02	.09	−.03	.04	−.02	.03	.10	.16*	.00	.06
Lexical	.09	.02	−.05	.10	.03	.07	.17*	−.04	.06	−.08
Verbal	.12	.08	.02	.16*	.08	.05	.06	−.03	.09	.02
Imitation	−.02	−.02	.08	−.03	−.02	.06	−.03	−.08	−.08	−.07
12-Month MDI	.12	.00	.02	.08	.00	.06	.15*	.00	.06	−.09
24-Month MDI	.09	.08	.03	.12	.02	.08	.13*	.03	.02	.01

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

bal scores. At 12 months, adoptive mothers' and fathers' Spatial scores correlate −.06 and .10, respectively, with Lewis–Enright Means–End; parental Verbal correlates −.04 and .08 with infants' Verbal Skill. At 24 months, the parent/offspring correlations for the spatial measures are −.03 and .04. Parental Verbal scores correlate .03 and .07 with the Lewis–Enright Lexical score and .08 and .05 with the Lewis–Enright Verbal score.

In summary, unlike the results in control families, the results for adoptive parents and their adopted infants show no parent/offspring resemblance for parental general cognitive ability. Similar to the control family results, parental specific cognitive abilities show little relationship to the infant measures.

Biological Parents and Their Adopted-Away Infants

General Cognitive Ability. The correlations in Table 3 for the biological parents and their adopted-away offspring suggest the possibility of some genetic influence. For biological parents' general cognitive ability, 5 of the 14 correlations are significant. Most notably, the significant correlation between control parents' general cognitive ability and the Lewis–Enright Spatial factor at 24 months is replicated by the biological parent/adoptee correlations, suggesting that spatial ability at 24 months is genetically related to adult general cognitive ability. The fact that the biological parents' data do not replicate the significant relationship between control fathers' general cognitive ability and the Lewis–Enright Lexical factor suggests that this relationship is not due to heredity. Although significant biological parent/adoptee correlations emerge at 12 months between biological mothers' cognitive ability and infants' Lewis–Enright Means–End scores and between parental *g* and infants' Verbal Skill scores, these relationships are not observed in the control families and thus cannot be considered reliable.

Specific Cognitive Abilities. The biological parent/adoptee correlations for specific cognitive abilities of the parents are similar to the low correlations found for the control parents and their infants. Biological mothers' and fathers' Spatial scores correlate .09 and −.04, respectively, with infants' Means–End scores at 12 months; parental Verbal scores correlate .02 and .09 with infants' Verbal Skill. Similar to the control family results, the Lewis–Enright Means–End score at 12 months is correlated significantly with Memory scores of the biological mothers and fathers, and this correlation remains significant when the effect of parental general cognitive ability is removed (biological mother, r = .11, biological father, r = .27). This result suggests that whatever is measured by the Lewis–Enright Means–End score at 12 months may be related genetically to adult memory ability.

At 24 months, another result similar to the control family data emerges for biological parents and their adopted-away infants: Biological mothers' Spatial

TABLE 3
Correlations of Biological Parent General and Specific Cognitive Abilities with Adopted Infant Bayley Factors and the Bayley MDI

	Parental Cognitive Abilities									
	General		Spatial		Verbal		Perceptual Speed		Memory	
Bayley Factors	Mother	Father	Mother	Father	Mother	Father	Mother	Father	Mother	Father
12 Months										
Means-End	.20**	.18	.09	−.04	.17*	−.16	.01	.32*	.16*	.31*
Imitation	.07	.03	−.05	−.13	.11	.04	.09	−.02	.03	.30*
Verbal Skill	.17**	.31*	.10	.26*	.02	.09	.08	.05	.10	.34*
24 Months										
Spatial	.18**	.37**	.13*	.06	.12	.20	.10	.34*	.06	.08
Lexical	−.06	.15	−.05	.19	−.02	.35*	−.02	−.25	.07	.04
Verbal	−.01	.12	−.05	.00	.10	.28	−.04	−.04	.02	−.03
Imitation	−.04	.12	.01	.00	−.04	.39**	−.07	−.24	.05	.16
12-Month MDI	.12	.29*	.06	.19	.00	−.05	.07	.16	.09	.42**
24-Month MDI	.06	.38**	.02	.28*	.07	.45**	.05	−.08	.09	.15

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

scores correlate significantly with Lewis–Enright Spatial scores at 24 months. As in the control families, however, the correlation becomes nonsignificant when the effect of parental general cognitive ability is removed (biological mother, r = .00). Finally, also in accordance with the control data, the Lewis–Enright Lexical and Verbal scores at 24 months are not significantly correlated with biological parents' Verbal scores with the exception of a significant correlation for the Lexical score and biological fathers' Verbal scores.

In summary, like the results found in the control families, some parent/offspring resemblance is observed for general cognitive ability between biological parents and their adopted-away infants, a finding suggestive of possible genetic influences. Again, little resemblance is detected for parental specific cognitive abilities and infant Lewis–Enright factor scores.

DISCUSSION

Previous reports on the CAP have indicated low but significant correlations between parental general cognitive ability and Bayley MDI scores in infancy. The purpose of the present study was to examine the relationship between separable dimensions of intelligence in infancy and specific cognitive abilities as measured in the infants' parents. Overall, the Lewis–Enright Bayley factors seem to measure abilities somewhat different from those measured by the total Bayley MDI score. Correlations between the Lewis–Enright factors and total MDI score vary from .49 to .72. However, these infant abilities cannot be assumed to be the same abilities measured in adults using specific cognitive abilities tests.

In general, the results indicate that the Lewis–Enright Bayley factors are related to parental general cognitive ability rather than to parental specific cognitive abilities. At 12 months, however, there appears to be a genetic relationship between the infants' Lewis–Enright Means–End factor and parental memory, although the connection between these two variables in terms of cognitive processes is not immediately apparent. The relationship cannot be accounted for strictly by g in that the correlations remained significant when the effect of parental general cognitive ability was partialed out. A possible explanation may be found outside the realm of behaviors defined as strictly cognitive by examining characteristics of the infants' and parents' test-taking behavior. For example, success on a memory test may be determined in part by the subject's attentiveness during the memorization phase and a child's success on the tasks which make up the Lewis–Enright Means–End factor may also be in part determined by the child's attentiveness—the items that load on this factor are indeed somewhat difficult for a 12-month-old to complete. This line of reasoning suggests that these measures might be genetically related due to the degree of attention required by the tasks. That the attentiveness variable from the 12-month Infant Behavior Record is significantly correlated with the Lewis–Enright Means–End factor, but not with the other two Lewis–Enright factors, at 12 months lends some support to this hypothesis.

At 24 months, the Lewis–Enright Spatial factor is related to both spatial ability and general cognitive ability in the control and biological parents, but the spatial–spatial correlation becomes nonsignificant when parental *g* is partialed out. Therefore, the Lewis–Enright Spatial factor appears to be related more to parental *g* than to a specific spatial ability. Most interestingly, this relationship seems to be genetically mediated, which suggests some genetic continuity from infancy to adulthood.

When Bayley designed her infant test, she purposely incorporated a wide range of heterogeneous items in an attempt to measure *g* (Bayley, 1969). The results of the present study indicate that the Bayley Scales to some degree do assess processes related to adult *g*. Because so many different items are included in the Bayley, certain groupings may predict *g* better than others—as suggested by the present results for the Lewis–Enright Spatial factor at 24 months. Also, although the Bayley items can be grouped into measures of separable dimensions of cognition within infancy, these dimensions apparently do not predict specific abilities in the parents. Results of the present study and several others (DeFries et al., 1981; Fagan & McGrath, 1981; Rice et al., 1984) converge on the hypothesis that mental abilities during infancy which are predictive of later intellectual functioning are measures of processes that are precursors of adult *g*. This hypothesis suggests that future attempts to design infant tests with predictive validity should be directed towards the assessment of processes related to adult general cognitive ability.

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