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Maternal supportiveness is predictive of childhood general intelligence

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ABSTRACT

Data from the Early Head Start Research and Evaluation Project ($N = 1075$) were used to test the hypothesis that maternal supportiveness (measured at three waves from 14 to 36 months) is positively and prospectively associated with a child's general intelligence (measured at five waves from 14 months to 10 years). Bivariate correlations showed that maternal supportiveness was consistently and positively associated with a child's general intelligence. For example, maternal supportiveness as measured at 14 months was correlated with a child's general intelligence at age 10; $r = 0.35$. Results of autoregressive cross-lagged panel models showed maternal supportiveness directly predicted future general intelligence through age four and indirectly, via age four general intelligence, up to age 10. Additional analyses verified that the effect of maternal supportiveness was on general intelligence and not specific abilities. The results point to the importance of maternal supportiveness on general intelligence in the first decade of life.

1. Introduction

The conviction that a mother's behavior has a profound impact on the psychological development and outcomes of her children is a foundational principle of many of the most eminent theories in Developmental Psychology (e.g., Bowlby, 1969). These approaches have often been contrasted with general findings from Differential Psychology that deemphasize the impact of the shared family environment in general and maternal behavior in particular. (e.g., Galton, 1869; Plomin, 2018). It is now well established, for example, that by adulthood individual differences in general intelligence are primarily the result of differences in genetics and experiences unique to individual (e.g., Turkheimer, 2000). These findings have led to erroneous conclusions that families don't matter (e.g., Harris, 1995); or that variance in parenting within a wide parameter (minus neglect or abuse) has a negligible impact (Scarr, 1992). However, from a developmental perspective it is assumed that the influences of genes, shared environment, and non-shared environment on intelligence wax (Plomin & Deary, 2015; Tucker-Drob & Briley, 2014; Trzaskowski, Yang, Visscher, & Plomin, 2014; Tucker-Drob, Briley, & Harden, 2013) and wane (Lee, Henry, Trollor, & Sachdev, 2010) across the lifespan.

While the so-called Wilson effect (Bouchard, 2013; Wilson, 1983), defined as the increasing heritability of intelligence from childhood into adolescence and adulthood, is often referenced to highlight the diminishing effect of the shared environment (estimated heritability of $h^2 = 0.80$ by young adulthood), from a developmental perspective one could just as well reference the Wilson effect to stress the importance of the shared environment in the first decades of life. It is estimated that, with some deviation depending on the method, that the shared environment effect is as great or greater than heritability during first half to full decade of life (Plomin & Spinath, 2004; Tucker-Drob & Briley, 2014). The shared environment most likely continues to explain, again depending on the method reviewed, a diminishing yet still significant amount of the variance through adolescence (Bouchard, 2013). Thus, overall, the behavioral genetic evidence suggests that in the first two decades of life the shared environment could be quite important in accounting for variance between individuals.

While the shared environment includes many possible factors outside of the family (e.g., neighborhood, school, peers) there is also more direct evidence for the specific effect of the family. It has been shown that shared-environmental effects associated with a chaotic home environment and low socioeconomic status could explain the variance of verbal and nonverbal cognitive abilities at the age of 3 and 4 (Petrill, Pike, Price, & Plomin, 2004). Likewise, Flynn (2016) reasoned that the intellectual level of the family environment does not perfectly match the genotypic intelligence of a given child and this mismatch would be more

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extreme for those children who were outliers. As such, the family environment would act as a slight pull downward for those children with higher genetic potential and substantial push up for those with lower genetic potential. In a complex analysis, Flynn (2016) used IQ test manuals to show that even in adolescence the family environment can exert up to a one-half a standard deviation effect on verbal intelligence. Thus, there is some evidence that the family environment, in the broad sense, can play an important role in not only a child's, but also an adolescent's developing intelligence.

In the present study, we wish to narrow the focus even more and concentrate solely on the possibility that *maternal supportiveness* helps to shape a child's intelligence. To that end, there is substantial and long-standing evidence for at least a moderately strong correlation between the specific variable of maternal supportiveness and a child's cognitive ability (e.g., Bradley et al., 1993; Clarke-Stewart, 1973; Mcfadden & Tamis-LeMonda, 2013; Merz et al., 2015; Wadsworth, 1986; Gao & Harris, 2000; Yarrow, 1963). The problem with these simple associations is that they may be spurious as they are not free of genetically based explanations. While the association remains after controlling for maternal intelligence and/or level of education, other explanations remain. For example, an intelligent and temperamentally easy child may elicit or evoke positive maternal behavior thus explaining the association between maternal supportiveness and child's intelligence (e.g., Lamb, 1982; Scarr, 1985). In short, when attempting to test for a direct path from maternal supportiveness to child's intelligence controlling for maternal intelligence may not be sufficient.

To that end, in a genetically-informed study, Beaver et al. (2014) found no evidence that maternal behavior was related to adolescent or young adult verbal intelligence. However, there were a number of limitations to the Beaver et al. (2014) study. First, contrary to several previous studies that documented a positive maternal support –child's intelligence association; Beaver et al. (2014) found scant evidence for such an association even *before* controlling for a genetic confound. Second, the sample was composed of adolescents who were tested and then retested in young adulthood. The age of the sample precludes testing for the effects of maternal supportiveness in the first decade of life. Third, the measures used may not be adequate to detect such an effect. Intelligence was assessed using a single scale of verbal intelligence; the Peabody Picture Vocabulary Test. And more importantly, maternal behavior was assessed via the participants' (i.e., the adolescents) reports of their mother's behavior. More comprehensive measures of intelligence and more objective (i.e., observable) measure of maternal behavior may yield different results.

In another genetically informed study that used twins, Tucker-Drob and Harden (2012) not only reported the positive association between parental behavior and a child's reading ability, but also, as described by Scarr (1985), examined the possible reciprocal nature of the two variables. Their study seemed to indicate a causal relation from parental behavior to the child's reading ability. Importantly, the sample used by Tucker-Drob and Harden (2012) was composed of preschool children and their parents. Parental behavior (i.e., parental stimulation) was measured via objective behavioral ratings. Using such measures, Tucker-Drob and Harden (2012) found significant positive relation between parental behavior and the child's reading ability, and this relation remained significant after controlling for genetic factors. As expected this association was bidirectional with parents influencing a child's developing reading ability and a child's early cognitive ability evoking parental behaviors. However, recognized limitations of the study include the fact that the outcome variable was the single specific cognitive skill of reading ability, not general intelligence, and the children were only followed to age four.

Similarly Roisman and Fraley (2012) examined the role of supportive parental behavior on kindergartners' academic skills using a sample of twins. They found that parental support was predictive of a child's academic skills. More importantly, however, was that this effect remained after controlling for a child's baseline (i.e., pre—K) academic skills. Additionally, the shared environment not only accounted for the majority of the variance in each parental support and academic skills individually, but fully 95% of the variance in the correlation between the two variables was due to the shared environment. The remaining 5% was due to the nonshared environment, with additive genetic component accounting for 0%. While the results clearly point to the importance of supportiveness in early childhood on academic skills, the study suffers from the same limitations as the study described in the preceding paragraph. Namely, that cognitive ability was narrowly measured and the children were not followed passed early childhood.

There have been several investigations (e.g. Estrada, Arsenio, Hess, & Holloway, 1987; Fagot & Gauvain, 1997; Hubbs-Tait, Culp, Culp, & Miller, 2002; Kirsh, Crnic, & Greenberg, 1995; Olson, Bates, & Kaskie, 1992) into the enduring impact of maternal supportiveness on subsequent cognitive ability that have also addressed several of the limitations that have been broached (i.e., objectively measuring maternal behavior, following children at least through kindergarten, controlling for children's baseline cognitive ability, administering a test of more generalized cognitive ability or several tests). However, it is only recently that developmental impact of early maternal supportiveness has been tracked into adolescence. Fraley, Roisman, and Haltigan (2013) found the effect for maternal sensitivity on academic skills lasted at least through middle adolescence. Raby, Roisman, Fraley, and Simpson (2015) replicated and extended these results; finding that maternal sensitivity in early childhood was predictive of achievement test scores in adolescence and educational attainment in adulthood.

Note that in each of these recent studies, Roisman and Fraley (2012), Fraley et al. (2013) and Raby et al. (2015), the authors refer to the cognitive outcome variables as academic competence or skills, but the measures used (i.e., Woodcock–Johnson Psycho-Educational Battery–Revised; Woodcock-Johnson Tests of Achievement; Peabody Individual Achievement Test. Peabody Picture Vocabulary Test) are strong indicators of general intelligence. Thus the results of these studies are strongly suggestive of the enduring influence of maternal supportiveness on general intelligence.

In support of this contention, Dunkel and Woodley (2019) found that an maternal sensitive behavior at ages three to four was predictive of both performance and verbal intelligence as measured by the Wechsler IQ tests (i.e., WISC; WAIS) at ages 11 and 18. Dunkel and Woodley (2019) also included a large number of covariates in their analyses including aspects of childhood temperament to address the possible confound of an evocative gene-environment correlation. After implementing these controls, they still found that maternal sensitivity predicted verbal intelligence at ages 11 and 18. The effect for performance intelligence was no longer statistically significant. However, the sample used in the study was quite small, but with some analyses including a sample as small as $N = 62$. This leads to the general purpose of the current investigation, which is to test the replicability of the continued effect of early maternal support on general intelligence using the large sample of the Early Head Start Research and Evaluation Study 1996–2010 (EHSRE; United States Department of Health and Human Services Administration for Children and Families, 2011).

Previous research using the EHSRE data set, though not explicitly examining general intelligence, is relevant to the question of the association between maternal supportiveness and cognitive abilities. Several studies have already documented a positive association between the EHSRE measure of maternal supportiveness and a child's developing vocabulary (e.g., Chazan-Cohen et al., 2009; Lugo-Gil & Tamis-LeMonda, 2008; Ober & Brooks, 2022; Vallotton, Mastergeorge, Foster, Decker, & Ayoub, 2017). Using a summed score of various elements, including maternal supportiveness, to create a quality parenting factor, Lugo-Gil and Tamis-LeMonda (2008) found that parenting quality fully mediated the effect of economic resources on the child's Bayley MDI score at ages 14, 24, and 36 months. Vallotton et al. (2017) found that maternal sensitivity, in particular, had a positive association with children's vocabulary development at the same three age points. Most recently, Ober and Brooks (2022) found that a measure of joint attention, that included maternal supportiveness, as measured at 14 months predicted vocabulary through late childhood. Taken together the results of these three studies clearly show that in the EHSRE data set maternal behavior is predictive of specific cognitive childhood outcomes.

However, to the best of our knowledge the EHSRE data set has not been utilized to examine the association between maternal supportiveness and general intelligence and we believe that the qualities inherent in the EHSRE data set could be used to go beyond previous studies in this area and address some of the limitations in previous research on this topic. First, the EHSRE has objective measures of maternal behavior. Independent raters were used to score maternal behavior during a semi-structured interaction with her child. Second, the EHSRE includes several possible confounds allowing statistical controls to be implemented. These controls include important baseline characteristics of the child in toddlerhood (i.e., cognitive ability and temperament). Third, EHSRE includes data from 14 months up to 5th grade (roughly 10 years of age). Thus the role of maternal supportiveness beyond early childhood can be tested. Fourth, at each wave of data collection several cognitive measures were administered to the participants. Factor analyzing the scores for the individual tests allows for the creation of a *g*-factor and thus the association between maternal supportiveness and general intelligence can be examined. Lastly, the EHSRE has a sizable sample which means that it can be used to test the replicability of similar studies on maternal supportiveness that had much smaller samples. Thus in the current investigation the EHSRE data set is used to test the hypothesis that maternal supportiveness is a significant predictor of a child's *general intelligence*, that this association remains after the implementation of several statistical controls, and continues through late childhood.

2. Method

2.1. Participants

Head Start is a program designed to assist in the development of children from low-income families. The Early Head Start Research and Evaluation Study 1996–2010 study was designed to test the efficacy of the Early Head Start program (United States Department of Health and Human Services Administration for Children and Families, 2011). The study was made up of families selected from 17 Head Start program sites across the United States. Site selection for inclusion in the EHSRE was based on several factors including over enrollment in the program, the availability and proximity of research personnel, and the demographic representativeness of the families being served. The EHSRE administrators note that, because selection was not random, generalizability to the full Early Head Start program is not possible. However, the characteristics of the sites and individual families enrolled in the study were similar to the broader Early Head Start population. Families that enrolled in the study were then randomly assigned to a treatment (i.e., enrolled in Early Head Start) or control group.

To eliminate the possible confounding role of the intervention, only children in the control group were selected for inclusion. Likewise, because in the current study mother's intelligence was used as a control for possible confounding, cases were also selected on the criteria that the mother was the child's biological mother. Implementing this selection criterion left a sample of 1113 children. Of the 1113 children, all the scores of maternal supportiveness and cognitive ability were missing for 38 children. Therefore, we excluded them from the sample, which remain the 1075 children (529 girls and 546 boys) in the present analysis. Four hundred and nine of the children were White, 347 were Black, 241 were Hispanic, and 54 were "other."

2.2. Measures

2.2.1. Maternal supportiveness

Maternal supportiveness was measured using a semi-structured play procedure called the 3-bag task at ages 14 months, 24 months, and 36 months. In the 3-bag task the parent-child dyad was given three bags full of toys and was simply instructed to play with the toys in succession. The task lasted a total of ten minutes. The first bag contained an age-appropriate book, and the next two bags contained a set of toys (e.g., a Noah's ark with the associated animals). Mothers were given latitude with regards to the structure of the play and deciding when to transition to the next bag. These interactions were videotaped, and several aspects of the interactions were rated by trained graduate students. The raters were trained in groups of five to eight and meetings were held weekly to aid in the understanding and agreement between raters. One of the resulting scales, i.e., parental supportiveness, is the focal scale of the current investigation.

Parental supportiveness is a combination of three aspects of the mothers' behavior exhibited during the 3-bag task; i) parental sensitivity, ii) cognitive stimulation, and iii) positive regard. Parental sensitivity is defined by behaviors such as recognizing the child's emotions and facilitating the child's play in a developmentally appropriate manner. Sensitivity ratings were based the mother tailoring her responses to her child's cues. More sensitive mothers are able to adjust their levels of encouragement and support for autonomy by taking the child's interest and level of engagement into account. Mother's rated low in sensitivity may be too controlling, focusing on their own mood and goals and not those of the child (Fuligni & Brooks-Gunn, 2013).

Cognitive stimulation involves the parental use of the toys to encourage intellectual development, for example, by discussing the various characteristics and potential uses of the toys. High levels of cognitive stimulation by the mother are designed to lead the child to greater understanding. Engaging in pretend play, organizing play in the correct sequences of events, and relating the play to the child's personal experiences are examples of behaviors that are rated high in cognitive stimulation (Fuligni & Brooks-Gunn, 2013).

Positive regard is defined by the expression of empathy, praise, and affection directed toward the child. Verbal (e.g., warm tone of voice) and physical (e.g., hugging) manifestations of positive emotions directed toward the child led to high ratings on the scale of positive regard. These three aspects of parental behavior (i.e., sensitivity, cognitive stimulation, positive regard) were rated using a seven-point Likert-type scale anchored by 1 = a low level of the behavior and 7 = a very high level of the behavior.

In the original scoring, the three aspects of parental supportiveness were recorded separately, but because the three aspects were highly correlated the use of the composite parental supportiveness measure, the average of the three aspects, is the variable included in the data set. The raters were trained so that inter-rater reliability reached 85% to within one point of on all of the scales prior to the ratings being recorded in the data file. Periodic reliability checks were performed as each dyad interaction was scored. The agreement across raters within one point on the scales remained high at 87% - 96% (Fuligni & Brooks-Gunn, 2013). Additionally, the composite parental supportiveness scale has good internal consistency at each age ranging from $\alpha = 0.82–0.83$ (Fuligni & Brooks-Gunn, 2013). Detailed information concerning the procedures and psychometrics can be found at http://policyforchildren" http://policyforchildren.org/research-projects/early-care-education/national-evaluation-of-the-early-head-start-program-ongoing-analyses/. Because we restrict the sample to mothers the term parental supportiveness was replaced with the more accurate maternal supportiveness.

2.2.2. Cognitive ability

2.2.2.1. 14 months. At 14 months four measures of cognitive ability were administered. The four measures included three of the Macarthur Communicative Development Inventories (i.e., vocabulary production, vocabulary comprehension, and early gestures) or CDI and the Bayley Mental Development Index. To create a measure of general intelligence the scale scores were factor analyzed using Principal Axis Factoring (PAF) and saving the first unrotated extracted factor. This factor accounted for 35.18% of the variance, the factor loadings are described in Table 2.

2.2.2.2. 24 months. At two years of age four measures of cognitive ability were administered. The four measures included Macarthur CDI scores for sentence complexity and vocabulary production and Bayley MDI scores for the visual/spatial factor and the language factor. To create a measure of general intelligence the scale scores were factor analyzed using PAF and saving the first unrotated extracted factor. This factor accounted for 44.23% of the variance.

2.2.2.3. 36 months. At 36 months three measures of cognitive ability were administered. The three measures included Bayley MDI scores for the spatial factor and the reasoning factor and the Peabody Picture Vocabulary Test (PPVT). To create a measure of general intelligence the scale scores were factor analyzed using PAF and saving the first unrotated extracted factor. This factor accounted for 41.31% of the variance.

2.2.2.4. Pre-K or approximately age four. The wave of data collection referred to Pre-K in the codebook occurred at four years of age. At this wave of data collection six tests of cognitive ability were administered. Two measures were from the *Goodnight Moon* story and print concept questions; book comprehension and book knowledge. Two measures were from the Woodcock-Johnson Tests; applied problems and word identification. The fifth test was the Leiter-R Attention Standardized Test. The sixth test was the PPVT. To create a measure of general intelligence the scale scores were factor analyzed using PAF and saving the first unrotated extracted factor. This factor accounted for 42.43% of the variance.

2.2.2.5. Grade 5 or approximately age 10. In the fifth grade when the participants were around 10 years of age four measures of cognitive ability were administered. Two measures from the Early Childhood Education Study (ECLS); language and math. The matrix reasoning subtest from the WISC was administered. The fourth test was the PPVT. To create a measure of general intelligence the scale scores were factor analyzed using PAF and saving the first unrotated extracted factor. This factor accounted for 59.14% of the variance.

2.2.3. Covariates

2.2.3.1. Maternal cognitive ability. Maternal cognitive ability was measured using the Woodcock Johnson Picture Vocabulary Test as administered to the mother when the child was 24 months of age.

2.2.3.2. Child's temperament. The Bayley Behavior Rating Scale was used to measure two aspects of temperament at 14 months of age. Using a five-point Likert-type scale, with five indicating more positive behavior, the interviewer assessed the child's emotional regulation and orientation/engagement. Emotional regulation is defined as the child's ability to control frustration and negative affect. Orientation/engagement is defined as the child's cooperation with the interviewer and interest in the activities.

2.3. Statistical analyses

Before conducting the statistical analyses, we checked the missingness in the present data. Regarding the missing values, we conducted Little's missing completely at random (MCAR) test (Little, 1988). The result showed that the null hypothesis of the MCAR in the present data was significantly rejected ($\chi^2 = 2131.38$, $df = 1916$, $p < 0.001$). Then, we calculated Cohen's *d*s to compare cases with and without missing values for each variable. This revealed that the missingness of maternal supportiveness and cognitive ability was only weakly associated with their own scores ($|d|s < 0.32$). Only the missingness of emotion regulation was strongly associated with orientation/engagement score ($d = 0.85$), which may have led to the rejection of the null hypothesis in Little's MCAR test. In the present data, the dependent variables, maternal supportiveness and cognitive ability, are not strongly related to the missingness. Given this, we can consider the present missing pattern as missing at random (MAR), although it cannot be regarded as MCAR. All these statistical processes were done using the *misty* package (Yanagida, 2022) on R.

To deal with the missing values, we used the multiple imputation (MI) technique on the present incomplete data. MI is one of the effective strategies for dealing with the missingness in the data under the assumption of MAR or MCAR (Van Buuren, 2018). The full-information maximum likelihood (FIML) estimation is another option for MAR or MCAR cases (Graham, 2009). However, the FIML cannot deal with the missingness in external variables. Due to this limitation, using the FIML estimation, the present sample size was reduced to 620 (57.67%) in the CL2PM model. Therefore, we utilized the MI technique for compensating the missing values in the data. In the MI technique, the missing values are multiply estimated by chained equations using the *mice* package on R (Van Buuren & Groothuis-Oudshoorn, 2011), and multiple imputed datasets are generated. The statistical analyses are respectively conducted in each dataset. After this, the results are aggregated based on the Rubin's rule (Rubin, 1987). We generated a total of 50 datasets considering the present sample size and the proportion of missingness (Graham, Olchowski, & Gilreath, 2007).

After generating the 50 imputed datasets, we calculated the bivariate correlation coefficients among the study variables. Then, we adopted an autoregressive cross-lagged panel model. There has been critique on classical cross-lagged panel models and it has been suggested that random-intercept cross-lagged panel models (RI-CLPM) may be superior as they differentiate between- and within-person variance (e.g., Hamaker, Kuiper, & Grasman, 2015). This latter approach is similar to a multi-level approach on longitudinal data. However, within-person variance basically implies fluctuations around a person's own mean, which is not the focus of the present study. In contrast, we aim to test whether stable individual differences in maternal support are longitudinally related to stable individual differences in intelligence. Regarding this, Lüdtke and Robitzsch (2021) recently compared the assets and limitations of classical CLPMs and RI-CLPMs and concluded that the type of research questions has to determine which model is applied. According to them, the RI-CLPM is more suitable for studies focusing on more situational variables with shorter time lags between assessments. However, our focus is on maternal supportiveness and the child's intelligence which are more trait-like variables, and they were measured with relatively long time lags between waves. For the type of questions we adopt in this study, they recommended the autoregressive cross-lagged panel model with the cross-lagged effects of the mutual variables from two previous time points (CL2PM: Little, 2013), which in this case, allows for the inference of the reciprocal relations between general intelligence and maternal supportiveness. This model simultaneously reveals how much of the variance in general intelligence and maternal supportiveness can be predicted by the previous values of the same measure and how much can be explained by the values of the other variables at the one and two previous time points. The autoregressive paths indicate the relative stability of a variable. The cross-lagged paths indicate the reciprocal relations between variables. Because general intelligence as well as maternal supportiveness scores were obtained up to 36 months of age, the CL2PM was applied to the present data from 14 months to 36 months (i.e., Wave 1 to Wave 3) in the structural equation modeling. After wave 3 (36 months), we also entered general intelligence scores at four and ten years of ages (Waves 4 and 5) to the CL2PM. The complete path model is shown in Fig. 1. In the CL2PM, we included the assumption of equality of coefficient estimates among time points on the autoregressive paths and the first-order cross-lagged paths, respectively, from 14 months (Wave 1) to 36 months (Wave 3).

Before applying the CL2PM to the data, we calculated the residual scores using a series of regression analyses of general intelligence and maternal supportiveness scores on covariates, including maternal cognitive ability, child's temperament (orientation/engagement and emotion regulation), and child's sex on each dataset. Then we applied the CL2PM to the residual scores of general intelligence and maternal supportiveness. To evaluate the model fit, we utilized the following fit indices: Comparative fit index (CFI: Bentler, 1990); Tucker-Lewis index (TLI: Tucker & Lewis, 1973); Root-mean-square error of approximation (RMSEA: Steiger, 1990); and the standardized root mean-square residual (SRMR: Bentler, 1995). Hu and Bentler (1999) suggested that values of CFI > 0.95, TLI > 0.95, RMSEA <0.06, and SRMR <0.08 are regarded as good fit, and that those of CFI > 0.90, TLI > 0.90, RMSEA <0.08, and SRMR <0.10 are regarded as acceptable fit to the data. We used *semTools* package (Pornprasertmanit, Miller, Schoemann, & Rosseel, 2013) to aggregate the results of the CL2PM.

Beyond the CL2PM model, we also applied the Method of Correlated Vectors (MCV; Jensen, 1998) as an additional test of whether the association between maternal supportiveness with cognitive ability occurred at the level of general intelligence. MCV follows the logic that if a variable's potential impact on intelligence is primarily on general intelligence, and not specific for independent abilities, then the variable should have the strongest associations with the cognitive tests that are most representative of general intelligence.

MCV entails, first, submitting the individual cognitive tests to a factor analysis and recording the factor loadings on the first unrotated factor or *g*-factor. Next the correlations of the target variable (i.e., maternal supportiveness) with the individual cognitive tests are, in turn, correlated with the factor loadings. The resulting correlation between the factor loading and the correlation between the specific cognitive test and the target variable is interpreted as any other correlation would be. A strong positive correlation would indicate that maternal supportiveness is most strongly associated with the cognitive tests that are most representative of general intelligence.

Prior to calculating the MCVs, a composite measure of maternal supportiveness was computed by factor analyzing the three maternal supportiveness scores using PAF and saving the value of the first factor. The resulting maternal supportiveness factor had an Eigenvalue of 2.06 and explained 53.35% of the variance.

3. Results

3.1. Correlations

The bivariate correlations between the study variables can be seen in Table 1. The table shows that each of the three measures of maternal supportiveness were positively correlated with each measure of intelligence. Additionally, the covariates of maternal intelligence and the two aspects of temperament were positively correlated to each of the three measures of maternal supportiveness and each of the five measures of general intelligence.

3.2. Autoregressive cross-lagged panel model

The CL2PM showed a good fit to the data. The initial levels of general intelligence and maternal supportiveness were weakly, but significantly and positively correlated ($r = 0.18$). The adjusted model's result shows that the child's general intelligence was not significantly associated with later maternal supportiveness scores. However, maternal supportiveness was positively and significantly associated with both the one- and two-time later general intelligence scores from 14 months to 36 months of age. The standardized cross-lagged effects were approximately 0.08 for one-time lag and 0.12 for second-time lag. Additionally, maternal supportiveness at 36 months of age was significantly associated with general intelligence at 4 years of age, independently from general intelligence at 36 months of age. Moreover, maternal supportiveness at 36 months of age did not directly significantly relate to general intelligence at fifth grade. However, the indirect effect through general intelligence at 4 years of age was statistically significant, suggesting complete mediation. The detailed estimates and model fit indices are shown in Fig. 1. We complementarily conducted the same analysis using the full-information maximum likelihood estimation ($n = 620$) and listwise deletion ($n = 125$). In addition, we also applied the statistical model to the non-adjusted data. These results are presented in the supplemental materials (Figs. S1-S3). The observed cross-lagged effects in the results using the FIML estimation were nearly equal to the corresponding effects using the MI (see Fig. S1). Due to the small sample size in the complete case data, the second-lagged effects from maternal supportiveness to general intelligence were not statistically significant.

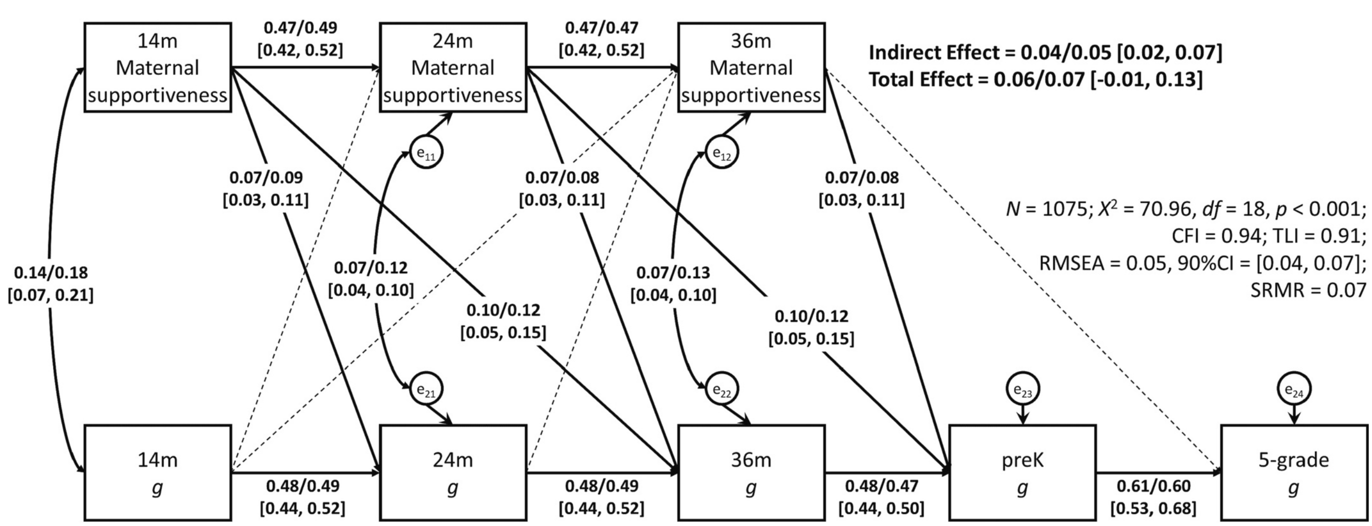

Fig. 1. Path diagram and estimated path coefficients of the autoregressive cross-lagged panel model using the multiply imputed data.
The value to the left of the slash represents the unstandardized estimates and the value to the right represents the standardized estimates. 95% confidence intervals for the unstandardized estimates are shown in parentheses. Dashed arrows represent statistically insignificant paths.

Table 1
Correlation matrix of study variables.

	Maternal Supportiveness (MS)			Covariates			Intelligence			
	14 m	24 m	36 m	Maternal IQ	Emotional regulation	Orientation /engagement	14 m	24 m	36 m	Pre-K
MS 14 m										
MS 24 m	0.60 [0.55, 0.64]									
MS 36 m	0.48 [0.42, 0.53]	0.52 [0.46, 0.58]								
Maternal IQ	0.40 [0.33, 0.46]	0.35 [0.29, 0.42]	0.32 [0.25, 0.38]							
Emotional regulation	0.15 [0.08, 0.21]	0.14 [0.07, 0.21]	0.11 [0.03, 0.18]	0.07 [0.00, 0.15]						
Orientation /engagement	0.16 [0.09, 0.22]	0.11 [0.04, 0.18]	0.07 [0.00, 0.14]	0.17 [0.10, 0.25]	0.45 [0.40, 0.51]					
Intelligence 14 m	0.22 [0.14, 0.29]	0.18 [0.11, 0.26]	0.11 [0.02, 0.20]	0.10 [0.01, 0.18]	0.11 [0.03, 0.18]	0.16 [0.08, 0.23]				
Intelligence 24 m	0.32 [0.25, 0.38]	0.33 [0.26, 0.40]	0.13 [0.04, 0.21]	0.27 [0.20, 0.34]	0.17 [0.09, 0.24]	0.21 [0.14, 0.28]	0.48 [0.41, 0.54]			
Intelligence 36 m	0.44 [0.38, 0.51]	0.36 [0.29, 0.43]	0.28 [0.21, 0.35]	0.37 [0.30, 0.43]	0.19 [0.11, 0.27]	0.23 [0.14, 0.31]	0.35 [0.26, 0.43]	0.56 [0.49, 0.62]		
Intelligence pre-K	0.36 [0.29, 0.42]	0.32 [0.24, 0.39]	0.28 [0.21, 0.35]	0.37 [0.30, 0.44]	0.18 [0.10, 0.25]	0.23 [0.16, 0.30]	0.22 [0.13, 0.30]	0.41 [0.34, 0.48]	0.66 [0.60, 0.70]	
Intelligence grade 5	0.35 [0.27, 0.41]	0.35 [0.28, 0.42]	0.23 [0.15, 0.31]	0.36 [0.28, 0.44]	0.17 [0.09, 0.25]	0.19 [0.11, 0.26]	0.21 [0.12, 0.29]	0.41 [0.33, 0.48]	0.55 [0.48, 0.61]	0.67 [0.62, 0.72]

However, the one-time cross-lagged effects were still statistically significant, although the opposite cross-lagged effects from general intelligence to maternal supportiveness were never significant (see Fig. S2). Using the non-adjusted data, the one- and two-time cross-lagged effects were slightly larger than adjusted case (see Fig. S3).

3.3. Method of correlated vectors

Four MCVs were calculated. The first MCV looked at the association between the maternal supportiveness factor and the pre-*K* cognitive tests. The second MCV repeated the first analysis with the difference being that prior to the analysis the maternal supportiveness factor was regressed on the child's sex, general intelligence at 14 months, maternal cognitive ability, and the two aspects of temperament. The residuals from the regression were saved and correlated with the factor loadings of the cognitive tests. For the subsequent two MCVs the cognitive tests from the grade 5 wave of data collection were added. Not only does the MCV benefit from the inclusion of a greater number of cognitive tests (Jensen, 1998), but by expanding to include tests administered in grade 5 we can test whether the effect of maternal supportiveness continues to be on the *g*-factor into late childhood.

The results of the MCVs are displayed in Table 2 showing that, each MCV resulted in a strong positive correlation. This finding implies that the effect of maternal supportiveness on cognitive ability has a tendency to mainly occur at the level of general intelligence. The inclusion of the statistical controls and the expansion of the cognitive tests and age range to include the cognitive tests administered in grade 5 only slightly diminished the strength of the correlations.

4. Discussion

It is well accepted that there are significant shared environmental

Table 2
Method of correlated vectors (MCV)s for Maternal Supportiveness (MS) on g.

	MCVs using Pre-K Cognitive Tests			MCVs using Pre-k and 5th grade tests combined		
	Factor loading	*r* with MS factor	*r* with MS factor residual score	Factor loading	*r* with MS factor	*r* with MS factor residual score
Pre-K PPVT	0.81	0.37	0.17	0.77	0.371	0.17
Book comprehension	0.49	0.20	0.02	0.41	0.20	0.02
Book knowledge	0.60	0.15	0.01	0.59	0.15	0.01
WJ Applied problems	0.79	0.35	0.18	0.74	0.35	0.18
WJ Letter-word identificaiton	0.57	0.25	0.11	0.52	0.25	0.11
Leiter-R AS	0.61	0.20	0.08	0.57	0.20	0.08
Grade 5 PPVT				0.78	0.38	0.14
Math routing				0.76	0.29	0.15
Matrix reasoning				0.53	0.17	0.03
Language/literature				0.79	0.33	0.16
r		0.86	0.86		0.71	0.66

Imputed values were not used in the MCV analyses.

effects on general intelligence in the first, and possibility the second decade, of life (e.g., Bouchard, 2013). Additionally, a large cache of studies indicate that maternal supportiveness is positively correlated with various dimensions of cognitive ability and that this effect may be enduring.

The purpose of the current investigation was to test the hypothesis that maternal supportiveness is predictive of childhood *general intelligence* while statistically addressing a number of possible confounds and utilizing a much larger sample then has been previously been used. The comprehensiveness and size of EHSRE allowed for the testing the association between maternal supportiveness and general intelligence across the first decade of life while controlling for a substantial number of possible confounding variables.

Consistent with past findings (e.g., Merz et al., 2015; Yarrow, 1963) bivariate correlations showed a positive association between maternal supportiveness and general intelligence and, overall, the effect sizes were moderate in strength. Also consistent with past findings (e.g., Tucker-Drob & Harden, 2012) the autoregressive CL2PM using uncorrected values showed a bidirectional effect across measurement waves such that maternal supportiveness predicted future general intelligence and general intelligence predicted future maternal supportiveness (see supplemental material) However, when the same CL2PM was rerun in order to account for the potential confounds, only the first- and second-order cross-lagged effects of maternal supportiveness on child general intelligence remained statistically significant. This seems to suggest that the effect of the child's general intelligence on later maternal supportiveness is due to the confounding factors including the heritable component of general intelligence. Especially, we controlled for maternal general intelligence in the CL2PM. Maternal general intelligence was positively significantly correlated with maternal supportiveness and child general intelligence scores, which may derive from both genetic and environmental factors. In the present result, the cross-lagged effect of child general intelligence on later maternal supportiveness was diminished by controlling for the confounders including maternal general intelligence, which implies that genetic (and/or environmental) factors enhancing maternal general intelligence play a major role in the child general intelligence on maternal supportiveness paths. However, despite controlling for the maternal general intelligence, the maternal supportiveness on child general intelligence paths remained significant, which suggests that environmental (and/or genetic) factors contributing not to maternal general intelligence but to maternal supportiveness have a significant influence on enhancing child general intelligence. Investigation into this issue in more detail using behavioral genetic approach can be pursued in future research.

We can also speculate that the present findings may deviate from prior results because two aspects of child temperament were included in the covariates. It seems reasonable to expect that children who are engaged and receptive to parental cognitive stimulation may also elicit and sustain more encouragement from their mother. Actually, child temperament scores were weakly but significantly correlated with maternal supportiveness, child general intelligence, and maternal general intelligence in positive direction in the present data. Child positive temperament can draw favorable supportive parenting styles and opportunities to develop their cognitive abilities (e.g., Scarr, 1985). Therefore, when controlling for temperament, the cross-lagged effect was reduced. Nevertheless, the effect of maternal supportiveness on general intelligence continued up to age 10, albeit indirectly through general intelligence at age four. Whether or not maternal supportiveness would continue to have a direct effect was not able to be determined using the 3-bag task measure of maternal supportiveness.

A central purpose of the study was to test the hypothesis that the effect of maternal supportiveness on cognitive ability is not localized; not only having an effect on a specific ability (e.g., reading). The use of general intelligence factor scores as dependent variables is one way in which this hypothesis was tested. The MCV was used as an additional test of the hypothesis that the effect of maternal supportiveness is on general intelligence. The MCV is a commonly used method in intelligence research and is based upon the idea that if a variable's association is primarily on general intelligence then the effect should be most strongly seen in tests that are stronger tests of general, as opposed to specific, intelligence. The results showed strong support for the hypothesis that the effect of maternal support is indeed on general intelligence. Maternal supportiveness was most strongly associated with the cognitive tests with the strongest loadings on the *g*-factor and this pattern remained when using the residualized scores and when expanding the number of tests to include those administered at age 10.

4.1. Limitations and conclusions

While an attempt was made to recognize and control for genetic confounds, given the nature of the data this attempt necessarily falls short. The use of polygenic scores as derived from genome wide association studies as covariates would represent an increased level of sophistication that would, in turn, allow for more confidence in the results. In contrast, the current study used phenotypic proxies for the underlying genotypic traits; the use of these phenotypic proxies simultaneously under and over controls for the underlying genotypic traits. As polygenic scores are more frequently included in large data sets, it seems possible that these scores will be employed.

While a notable attribute of the current study over some of its predecessors is the measurement of general intelligence up to late childhood (i.e., 10 years of age), extending the waves of data collection even further is important for gauging the extent to which maternal supportiveness continues to have an effect. The results of this study suggest that the direct effect lasts until age four, with an indirect effect (via age four general intelligence) up to age 10. Indeed, there is evidence for the enduring effects of maternal sensitivity on cognition even into adulthood (Raby et al., 2015). It is also possible that if maternal supportiveness was measured into adolescence that it would also continue to have a more proximate effect (see Fraley et al., 2013).Alternatively, the diminishing shared environmental effect strongly suggests that it wanes to the point of being negligible in adulthood, but even a small effect in late adolescence can have a significant impact on one's life trajectory. For example, college admissions can be a highly competitive and selective process in which a slight edge could push an individual across the threshold needed to be accepted by an elite institution (Flynn, 2016).

Additionally, although a significant effect between maternal supportiveness and child general intelligence was found across time we did not venture (or test) the mechanism(s) which may lead to this effect. Turning to the more established role of maternal sensitivity in attachment formation (De Wolff & van Ijzendoorn, 1997) and vocabulary development (Ober & Brooks, 2022) may lead to some potential mechanism that could be explored in future research.

Along these lines, maternal effects may more directly and strongly impact variables such as self-regulation and attentional control. In turn, these factors may mediate the observed effects of maternal supportiveness on general intelligence. In support of this possibility, maternal support has been found to predict executive functioning in children both concurrently and across early childhood using cross-lagged analyses similar to those used in the current investigation (Zeytinoglu, Calkins, Swingler, & Leerkes, 2017; Zeytinoglu, Calkins, Swingler, & Leerkes, 2019).

Indeed, positive maternal interactions on cooperative cognitive tasks has been found to be associated with specific patterns of neural activity in the regions which also play a role in executive function (Bernier, Calkins, & Bell, 2016). Thus, it might be surmised that neurological responses associated with maternal supportiveness indirectly effect performance on tasks of general intelligence via regions in the frontal lobe.

To speculate further, the ultimate (as opposed to proximate or immediate) effect of maternal supportiveness or other environmental influences, such as interventions designed to increase cognitive abilities

(Protzko, Aronson, & Blair, 2013), on general intelligence (Protzko, 2016) could be due to a slowing life history strategy. Maternal supportiveness is thought to push a child's development toward a slower life history trajectory (e.g., Szepsenwol & Simpson, 2019) freeing bioenergetic resources to be allocated to cognitive growth and, hence, greater general intelligence (Dunkel et al., 2021). In conclusion, the results suggest that maternal supportiveness may play a significant role in the development of early childhood general intelligence and that this may last through late childhood. While the effect was small after implementing statistical controls, there are real world implications. A slight edge in cognitive performance at critical junctures during a child's development may have a sizeable impact on important outcomes. Better understanding the exact nature of the influence of maternal supportiveness on general intelligence and the extent to which the effect is maintained across development are possible avenues for future study.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.intell.2023.101754.

References

Beaver, K. M., Schwartz, J. A., Al-Ghandi, M. S., Kobeisy, A. N., Dunkel, C. S., & Van der Linden, D. (2014). A closer look at parenting-related influences on verbal intelligence over the life course: Results from an adoption based research design. *Intelligence, 46*, 179–187. https://doi.org/10.1016/j.intell.2014.06.002

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*, 238–246. https://doi.org/10.1037/0033-2909.107.2.238

Bentler, P. M. (1995). *EQS structural equations program manual*. Encino, CA: Multivariate Software.

Bernier, A., Calkins, S. D., & Bell, M. A. (2016). Longitudinal associations between the quality of mother-infant interactions and brain development across infancy. *Child Development, 87*, 1159–1174.

Bouchard, T. J. (2013). The Wilson effect: The increase in heritability of IQ with age. *Twin Research and Human Genetics, 16*, 923–930. https://doi.org/10.1017/thg.2013.54

Bowlby, J. (1969). *Attachment and loss: Volume 1. Attachment*. New York: Basic Books.

Bradley, R. H., Whiteside, L., Caldwell, B. M., Casey, P. H., Kelleher, K., Pope, S., … Cross, D. (1993). Maternal IQ, the home environment, and child IQ in low birthweight, premature children. *International Journal of Behavioral Development, 16*, 61–74. https://doi.org/10.1177/016502549301600104

Chazan-Cohen, R., Raikes, H., Brooks-Gunn, J., Ayoub, C., Pan, B. A., Kisker, E. E., … Fuligni, A. S. (2009). Low-income children's school readiness: Parent contributions over the first five years. *Early Education and Development, 20*, 958–977. https://doi.org/10.1080/10409280903362402

Clarke-Stewart, K. A. (1973). Interactions between mothers and their young children: Characteristics and consequences. *Monographs of the Society for Research in Child Development, 38*(6—7). Serial No. 153.

De Wolff, M. S., & van Ijzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development, 68*, 571–591.

Dunkel, C. S., Hammersley, J. J., Waters, M. L., van der Linden, D., Merrie, L. A., & Walen, A. L. (2021). The effect of early childhood intervention on risk-taking, mental health, and cognitive ability: The mediating role of life history strategy. *Evolutionary Behavioral Sciences, 15*, 27–41. https://doi.org/10.1037/ebs0000248

Dunkel, C. S., & Woodley of Menie, M. A. (2019). Maternal sensitivity and performance and verbal intelligence in late childhood and adolescence. *Journal of Biosocial Science, 51*, 48–58. https://doi.org/10.1017/S0021932017000669

Estrada, P., Arsenio, W. F., Hess, R. D., & Holloway, S. D. (1987). Affective quality of the mother-child relationship: Longitudinal consequences for children's school relevant cognitive functioning. *Developmental Psychology, 23*, 210–215. https://doi.org/10.1037/0012-1649.23.2.210

Fagot, B. I., & Gauvain, M. (1997). Mother-child problem solving: Continuity through the early childhood years. *Developmental Psychology, 33*, 480–488. https://doi.org/10.1037/0012-1649.33.3.480

Flynn, J. R. (2016). *Does your family make you smarter?* Cambridge, UK: Cambridge University Press.

Fraley, R. C., Roisman, G. I., & Haltigan, J. D. (2013). The legacy of early experiences in development: Formalizing alternative models of how early experiences are carried forward over time. *Developmental Psychology, 49*, 109–126. https://doi.org/10.1037/a0027852

Fuligni, A. S., & Brooks-Gunn, J. (2013). Mother-child interactions in early head start: Age and ethnic differences in low-income dyads. *Parenting: Science and Practice, 13*, 1–26.

Galton, F. (1869). *Hereditary genius*. London: Macmillan.

Gao, G., & Harris, K. M. (2000). The mechanisms mediating the effects of poverty on children's intellectual development. *Demography, 37*, 431–447. https://doi.org/10.1353/dem.2000.0005

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology, 60*, 549–576.

Graham, J. W., Olchowski, A. E., & Gilreath, T. D. (2007). How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Prevention Science, 8*, 206–213. https://doi.org/10.1007/s11121-007-0070-9

Hamaker, E. L., Kuiper, R. M., & Grasman, R. P. P. P. (2015). A critique of the cross-lagged panel model. *Psychological Methods, 20*, 102–116. https://doi.org/10.1037/a0038889

Harris, J. R. (1995). Where is the child's environment? A group socialization theory of development. *Psychological Review, 102*(3), 458–489. https://doi.org/10.1037/0033-295X.102.3.458.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55. https://doi.org/10.1080/10705519909540118

Hubbs-Tait, L., Culp, A. M., Culp, R. E., & Miller, C. E. (2002). Relation of maternal cognitive stimulation, emotional support, and intrusive behavior during head start to children's kindergarten cognitive abilities. *Child Development, 73*, 110–131. https://doi.org/10.1111/1467-8624.00395

Jensen, A. R. (1998). *The g factor: The science of mental ability*. Praeger Publishers/Greenwood Publishing Group.

Kirsh, S. J., Crnic, K. A., & Greenberg, M. T. (1995). Relations between parent-child affect and synchrony and cognitive outcome at 5 years of age. *Personal Relationships, 2*, 187–198. https://doi.org/10.1111/j.1475-6811.1995.tb00085.x

Lamb, M. E. (1982). Individual differences in infant sociability: Their origins and implications for cognitive development. *Advances in Child Development and Behavior, 16*, 213–239. https://doi.org/10.1016/s0065-2407(08)60071-3

Lee, T., Henry, J. D., Trollor, J. N., & Sachdev, P. S. (2010). Genetic influences on cognitive functions in the elderly: A selective review of twin studies. *Brain Research Reviews, 64*, 1–13. https://doi.org/10.1016/j.brainresrev.2010.02.001

Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association, 83*, 1198–1202. https://doi.org/10.1080/01621459.1988.10478722

Little, T. D. (2013). *Longitudinal structural equation modeling*. The Guilford Press.

Lüdtke, O., & Robitzsch, A. (2021, July 29). *A Critique of the Random Intercept Cross-lagged Panel Model*. https://doi.org/10.31234/osf.io/6f85c

Lugo-Gil, J., & Tamis-LeMonda, C. S. (2008). Family resources and parenting quality: Links to children's cognitive development across the first 3 years. *Child Development, 79*, 1065–1085. https://doi.org/10.1111/j.1467-8624.2008.01176.x

Mcfadden, K. E., & Tamis-LeMonda, C. S. (2013). Maternal responsiveness, intrusiveness, and negativity during play with infants: Contextual play with infants: Contextual associations and infant cognitive status in a low-income sample. *Infant Mental Health Journal, 34*, 80–92. https://doi.org/10.1002/imhj.21376

Merz, E. C., Zucker, T. A., Landry, S. H., Williams, J. M., Assel, M., Taylor, … School Readiness Research Consortium. (2015). Parenting predictors of cognitive skills and emotion knowledge in socioeconomically disadvantaged preschoolers. *Journal of Experimental Child Psychology, 132*, 14–31. https://doi.org/10.1016/j.jecp.2014.11.010

Ober, T. M., & Brooks, P. J. (2022). Identifying direct and indirect influences on vocabulary development of children from low-income families from infancy to grade 5. *Cognitive Development, 62*, Article 101163. https://doi.org/10.1016/j.cogdev.2022.101163

Olson, S. L., Bates, J. E., & Kaskie, B. (1992). Caregiver-infant interaction antecedents of children's school-age cognitive ability. *Merrill-Palmer Quarterly, 38*, 309–330.

Petrill, S. A., Pike, A., Price, T., & Plomin, R. (2004). Chaos in the home and socioeconomic status are associated with cognitive development in early childhood: Environmental mediators identified in a genetic design. *Intelligence, 32*, 445–460. https://doi.org/10.1016/j.intell.2004.06.010

Plomin, R. (2018). *Blueprint: How DNA makes us who we are*. Cambridge, Massachusetts: MIT Press.

Plomin, R., & Deary, I. J. (2015). Genetics and intelligence differences: Five special findings. *Molecular Psychiatry, 20*, 98–108. https://doi.org/10.1038/mp.2014.105

Plomin, R., & Spinath, F. M. (2004). Intelligence: Genetics, genes, and genomics. *Journal of Personality and Social Psychology, 86*, 112–129. https://doi.org/10.1037/0022-3514.86.1.112

Pornprasertmanit, S., Miller, P., Schoemann, A., & Rosseel, Y. (2013). semTools: Useful tools for structural equation modeling. R Package available on CRAN. http://CRAN.R-project.org/package=semTools. Retrieved from:.

Protzko, J. (2016). Does the raising IQ-raising g distinction explain the fadeout effect? *Intelligence, 56*, 65–71. https://doi.org/10.1016/j.intell.2016.02.008

Protzko, J., Aronson, J., & Blair, C. (2013). How to make a young child smarter: Evidence from the database of raising intelligence. *Perspectives on Psychological Science, 8*, 25–40. https://doi.org/10.1177/1745691612462585

Raby, K. L., Roisman, G. I., Fraley, R. C., & Simpson, J. A. (2015). The enduring predictive significance of early maternal sensitivity: Social and academic competence through age 32 years. *Child Development, 86*, 695–708. https://doi.org/10.1111/cdev.12325

Roisman, G. I., & Fraley, R. C. (2012). A behavior-genetic study of the legacy of early caregiving experiences: Academic skills, social competence, and externalizing behavior in kindergarten. *Child Development, 83*, 728–742. https://doi.org/10.1111/j.1467-8624.2011.01709.x

Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. John Wiley & Sons Inc.

Scarr, S. (1985). Constructing psychology: Making facts and fables for our times. *American Psychologist, 40*, 499–512. https://doi.org/10.1037/0003-066X.40.5.499

Scarr, S. (1992). Developmental theories for the 1990s: Development and individual differences. *Child Development, 63*, 1–19. https://doi.org/10.2307/1130897

Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research, 25*, 173–180. https://doi.org/10.1207/s15327906mbr2502_4

Szepsenwol, O., & Simpson, J. A. (2019). Attachment within life history theory: An evolutionary perspective on individual differences in attachment. *Current Opinion in Psychology, 25*, 65–70. https://doi.org/10.1016/j.copsyc.2018.03.005

Trzaskowski, M., Yang, J., Visscher, P. M., & Plomin, R. (2014). DNA evidence for strong genetic stability and increasing heritability of intelligence from age 7 to 12. *Molecular Psychiatry, 19*, 380–384. https://doi.org/10.1038/mp.2012.191

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika, 38*, 1–10. https://doi.org/10.1007/BF02291170

Tucker-Drob, E. M., & Briley, D. A. (2014). Continuity of genetic an environmental influences on cognition across the life span: A meta-analysis of longitudinal and adoption studies. *Psychological Bulletin, 140*, 949–979. https://doi.org/10.1037/a0035893

Tucker-Drob, E. M., Briley, D. A., & Harden, K. P. (2013). Genetic and environmental influences on cognition across development and context. *Current Directions in Psychological Science, 22*, 349–355.

Tucker-Drob, E. M., & Harden, K. P. (2012). Early childhood cognitive development and parental cognitive stimulation: Evidence for reciprocal gene-environment transactions. *Developmental Science, 15*, 250–259. https://doi.org/10.1177/0963721413485087

Turkheimer, E. (2000). Three laws of behavioral genetics and what they mean. *Current Directions in Psychological Science, 9*, 160–164. https://doi.org/10.1111/1467-8721.00084

United States Department of Health and Human Services Administration for Children and Families. (2011). *Early Head Start Research and Evaluation (EHSRE) Study, 1996–2010: [United States]. Inter-university Consortium for Political and Social Research [distributor], 2011-09-27*. https://doi.org/10.3886/ICPSR03804.v5

Vallotton, C., Mastergeorge, A., Foster, T., Decker, K. B., & Ayoub, C. (2017). Parenting supports for early vocabulary development: Specific effects of sensitivity and stimulation through infancy. *Infancy, 22*, 78–107. https://doi.org/10.1111/infa.12147

Van Buuren, S. (2018). Flexible imputation of missing data. (2nd ed.). Chapman and Hall/CRC. CRC Press.

Van Buuren, S., & Groothuis-Oudshoorn, K. (2011). Mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software, 45*, 1–67. https://doi.org/10.18637/jss.v045.i03

Wadsworth, M. E. (1986). Effects of parenting style and preschool experience on children's verbal attainment: Results of a British longitudinal study. *Early Childhood Research Quarterly, 1*, 237–248.

Wilson, R. S. (1983). The Louisville twin study: Developmental synchronies in behavior. *Child Development, 54*, 298–316. https://doi.org/10.1016/0885-2006(86)90032-3

Yanagida, T. (2022). Misty: Miscellaneous functions 'T. Yanagida'. R package version 0.4.6. https://CRAN.R-project.org/package=misty.

Yarrow, L. J. (1963). Research in dimensions of early maternal care. *Merrill-Palmer Quarterly, 9*, 101–114.

Zeytinoglu, S., Calkins, S. D., Swingler, M. M., & Leerkes, E. M. (2017). Pathways from maternal effortful control to child self-regulation: The role of maternal emotional support. *Journal of Family, 31*, 170–180. https://doi.org/10.1037/fam0000271

Zeytinoglu, S., Calkins, S. D., Swingler, M. M., & Leerkes, E. M. (2019). Maternal emotional support but not cognitive support during problem-solving predicts increases in cognitive flexibility in early childhood. *International Journal of Behavioral Development, 43*, 12–23. https://doi.org/10.1177/0165025418757706