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The Ecology of Early Development: Fathers' Home Involvement and Child's Later Educational Outcomes

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Abstract
This study examined the relationship between young children's cognitive development and fathers' engagement in early childhood. The study examined fathers' home engagement patterns based on literacy, play, and caregiving activities when their children were 9-month-old and these patterns of engagement in 9-month-old were related to children's cognitive development in preschool. Latent class analysis (LCA) procedure was used to create subgroups/classes of fathers based on their actual engagement. The study employed multiple data sources from Early Childhood Longitudinal Study-Birth Cohort (ECLS-B). The data sources include a self-administered resident father survey, direct child assessment, and parent interviews. The results of the study suggested that there were five distinct classes of fathers based on their actual engagement. A total of 6.200 fathers were included in the analysis to create father classes. In the regression analysis, a total 0f 4.800 children were included. Although father classes were mostly similar, there were two distinct father classes with different actual engagement patterns based on child's gender. Although, the class of fathers with the highest likelihood of engaging their infant girls had a negative effect on girls' literacy and mathematics scale score in preschool, the results regarding children's later educational outcomes were mixed.

Keywords: Cognitive Development, ECLS-B, Father Involvement, Latent Class Analysis, Young Children

1. Introduction

During the past few decades, the roles of fathers and mothers within families have changed significantly. Starting in the 20th century, as increasing numbers of women entered the workforce, fathers had to assume more of the caretaking responsibilities (Warin, Solomon, Lewis, & Langford, 1999; Olavarri´a, 2003). Such developments altered the traditional breadwinning and caregiving roles between mothers and fathers by creating an environment where both parents assume parenting roles more equally (Carlson & Magnuson, 2011; Barbeta & Cano, 2017). Thus, the focus of father involvement has shifted from that of an indirect "breadwinning" role to the emerging concept of direct fatherhood and a fathering role.

Findings from both parental and paternal involvement research suggested that active parent involvement and a strong partnership between the home and school contribute to the healthy development of young children in early

childhood (Connors & Epstein, 1995; Powell, 1993). Such findings, in turn, helped shape our understanding of how fathers' roles contribute to the healthy development of young children.

The related literature measuring father involvement in terms of the time that fathers spend with their children could be too simplistic. While the earlier studies of father engagement measured the effects of total time fathers spend with their children (Lamb et al., 1987; Pleck & Pleck, 1997), more recent studies have chosen a different approach (Cabrera, 2020; Diniz et al., 2021; Palkovitz, 2019). This was most probably because simply focusing on the time factor limited researchers' ability to make assumptions about different types of fathering styles. Gradually, as more father involvement studies were conducted and reported, the general conceptualization of father engagement was refined.

Fathers' engagement is now described as the fathers' presence with three dimensions: responsibility, availability, and engagement (Lamb et al., 1987). Although these dimensions overlap each other to a certain degree, the majority of studies (Del Bono et al., 2016; Fomby & Musick, 2017) have generally found positive correlations between fathers' engagement and children's cognitive development and others found none (Milkie et al., 2015). It seems that fathers can engage their children through numerous activities such as playing games, preparing a meal, or reading a book and these activities could be related to positive child outcomes. The cognitive effort a child put through these activities usually helps them practice their thought process and increase their brain development (Takeuchi, et al., 2015). In and of itself, such activities can be beneficial and rewarding for children. Yet, it is the relationship between father involvement and children's cognitive development that is most noteworthy, and of particular interest to educators and researchers. In sum, father involvement and father engagement do matter, and children's cognitive development seems to benefit when their fathers consistently engage in caregiving, play, and literacy activities (Cowan, Cowan, Pruett, Pruett, & Wong, 2009; Futris & Schoppe-Sullivan, 2007). When father engage in a structured and educational activities, children seem to benefit most (Hsin & Felfe, 2014).

Despite an increasing interest in paternal involvement, few studies have examined fathers' direct roles and their effects on children's cognitive development in early childhood. Most studies (e.g., Raver, Gershoff, & Aber, 2007; Volling & Belsky, 1991) adopted a narrow approach by focusing on fathers' financial contributions and marital conflict. Typically, father involvement was examined without considering the quality of fathers' interaction with their children. Researchers associated fathers' lack of interest with old-fashioned conceptions of fatherhood, complications of working with fathers, and limited availability of data related to fathers (Lamb, 2010). The availability of large secondary data and wide ranging of information on fathers, their roles in the family, and family characteristics make it feasible to study the effects of father involvement on their children's cognitive development.

Our study is grounded in Bronfenbrenners' ecological theory of cognitive development. Bronfenbrenner's ecological model considers experience as the building blocks of human development (Bronfenbrenner & Morris, 200). Through experience, factors affecting the development and feelings attached to these factors become unique for every individual. Unique experiences of past determine the direction of human development later in life (Bronfenbrenner & Evans, 2000; Bronfenbrenner & Morris 1998).

For healthy growth and development, children need a stable environment where they are exposed to "progressively more complex reciprocal activity, on a regular basis over extended period of time" (Bronfenbrenner & Morris, 2007). Significant others play an important role in these processes by utilizing these reciprocal activities. Parents mostly assume these responsibilities, and the level of their determination and commitment ultimately shapes their children's development.

Research in psychology and education suggest that intervention is the most beneficial at early ages (Futris & Schoppe-Sullivan, 2007). It follows that economic investment in educational provision may be most fruitful in early childhood (Shonkoff & Phillips, 2000). While investing in direct educational services in early childhood will most likely be beneficial, such investments will probably prove optimal for children's cognitive development when

the whole family system is included. To this end, studying the effects of father involvement within the family system could be rewarding. This is because the majority of fathers' child-rearing activities are shaped by important factors within the complex and dynamic family system (Lamb, 2010). Positive child outcomes are most likely the products of interactions among various factors (e.g. father-mother relation, siblings, and positive atmosphere in the family).

This study aims to contribute to existing literature on fatherhood by examining father involvement in depth based on advancements in science and availability of large data. The study was guided by the following research questions:
Research Question 1: How often do fathers engage their infants and toddlers through child-bearing activities?
Research Question 2: How does fathers' home engagement with their infant children influence children's cognitive development later in early childhood?
Research Question 3: Is there evidence of significant gain in children's cognitive development in early childhood related to levels and quality of fathers' direct engagement after controlling for SES, sex, and race?

2. Method

2.1 Research Design

The study had two main goals. The first was to examine fathers' engagement patterns and to determine the nature, amount, and frequency of resident fathers' interaction and engagement with their children in early childhood. Thus, fathers' interaction and engagement were examined in a systematic manner using latent class analysis (LCA). Second, the effects of fathers' direct engagement in 9-month on children's academic achievement were examined longitudinally. The study employed a correlational study design. Correlational design helps researchers answer questions when the effects of independent variables on a dependent variable(s) are of interest (Russo, 2011; Leedy & Ormrod, 2001) among subgroups of population with different level of exposure to the same conditions. The nature and design of the ECLS-B study (NCES, 2010) allow researchers to explore prevalent conditions among groups, and help them determine if the differences in these conditions produce the observed difference in selected outcome variables.

2.2 Data

The research examined the developmental status of children who were part of a nationally representative sample of approximately 14.000 born in 2001. The sample employed in the current study included approximately 11.000 children and 8.392 resident fathers from different racial/ethnic and socioeconomic backgrounds. Only children with both parents residing in the same household were selected for the study. Sample students were selected with unequal probabilities and therefore sampling weights were used to obtain unbiased population estimates in all of the analyses. Furthermore, because of the multi-level nature of the data, the sample section was adjusted by a design effect, resulting in more conservative tests of significance.

Children's IRT-based standardized scale scores, father's home interaction and engagement, children's age at the assessment, gender, ethnicity, mother's home involvement, and socioeconomic status variables were included in the analyses. Children with a resident father
in their household were included in the cross-sectional analyses. Cases with missing outcome variables (cognitive assessment or missing cognitive assessment component) were excluded from
the analyses.

A total of 11 observed variables related to three dimensions of father involvement: (1) engagement in caregiving, (2) engagement in play and (3) engagement in literacy activities, were considered in LCA to create father engagement latent classes. There were six engagement in caregiving and 5 engagement in play and literacy activities. These activities were
1. Change your child's diaper

2. Prepare meals or bottles for your child (9-month only)
3. Feed your child or give your child a bottle (9-month only)
4. Put your child to sleep
5. Wash or bathe your child
6. Dress your child
7. Read books to your child
8. Tell stories to your child
9. Play peek-a-boo with your child (9-month only)
10. Take your child outside for a walk or to play in the yard, a park, or a playground
11. Tickle the child

These variables indicating fathers' actual engagement were used in LCA. They were recoded as dichotomous variables to examine patterns of overall engagement. These categories were based on related literature. A dichotomous variable indicating high and low involvement was created for each item. The best model was chosen based on the G^2 statistic (likelihood ratio), Bayesian Information Criterion (BIC), and Akaike's Information Criterion (AIC). LCA estimates two sets of parameters: class membership probabilities (γ's) and item-response probabilities (ρ's). Class membership probabilities are used to identify which latent class each subject most likely belongs and this is accomplished through item-response probabilities. There were significant differences in item response probabilities for boys and girls, two different LCA analysis were performed based on two genders.

2.3 Procedure

The first step of the analysis was to determine direct and bivariate associations. Fathering practices were investigated and fathering profiles were created based on those practices using LCA. LCA is useful when identifying characteristics of different class membership based on covariates (Collins & Lanza, 2010). Observed categorical variables were used to create these latent classes of fathering profiles. For each of 9-month, and preschool data collection points, a baseline model was developed. These baseline models were evaluated by examining likelihood ratio ^{2}. LCA estimated following parameters: "The item-response probabilities (p's) and the latent class prevalences (Ƴ's)" (Collins & Lanza, 2010, p.154).

In the longitudinal part of the study, the effects of fathering profiles on children's cognitive development in preschool were examined. Father involvement profiles helped the current study identify whether or not fathers' high level of home engagement and interaction influenced children's cognitive development over time. Initial models only included the outcome, fathers' classes, age-adjusted previous score, and chronological age. In the next model, controlling variables were included. Children's literacy and mathematics performance in preschool were examined in relation to father interaction and engagement level. Ordinary least square (OLS) regression models were used to analyze the relationship between fathers' direct engagement patterns and children's cognitive development. Eight models were developed for measuring fathers' engagement patterns in 9 months and 24 months on girls' and boys' literacy and mathematics performance.

2.4 Analytic Strategy

LCA is appropriate for the proposed study because its fundamental principles allow researchers to examine complex relations of underlying factors present in survey designs (Curran & Hussong, 2002). These models are quite useful for researchers who wish to examine latent trajectories contributing to the observed measures. Observed categorical variables were used to create these latent classes of fathering profiles. For each of 9-month, 2-years, and preschool data collection points, a baseline model was developed. These baseline models were evaluated by examining likelihood ratio X^2. LCA estimated following parameters: 'the item-response probabilities (p's) and the latent class prevalences (Ƴ's)" (Collins & Lanza, 2010, p. 154). The following baseline model was used for each data collection point:

"Let y = $(r_1, \ldots, r_j)$ represent the vector of a particular subject's responses to the J variables. Let L represent the latent variable with c = 1,…,C latent classes. Finally, I($y_j = r_j$) is an indicator function

that equals 1 when the response to variable j = r_j, and equals 0 otherwise and $\Upsilon_c(X)$ is a standard baseline-category multinomial logistic model(e.g., Agresti, 1990).

$$P(Y = y|X = x) = \sum_{C=1}^{C} \Upsilon_c(X) \prod_{j=1}^{J} \prod_{r_j=1}^{R_j} p_{j,r_j|c}^{I(y_j=r_j)}$$

(Collins & Lanza, 2010, p. 153).

Once probabilities for fathering profiles were calculated based on Bayes' theorem (Lanza et al. 2007), each case was assigned to a latent group and a categorical variable was created using these probabilities.

The second part of the analysis examined the development of the association between fathering profiles and children's cognitive development. The analysis was conducted to explore two latent variables: (1) fathering profile and (2) children's reading and mathematics performance test scores in preschool. The nature and level of father involvement tend to change as children develop and transition through childhood. Evaluating the complex relationship between two outcomes longitudinally (Fieuws & Verbeke, 2004) becomes feasible with the multivariate model. In the current study, we examined changes in young children's cognitive development associated with fathering profiles with consideration of socio-demographic variables. Appropriate weight were used in the analysis to minimize the effects of having unequal probabilities of being included in the survey.

The effects of fathering profiles on children's cognitive skills were analyzed using ordinary least squares (OLS) regression, because the outcome measure of interest is a continuous measure. The effects of these fathering profiles were then evaluated across ethnic groups. Children literacy and mathematics performance in preschool were examined in relation to father interaction and engagement level. Ordinary least square (OLS) regression models were used to analyze the relationship between fathers' direct engagement patterns and children cognitive development. Four models were developed for measuring fathers' engagement patterns in 9 months on girls' and boys' literacy and mathematics performance.

For the preschool year

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{Father Classes}) + \beta_{2j}(\text{Previous Score}) + \beta_{3j}(\text{Assessment Age}) + \beta_{4j}(\text{Special Education}) + \beta_{5j}(\text{Black}) + \beta_{6j}(\text{Asian}) + \beta_{7j}(\text{Hispanic}) + \beta_{8j}(\text{Multirace}) + \beta_{9j}(\text{Other}) + \beta_{10j}(\text{Region}) + \beta_{11j}(\text{SES}) + \beta_{12j}(\text{Relationship Happines}) + \beta_{13j}(\text{Mother Inv. Index}) + \beta_{14j}(\text{Children under 18}) + \beta_{15j}(\text{Mother Work Status}) + \beta_{16j}(\text{Father's Age}) + r_{0i}$$

β_{0j} is the predicted preschool mathematics or reading scale score for White girls (or White boys) with LIF fathers, with no special education status, from Northeast region, with happy parent reported relationship status, with mothers who work more than 35 hours.

$\beta_{1j}(\text{Father Classes})$ is the slope used to compare each of four classes of fathers versus LIF fathers on preschool mathematics or literacy performance after controlling for race, socioeconomic status, mental score in 9-month or 2-year, assessment age, mother involvement, special education status, relationship happiness, children in the household under 18 years old, mother's work status, and father's age.

$\beta_{2j}(\text{Previous Score})$ is the effect of age-adjusted previous mental score (9 month or 2 year) on preschool mathematics or literacy performance after controlling variables listed in $\beta_{1j}(\text{Father Classes})$.

$\beta_{3j}(\text{Assessment Age})$ is the effect of assessment age in months on preschool mathematics or literacy performance after controlling variables listed in $\beta_{1j}(\text{Father Classes})$.

$\beta_{4j}(\text{Special Education})$ is the slope used to compare children with reported special education status versus children with no reported special education status on preschool mathematics or literacy performance after controlling variables listed in $\beta_{1j}(\text{Father Classes})$.

β_{5j}(Black) is the slope used to compare Black children versus White children on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{6j}(Asian) is the slope used to compare Asian children versus White children on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{7j}(Hispanic) is the slope used to compare Hispanic children versus White children on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{8j}(Multirace) is the slope used to compare children with multiracial race versus White children on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{9j}(Other) is the slope used to compare children in other race group versus White children on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{10j}(Region) is the slope used to compare each of three regions versus Northeast region on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{11j}(SES) is the slope used to compare each of four remaining SES quintiles versus SES quintile on preschool mathematics or literacy performance after after controlling variables listed in β_{1j}(Father Classes).

β_{12j}(Relationship Happines) is the slope used to compare no-relationship happiness versus yes-relationship happiness on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{13j}(Mother Inv. Index) is the effect of mother's involvement index on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{14j}(Children under 18) is the effect of children under 18 years old in the household on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{15j}(Mother Work Status) is the slope used to compare each of three remaining mother work status versus mothers who work more than 35 hours on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

β_{16j}(Father's Age) is the effect of father's age on preschool mathematics or literacy performance after controlling variables listed in β_{1j}(Father Classes).

r_{0i} is the unexplained residual variance after controlling variables listed in β_{1j}(Father Classes).

3. Results

LCA analysis results based on G^2 statistic, AIC, and BIC values confirmed the model five classes as the best fit. The current study found differences in fathers' actual engagement based on child's gender when infants are around 9-month-old. Item response probabilities for fathers' likelihood of engaging in activities for girls and boys are displayed in Table 1 and Table 2, respectively. Although the majority of father classes were similar for boys and girls, there were two distinct groups of fathers who exhibited different engagement patterns for boys and girls. None of the father classes were likely to engage in literacy activities with their infant daughters while one group of fathers was highly likely to perform literacy activities with their infant sons.

Some fathers were highly engaged in caregiving activities, some only engaged their infants through play activities and others engaged their infants through combination of caregiving, play and literacy activities. Additionally, some fathers engaged in less-occurring caregiving and play activities. Analyses also revealed that a group of fathers simply avoided engaging their infants through these activities.

An overview of father classes are shown in Table 4. First father group named as daily playful caregiver (DPC) as they were involved in most caregiving activities and play with the child sometimes but avoid literacy activities. Second group, primary playful caregiver (PPC), performed all caregiving activities and play with the child but avoided literacy activities. Third group was "occasional caregiver" (OC) and this group of fathers performed less-occurring caregiving activities, played games like tickle the child and take the child for outside play, and avoided literacy activities.

3.1 Father Profiles

Separate LCA analysis for infant girls and boys were conducted. The results of the analysis are further discussed below for each group.

3.1.1 Fathering profiles for girls at 9-months.

In the 9-Month LCA sample, there were 3.000 girls with biological resident fathers. More than half of the fathers were White (60.7 %), 8.21 % were Black, and 12.43 % were Asian and 16.97% were Hispanic. The first class of fathers (22.84%) had high probabilities of involving in four caregiving activities, the highest probabilities of reading books and telling stories, and likely to take child outside to play and tickle the child. These fathers highly valued literacy activities and were named as "daily playful caregivers" (DPC). The second group of fathers (21.88%) highly valued caregiving activities and play activities, but less likely to read books and tell stories, and were named as "primary playful caregivers" (PPC). The third class of fathers (21.39%) were likely to engage in some caregiving activities and some play activities, and were named as "occasional caregivers (OC)". The fourth class of fathers (7.3%) were named as "average playful" (AP) fathers as they had high probability of engaging their child only in three play activities. AP fathers were an exclusive class of fathers for girls. The last group of fathers was the least likely to be involved in any of the activities except for tickling the child and was named as "low involving" (LI) fathers. This group of fathers was used as base group in OLS regression analysis. A brief summary of all father classes for girls is shown in Table 2.

3.1.2 Fathering profiles for boys at 9-months.

In the 9-month LCA sample there were 3.000 boys with biological resident fathers. More than half of fathers were White (56.4 %), 7.8 % were Black, and 14.5 % were Asian and 15.8 % were Hispanic. The model with five latent class had the best fit for the data. Out of five fathers classes four classes of fathers were showed similar characteristics to those of girls. These classes of fathers were DPC fathers (19.52%), PPC fathers (27.41%), LI fathers (28.47%), and OC fathers (20.12%). The fifth class of fathers were exclusive for boys and showed distinct characteristics as they were highly likely to be involved in all 12 activities and was named as "highly engaged caregiver" (HEC). This group of fathers represented 4.47% percent of all fathers in the analysis. A brief summary of all father classes is shown in Table 2.

3.2 Father Profiles and Children's Preschool Literacy Performances

The results of regression analyses for literacy scores are shown in Table 5. In the first model, father profiles were regressed on girls' literacy scores without control variables and then, the analysis proceeded with the second model that included control variables. In the third model, father profiles were regressed on boys' literacy scores and father profiles on boys' literacy scores with control variables included. Father profiles with lowest involvement patterns (LI fathers) were used as the reference class in all four models. Due to the differences in the nature of father profiles in 9-month, the results were presented based on gender and a comparison between boys and girls were discussed in the following section.

In Model 1, the effects of fathering profiles on girls' literacy scores were examined after controlling only for age adjusted 9-month mental score and assessment age when literacy test was administered. The results indicated that the initial model explained 8.1% of the variance (R^2=0.08, F(6,84)=26.53, p<.01). With the LI fathers as the reference group, DC father class was significantly related to the children's literacy performance at 9-months. Interestingly, three father classes had negative effects on girls' literacy scores in preschool years. Girls with DC fathers scored 9% less than girls with LI fathers and girls with AP fathers also scored 6.5% less than those with LI fathers. OC and PP fathers were not significantly related to the outcome. Both age- adjusted 9-month mental score and assessment age in preschool data wave were significantly related to literacy score.

In the next model, control variables; age-adjusted 9-month mental score, child's age at preschool assessment, child's race, special education at 9-month, family characteristics and father characteristics; were included. The initial model explained 33% of the variance (R^2=0.33, F(26,64)=41.86, p<.01). Two of the father classes, DC and AP, were still significantly related to girls' literacy scores. Girls with DC fathers scored 6.3% less and those with AP fathers scored 5.5% less than those in the reference group. The remaining two father groups were not significantly related to the outcome. Among the child characteristics, special education status was not significant but assessment age in preschool and age adjusted 9-month score were significantly related to girls' literacy scores. There were some differences among race groups; Asian girls scored 4.2% higher than those girls in the reference group. Additionally, girls in the West region scored 10% lower compared to the reference group. Socioeconomic status of the family was significantly related to the girls' literacy scores; each increase in SES level was significantly and gradually related to the outcome. Relationship happiness was not significantly related to girls' literacy scores. Mother involvement index was significant and the girls whose mothers were involved more scored better. The number of children under 18-years old in the household was also related to the outcome and as the number of children increased, the girls' literacy score was affected negatively. Mothers' work status was not significantly related to girls' literacy scores in 9-month. Lastly, girls with older fathers scored better on literacy assessment.

In Model 2, father profiles were, first, regressed on boys' literacy scores with assessment age in preschool and age-adjusted 9-month mental score and then, proceeded with the model in which children, family, and father characteristics for literacy scores were included. The same convention was followed with Model 2. Again, fathers with lowest involvement pattern (LI fathers) were assigned as the reference group in all four models. In the initial model, 8% of variance was explained (R^2=0.08, F(6,84)=41.86, p<.01). Boys with PP fathers scored about 0.07% less than the reference group. Remaining father groups were not significantly related to boys' literacy scores in preschool. Age-adjusted 9-month mental score was significant and it meant boys who had higher previous scores performed better on preschool literacy assessment. Children's age during the assessment in preschool also contributed to their literacy scores; older children simply performed better.

In the model with father profiles, child characteristics, family characteristics, and father characteristics included, PPC fathers were no more related to the outcome. In this model, 34% of the variance was explained (R^2=0.33, F(26,64)=41.86, p<.01)As expected, age-adjusted previous score and assessment age in preschool were positively related to boys' literacy score in preschool. Special education status was not related to the outcome. Black boys scored 6.2% more, and Hispanic boys scored 11% less than those White boys in the reference group. A close examination of family characteristics in Model 2 revealed that relationship happiness at 9- months was not related to boys' literacy scores in preschool. Boys in the South and West regions scored 8.4% and 6.7% less than those in the reference group. SES findings were similar to the previous model; each level of increase in the SES quintile was associated with better literacy scores in a gradual fashion with the exception of the second SES quintile. Mother index, as it was with girls' literacy and mathematics model, was also related to boys' success in literacy; higher mother involvement yielded better literacy scores for boys. The number of children under 18 years old in the household was again significant and as the number of children increased in the house, boys' literacy scores suffered. Mothers' work status was significantly related to the boys' literacy performances. Father's age, interestingly, was not related to the children's literacy score in the preschool assessment.

Using the adjusted Wald test, father classes were also compared to each other. In the girls' literacy models, none of the father classes were significantly different than each other. In the literacy model for boys, DC and PP fathers were significantly different than each other. In the next part, regression results of 9-month father profiles on boys' and girls' mathematics scores in preschool were discussed.

3.3 Father Profiles and Preschool Mathematics Performance

Table 6 displays regression analysis results for girls' father profiles on mathematics score including only adjusted 9-month mental score and assessment in preschool. This model explained 12% variance (R^2=0.12, F(6,84)=26.94, p<.01). Girls with DP fathers scored 2.17 points less and girls with PP fathers scored 2.74 points less on mathematics assessment compared to those in the reference group with LI fathers. OC fathers and AP fathers were not significantly related to girls' mathematics scores. Age adjusted 9-month mental score and assessment age in preschool were significantly and positively related to girls' mathematics scores in preschool.

The full model included child characteristics, family characteristics, and father characteristics; and explained 30% variance (R^2=0.30, F(26,64)=42.54, p<.01). Unlike the results from the regression analysis for literacy scores, two father classes, DP and PP fathers, were significantly related to girls' mathematics scores. Girls with DP fathers and girls with PP fathers scored 1.67 points and 1.9 points less, respectively than those in the reference group. OC fathers and AP fathers were not related to the outcome. Girls with better age-adjusted previous mental scores had better mathematics scores in preschool. Also, age at assessment was significantly and positively related to the outcome, simply stated: older girls scored higher. Special education status in 9-month was not related to girls' mathematics scores in preschool. Asian girls were significantly different from the reference group. Asian girls scored 2.6 more than White girls in the reference group.

There were some regional differences among girls' performance; the Northeast region was assigned as the reference group and girls in the remaining three groups, Midwest, South and West, scored 1.7, 1.4 and 1.66 points less than those in Northeast region, respectively. SES level, again, was significantly related to girls' mathematics scores and there was a significant score increase associated with quintiles. The coefficient for relationship happiness was also not related to the outcome in this model. Mother involvement index at 9-month was related to better mathematics scores for girls in preschool years, while the number of children under 18 years old in the household had a negative effect on girls' mathematics scores. Interestingly, the mothers' work status at 9-month was not related to better mathematics score for girls in preschool. Lastly, as fathers' age increased, their daughters seemed to get better scores on the mathematics assessment in preschool years.

In Model 4, father profiles were regressed on boys' mathematics scores only controlling for age-adjusted 9-month mental score and assessment age in the preschool wave, and about 11% variance was explained (R^2=0.11, F(6,84)=18.60, p<.01). Consistent with the findings in the previous reading model, PP fathers had a negative influence on boy's mathematics scores, and these boys scored 1.86 points less than those in the reference class with LI fathers. Higher age-adjusted mental scores and maturity both signified higher scores in preschool mathematics assessment.

In Model 4, once control variables were in the model, 31% of variance was explained (R^2=0.31, F(26,64)=38.77, p<.01). Father class PP lost its significance and they were no more related to the outcome. Age-adjusted 9-month mental score and assessment age in preschool were both significantly and positively related to the outcome, as in Model 3. Special education status was not related to the outcome consistent with previous models for both girls and boys. There were some differences among race groups. Asian boys scored 2.56 points more, while Hispanic boys scored 1.76 points less than White boys in the reference group. Additionally, there were not any significant differences between Black and White boys. Unlike previous models, there were no regional differences among boys' mathematics scores at 0.5 significance level in the full model. Second SES quintile was not related to the outcome, which was inconsistent with previous models. However, remaining quintiles signified a gradual score increase on boys' mathematics score in preschool.

Consistent with the previous models, parents' relationship happiness did not impose any effects on the outcome. Mother involvement index again signaled a positive impact on boys' performance and the inverse relationship of number of children under 18 years-old in the household persisted. Although fathers' maturity was a significant player for girls and their performance on reading and mathematics, it was not significant for boys' performance on mathematics in preschool, consistent with the boys' reading model. The adjusted Wald test did not reveal any differences among father classes in 9-month mathematics model for girls and boys.

4. Discussion

The current study found that differences in fathers' actual engagement based on children's gender when infants are around 9-month old. Fathers' engagement behavior may differ based on children's gender and this is consistent with the findings from other research (Furstenberg & Weiss, 2000). Although the majority of father classes were similar for boys and girls, there were two distinct groups of fathers who exhibited different engagement patterns for boys and girls. None of the father classes were likely to engage in literacy activities with their infant daughters while one group of fathers was highly likely to perform literacy activities with their infant sons. One possible reason for this finding could be that some fathers could place more value on raising their infant-son and therefore engage in more caregiving, play and literacy activities with their sons (Amato, 1994).

Some fathers were highly engaged in caregiving activities, some only engaged their infants through play activities and others engaged their infants through combination of caregiving, play and literacy activities. Additionally, some fathers engaged in less-occurring caregiving activities and play activities. Analyses also revealed that a group of fathers simply avoided engaging their infants through these activities. The differences in father engagement patterns could be explained by cultural differences. For example, a specific culture may value fatherhood more than others do and encourage fathers' engagement as much as possible (Chen, Liu, & Li, 2000). Another possible explanation could be that fathers' beliefs and attitudes toward child-rearing could affect their actual engagement. Clearly, providing a definitive explanation for such findings is beyond the scope of this study; therefore further research is recommended.

Surprisingly, DPC fathers who had the highest likelihood of engaging their infant children had generally negative effects on girls' literacy and mathematics scale scores in preschool. This finding did not hold true for boys. One possible explanation for this effect may be that fathers actually engage their infants significantly more because their mothers were unable to do so for some reason. Considering the importance of infants' emotional attachment to their mothers (Freeman, Newland, & Coyle, 2010), lacking mothers' attention might be taking a toll on their cognitive development throughout early childhood. It is obvious that there are differences in boys' literacy and mathematics performances, and boys' somehow avoid this negative effect in terms of their mathematics performances in preschool. This may be associated with the differences in the nature of learning reading and mathematics. Young children are quite capable learners and they may be able to construct their own knowledge and mathematical concepts such as quantity and symbols naturally may make sense to them (NAEYC, 2010).

5. Recommendations for Future Research

Children's cognitive development is only one dimension of early experience. Studying the effects of fathers' actual involvement on children's social and emotional development is also necessary, as these dimensions contribute to the healthy development of children throughout their lives. For future studies, we believe more qualitative studies should investigate the nature of emotional attachment between a father and a child. Once there are data available on this issue, researchers should be able to more precisely identify and measure the effects of fathers on their children.

Considering the benefit of early cognitive development on children's later academic achievement, researchers continue to investigate the nature of fatherhood and its connection to the children's development. Further research are needed to investigate the effects of fatherhood over time. Thus far, there are some studies that have measured

this effect in early childhood. Far fewer studies have measured these effects across and individual's lifespan. While such studies could be challenging for researchers they could yield interesting findings. For example, in a recent study, researchers found that fathers' early involvement had effects on children's emotional development and social adjustment in early adulthood (NICHD, 2004; Carpendale & Lewis, 2006). More studies similar to the aforementioned one are needed to determine how these early factors affect later development, and how society benefits from these positive effects.

Table 1: Model comparison fori Infant girls and infant boys

	Girls				Boys			
Number of Classes	Degrees of Freedom	Likelihood Ratio G^2	AIC	BIC	Degrees of Freedom	Likelihood Ratio G^2	AIC	BIC
2	2024.00	3372.64	3418.64	3556.91	2024.00	3046.86	3092.86	3232.46
3	2012.00	2643.96	2713.96	2924.37	2012.00	2440.40	2510.40	2722.84
4	2000.00	2139.39	2233.39	2515.94	2000.00	1881.38	1975.38	2260.65
5	**1988.00**	**2014.04**	**2132.04**	**2486.73**	**1988.00**	**1690.78**	**1808.78**	**2166.89**
6	1976.00	1937.04	2079.04	2505.87	1976.00	1611.42	1753.42	2184.37

Table 2: Item response probabilities for girls at 9-month

Item	DPC Fathers 22.84%	PPC Fathers 21.88%	OC Fathers 21.39%	AP Fathers 7.3%	LI Fathers 26.76%
Changing Diaper	**0.746**	**0.945**	0.436	0.038	0.062
Preparing Bottles	**0.935**	**0.977**	0.165	0.002	0.029
Feeding the Child	**0.948**	**0.976**	0.132	0.120	0.011
Putting to Sleep	**0.712**	**0.977**	**0.648**	0.378	0.183
Washing the Child	0.441	**0.981**	**0.772**	0.164	0.173
Dressing the Child	0.472	**0.920**	**0.520**	0.008	0.031
Reading Book	0.050	0.177	0.140	0.101	0.000
Telling Stories	0.060	0.237	0.134	0.206	0.005
Playing Peek a Boo	0.399	**0.658**	0.297	**0.579**	0.031
Tickling the Child	**0.940**	**0.934**	**0.910**	**0.892**	**0.593**
Outside Play	**0.512**	**0.952**	**0.755**	**0.541**	0.323

Table 3: Item response probabilities for boys at 9-month

	DPC Fathers % 19.52	PPC Fathers % 27.41	HEC Fathers % 4.47	LI Fathers % 28.47	OC Fathers % 20.12
Changing Diaper	**0.746**	**0.942**	**0.927**	0.079	0.338
Preparing Bottles	**0.916**	**0.941**	**0.851**	0.032	0.072
Feeding the Child	**0.810**	**0.989**	**0.970**	0.020	0.138
Putting to Sleep	**0.669**	**0.962**	**0.874**	0.198	**0.656**
Washing the Child	**0.526**	**0.942**	**0.875**	0.176	**0.710**
Dressing the Child	0.394	**0.958**	**0.929**	0.035	0.477
Reading Book	0.020	0.028	**0.856**	0.012	0.118
Telling Stories	0.056	0.086	**0.729**	0.040	0.109

Playing Peek a Boo	0.268	**0.619**	**0.719**	0.097	0.358
Tickling the Child	**0.882**	**0.979**	**0.926**	**0.661**	**0.857**
Outside Play	**0.528**	**0.843**	**0.937**	0.387	**0.812**

Table 4: Overview of father classes

Father Classes	Characteristics
Daily Playful Caregiver (DPC):	■ Involve in most caregiving activities ■ Play with the child sometimes but avoid literacy activities
Primary Playful Caregiver (PPC):	■ Perform all caregiving activities ■ Play with the child but avoid literacy
Occasional Caregiver (OC):	■ Performs less-occurring caregiving activities ■ Tickle the child and take the child outside for play. ■ Avoid literacy activities
Average Playful (AP): Girls Only	■ No caregiving activities ■ No literacy activities ■ Perform all play activities
Low Involving (LI):	■ Likely to avoid all caregiving, play, and literacy activities ■ Only little play
Highly Engaged Caregiver (HEC): Boys Only	■ Perform all caregiving activities ■ Substantial play with the child ■ Only class of fathers who likely perform literacy activities

Table 5: Regression results for 9-month on preschool literacy

	Literacy – Girls				**Literacy – Boys**			
	Model 1				**Model 2**			
Variables	B	se	b	Se	B	Se	b	Se
DPC fathers	-0.082*	0.03	-0.06*	0.03	0.03	0.05	0.07	0.04
PPC fathers	-0.07	0.04	-0.03	0.03	-0.06*	0.03	-0.01	0.03
OC fathers	-0.02	0.03	-0.03	0.03				
HEC fathers					0.06	0.05	0.07	0.04
AP fathers	-0.08*	0.04	-0.07*	0.04	0.03	0.03	0.03	0.04
Child								
Previous Score	0.04**	0.01	0.022*	0.01	0.04***	0.01	0.02**	0.01
Assessment age	0.02***	0.00	0.03***	0.00	0.02***	0.00	0.03***	0.00
Special ed. (YES)			0.07	0.12			0.04	0.05
Multirace			0.04	0.05			-0.02	0.05
Asian			0.09**	0.03			0.08	0.04

Hispanic			-0.12	0.06			-0.11***	0.03
Black			0.03	0.04			0.10*	0.04
Other			-0.07	0.04			-0.11	0.11
Family								
Region – Midwest			-0.04	0.03			-0.05	0.03
Region – South			-0.03	0.03			-0.07*	0.03
Region – West			-0.09**	0.03			-0.06*	0.03
SES 2			0.11**	0.03			0.08	0.04
SES 3			0.21***	0.04			0.17***	0.04
SES 4			0.28***	0.05			0.26***	0.04
SES 5			0.39***	0.04			0.40***	0.04
Rel happiness (NO)			-0.01	0.07			-0.06	0.06
Mother inv. Index			0.02***	0.01			0.03**	0.01
Children under 18			-0.06***	0.01			-0.05***	0.01
Mother work status								
Less than 35 hrs			0.01	0.02			0.05	0.04
Looking for work			0.00	0.05			0.00	0.04
Not in the labor force			0.03	0.02			0.03	0.03
Father's age			0.01***	0.00			0.00	0.00
_cons	2.08***	0.24	1.36***	0.14	1.906***	0.18	1.43***	0.16
r2	0.08		0.33		0.08		0.34	
N	2350.00†		2350.00 †		2450.00 †		2450.00 †	
F	26.53		41.86		20.52		40.35	

Note. *$p < .05$. **$p < .01$. ***$p < .001$

Note. † Sample sizes were rounded to nearest 50 as required by NCES

Table 6: Regression results for 9-month on preschool mathematics

	Girls				**Boys**			
	Model 3				**Model 4**			
Variables	b	Se	B	Se	B	Se	B	Se
DPC fathers	-2.17***	0.59	-1.67**	0.52	-0.444	0.84	0.38	0.75
PPC fathers	-2.74***	0.62	-1.89**	0.6	-1.86*	0.83	-0.59	0.64
OC fathers	-0.88	0.87	-1.11	0.66				
HEC fathers					-0.55	1.49	-0.08	1.31
AP fathers	-1.309	0.86	-1.02	0.77	0.48	0.9	0.47	0.83
Child								
Previous Score	0.97**	0.33	0.62**	0.22	1.07***	0.25	0.71**	0.22
Assessment age	0.72***	0.1	0.85***	0.05	0.75***	0.1	0.84***	0.07
Special ed. (YES)			2.42	2.45			0.41	1.62
Multirace			-0.32	1.14			-1.65	0.99
Asian			2.78***	0.72			2.55*	1.03
Hispanic			-2.00	1.26			-1.65*	0.67
Black			0.54	1.12			0.59	1.03
Other			-1.91	1.27			-3.81	2.56
Family								
Region – Midwest			-1.61	0.89			-0.36	0.66

Region – South			-1.30	0.77			-0.93	0.67
Region – West			-1.57*	0.75			-0.45	0.7
SES 2			1.84	1.17			1.48	1.22
SES 3			4.08**	1.46			4.10***	1.02
SES 4			5.88***	1.37			6.78***	1.06
SES 5			8.71***	1.2			9.99***	1.39
Rel happiness (NO)			-0.67	3.35			-0.21	1.19
Mother inv. index			0.45*	0.18			0.39	0.21
Children under 18			-1.16***	0.23			-0.81***	0.17
Mother work status								
Less than 35 hrs			-0.19	0.6			0.70	1
Looking for work			-0.73	1.11			-0.63	1
Not in the labor force			0.02	0.56			0.08	0.63
Father's age			0.09*	0.05			0.04	0.03
_cons	-5.02	5.45	-19.83***	3.01	-8.40	5.06	-20.05***	4.22
r2	0.118		0.305		0.111		0.312	
N	2350 †		2350 †		2450 †		2450 †	
F	26.937		42.538		18.602		38.768	

Note. *$p < .05$. **$p < .01$. ***$p < .001$

† Sample sizes were rounded to nearest 50 as required by NCES

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Notes

Note 1. This study is based on author's previously published doctoral thesis.