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The effect of mother-child interaction at six months on executive functioning at twenty-four months.

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Abstract

Research has shown that mother-child interaction influences children’s later development. While the effects of mother-child interaction on executive functioning have been examined previously, no studies were found examining the effect of mother-child interaction at 6 months on executive functioning at 24 months. In the present study this relationship was examined. During a home visit 227 mother-child dyads were videotaped in three different situations (i.e. free play, diaper change and, face-to-face). Interactions were rated using the NICHD-scales. At 24 months executive functioning was assessed using the BRIEF-P questionnaire. Results show no significant relationships between mother-child interaction domains (i.e. maternal sensitivity, positive regard and negative regard) and cognitive functioning. Also no relationship was found between interaction and inhibitory self-control, flexibility and emergent metacognition. Future research to examine the relationship using a more varied sample may give more insight into the relationship between the two.
The Effect of Mother-Child Interaction at Six Months on Executive Functioning at Twenty-four Months

Parents have a great influence on their children’s development (Maccoby, 2000). The early parent-child relationship influences children’s later social, social-emotional, and cognitive development (LeRoy, Mahoney, Pargament, & DeMaris, 2013; Lugo-Gil & Tamis-LeMonda, 2008; Maccoby, 2000; Sroufe, 2005). A poor parent-child relationship was also found to be a risk factor for poor health of the child later in life (Stewart-Brown, Fletcher, & Wadsworth, 2005). Lugo-Gil and Tamis-LeMonda (2008) found a relationship between parenting quality and children’s cognitive functioning at 14, 24, and 36 months. After controlling for earlier measures of parenting quality, family resources and child performance, the relationship between parenting quality and cognitive performance at 24 and 36 months continued (Lugo-Gil & Tamis-LeMonda, 2008).

Different aspects of the relationship between mother-child behaviour and children’s development have been examined (Assel et al., 2002; Main, 1983; Kelly, Morriset, Barnard, Hammond, & Booth, 1996). Maternal behaviour influences children’s later social, social-emotional, cognitive, and executive functioning (Assel et al., 2002; Bernier, Carlson, & Whipple, 2010; Kelly et al., 1996; Landry, Miller-Loncar, Smith, & Swank, 2010; Main, 1983; Murray & Hornbaker, 1997). Mother-child attachment at 12 months old seemed to be related to cognitive functioning at 21 months old. Securely attached children were found to have a larger vocabulary and used more verbal spontaneous self-direction. They were also more playful and had larger attention spans (Main, 1983).

Research also showed that mother-child interaction influenced children’s later cognitive functioning (Main, 1983; Kelly et al., 1996). Murray and Hornbaker (1997) examined the relationship between maternal interaction styles and cognitive and language development of infants at 12 and 24 months. Maternal interaction was rated for directiveness,
sensitivity, and elaborativeness. They found that maternal interaction style at 12 months was related to cognitive development of the infant at 12 and 24 months old. An elaborative maternal interaction style at 12 months positively predicted later cognitive development (Murray & Hornbaker, 1997). Kelly et al. (1996) also found a relationship between mother-child interaction and cognitive functioning. In this research mother-child interaction was observed at 12 and 20 months old and cognitive outcomes were measured at 3 and 5 years. The outcomes showed that elements of mother-child interaction were related to children’s cognitive functioning at 3 and 5 years old. Results indicated that the interaction quality is a predictor of preschool cognitive outcomes (Kelly et al., 1996).

A critical component in children’s cognitive and social development is executive function (Carlson, Davis, & Leach, 2005). Executive functions are the central control, supervisory and self-regulatory abilities of the child that organize their cognitive activity, emotional response, and overt behaviours (Isquith, Crawford, Epsy, & Gioia, 2005). Executive functions are processes that monitor and control thought and action (Carlson et al., 2005). These skills emerge at an early age and show ongoing development during childhood and adolescence, as the brain matures (Anderson, 1998). Earlier research found relationships between executive functioning and different factors, such as gender (Klenberg, Korkman, & Lahti-Nuuttila, 2001), having child-aged sibling (younger than 12 years) (McAlister & Peterson, 2006) and parents’ level of education (Ardila, Rosselli, Matute, & Guajardo, 2005).

The relationship between early verbal output and executive functioning has been examined in previous research. This research found that mother’s early verbal input influences children’s later executive functioning. Landry et al. (2010) examined the relationship between mother’s verbal input on later executive functioning. Scraffolding, verbal input providing information about associations between objects and actions, was measured at the age of 3 and 4 years old. Language, memory and nonverbal problem-solving
skills were measured as prerequisites for executive functioning at the age of 4. When the
children were 6 years old executive processing skills were measured. They found that
mother’s scaffolding at 3 years indirectly influenced executive functioning at 6 years old by
directly influencing children’s language and nonverbal problem-solving skills when they were
4 years old (Landry et al., 2010). This study did not include other mother-child interaction
aspects.

Children’s executive functioning was also found to be influenced by mother-child
interaction (Bernier et al., 2010; Landry et al., 2010). Bernier, Carlson, & Whipple (2010)
investigated the link between early parent-infant interactions and children’s later executive
functioning in 80 mother-child dyads. They found that maternal sensitivity, mind-mindedness
and autonomy support at 12 to 15 months old influenced executive functioning at both 18 and
26 months. Higher parent-infant interaction quality was found to have a positive effect on the
children’s working memory, impulse control and set shifting (Bernier et al., 2010).

A lot of research has been done including mother-child interaction in the first year of
life. However all studies that examined the relationship between mother-child interaction and
executive functioning, measured interaction when the child was at least one year old. No large
studies were found examining the relationship between specific mother-child interaction
aspects, rated in different situations at the age of 6 months, and executive functioning
outcomes at 24 months. This study examines the effects quality of mother-child interaction at
6 months on executive functioning at 24 months.

Based on results of earlier studies it is expected that high maternal sensitivity has a
positive effect on all different executive functioning domains (i.e. inhibitory self-control,
flexibility and emergent metacognition) and on total executive functioning. Both high positive
regard and low negative regard in mother-child interaction are expected to have a positive
effect on inhibitory self-control, flexibility, emergent metacognition, and total executive functioning.

Method

Participants

This part of the study ‘Expectant Parents’ by Maas, Vreeswijk, De Cock, Rijk, & Van Bakel (2012). This longitudinal study examines the prenatal risk factor and postnatal infant development, parenting and parent-infant relationship. The sample of the current study consist of 227 mother-child dyads. Dyads were only included if interaction was observed and the BRIEF-P questionnaire was scored.

From the 227 infants 119 infants were male (52%) and 108 infants were female (48%). Mean age of the infants at the home visit was 6.07 months, ranging from 5.32 months to 7.29 months. At the measurement of executive functioning mean age of the children was 24.23 months, ranging from 23.33 to 27.01 months. Mean age of the mothers at the home visit was 33 years, with the youngest mother being 18 years of age and the oldest mother 42 years. Most mothers were unmarried but living with a partner (53%), 42% of the mothers were married, 2% were single and 2% was with a partner but living alone. Majority of the mothers were highly educated (68%) and received 9 years or more education after primary school. A smaller part of the mothers (26%) received 5 to 8 years education after primary school and only 6% received 0 to 4 years of education after they left primary school. Most mothers were working at the time of the study (89%). Most infants were only child at the time of study (54%), 46% had one of more siblings.

Procedure

Data was retrieved by three researchers from the study ‘Expectant Parents’ (Maas et al., 2012). Participants were visited at their homes when the children were 6 months old. Mother-child interaction was videotaped in three different situations. In the first situation the
examiner asked the mother to interact with her child face-to-face without toys for 2 minutes, with the child sitting in front of the mother. In the second situation mother and child played with a given set of toys during 7 minutes. In the third situation a caregiving situation, mother changing the infants’ diaper, was recorded. Mothers were asked to interact in the way they normally do. Most dyads were videotaped in this order (68%), other dyads were observed in different order.

Mother-child interaction quality was rated by two researchers, independently using the NICHD-scales. When the children were 24 months old, the BRIEF-P questionnaire examining executive functioning was filled out by parents. This questionnaire was send to the participants one or two weeks before the infant was 24 months of age. The questionnaire was available in Dutch or English. Parents who failed to return the questionnaire were send a reminder.

**Instruments**

*Mother-child interaction.* The quality of mother-child interaction was rated on eight interaction aspects using the Qualitative Scales of the Observational Ratings of Mother-Child Interaction of the National Institute of Child Health and Human Development (NICHD scales) (NICHD, 1999).

Mother-child interaction dimensions were rated on a 7-point rating scale ranging from 1 = very low to 7 = very high. Ratings were based on both quality and quantity of behaviours. The NICHD measures eight aspects of maternal interaction behaviour: Sensitivity to distress, Sensitivity to non-distress, Intrusiveness, Detachment, Stimulation of development, Positive regard, Negative Regard and Flatness of affect. For the recent study only two aspects of maternal interaction behaviour were used, being 1) *Positive regard:* the degree to which mother expresses positive feelings; 2) *Negative regard:* assessment of mothers disconnectedness and disapproval to the child (NICHD, 1999). A maternal sensitivity
composite score was computed for every situation using the sum of Sensitivity to non-distress (quality of mother’s reaction to child’s social gestures, expressions and signals), Intrusiveness reverse coded (the degree to which the mother is over controlling and overinvolved) and Positive regard (the degree to which mother expresses positive feelings).

Higher scale scores indicate higher quality of mother-child interaction on the scale positive regard and the maternal sensitivity composite score. On the Negative regard scale a lower scale score indicates higher quality of the mother-child interaction (NICHD, 1999). Cronbach’s alpha of maternal sensitivity composite was .76 for the free play situation, .72 for the diaper change situation and, .74 for the face-to-face situation.

**Executive functioning.** Executive functioning was measured at 24 months using the Behaviour Rating Inventory of Executive Function Preschool version (BRIEF-P) (Gioia, Espy, & Isquith, 2002). The BRIEF-P is a rating scale for executive functioning domains. The BRIEF-P measures five subscales: 1) **Inhibit:** the ability to resist impulses and stop behaviour at the appropriate time, 2) **Shift:** the ability to move freely between situations, activities or aspects of a problem as circumstances demand, 3) **Emotional control:** the ability to modulate or control emotional responses, 4) **Working memory:** the ability to hold information in mind for the purpose of completing a task, encoding information or generating goals, plans and steps for achieving goals, 5) **Plan/organize:** ability to manage current and future task demands within the situational context. Based on these subscales three overlapping indexes can be measured: 1) **Inhibitory self-control** (Inhibit and Emotional control): the ability to modulate actions, responses, emotions and behaviour through appropriate inhibitory control; 2) **Flexibility** (Shift and Emotional control): the ability to move flexibly between different actions, responses, emotions and behaviour; 3) **Emergent metacognition** (Working memory and Plan/organize): ability to hold ideas and activities in the working memory and to plan and organize problem-solving approaches. It also provides a composite score, global executive
composite, and two validity scales (Inconsistency and Negativity). Items are problems that get rated on 3-point rating scale, ranging from 1 = never to 3 = often. High scale scores indicate lower executive functioning on all scales (Gioia, Espy, & Isquith, 2002). Cronbach’s alphas of the subscales in this study were .70, .56 and .76. Cronbach’s alpha of total executive functioning was .92.

Statistical analyses

Data was statistically analysed using SPSS 21. NICHD-scale negative regard was reverse coded, giving high scores on this scale indicating higher quality of mother-child interaction. The maternal sensitive composite score and BRIEF-P scales were computed and the assumption of normal distribution was examined. Correlations between NICHD-scales and BRIEF-P scales were calculated.

The relationship between maternal sensitivity and total executive functioning was further examined using hierarchical regression. Prior to conducting the analysis assumptions of normal distribution, linearity and homoscedasticity were tested. In this analysis maternal educational level, gender and whether the child had siblings were controlled for as background variables. MANCOVA was used to examine the relationship between maternal sensitivity in all three situations and executive functioning subscales inhibitory self-control, flexibility, and emergent metacognition, again controlling for the same background variables.

The relationship between both positive and negative regard was examined in the same way using hierarchical regression. The relationship between these two variables and BRIEF-P subscales inhibitory self-control, flexibility, and emergent metacognition was examined using MANCOVA. In both the hierarchical regression and MANCOVA was controlled for background variables educational level of the mother, gender and whether the child had siblings.

Results
In Table 1 and 2 descriptive statistics from the studies variables are presented. An examination of the assumption of normality showed that the negative regard variables were not normally distributed. Correlations between NICHD-scales and BRIEF-P scales were measured using Pearson’s correlation coefficient (i.e. Pearson’s r) and nonparametric Spearman’s rank order correlation coefficient (i.e. Spearman’s rho). Results are shown in table 3. Tests revealed no statistically significant relationship between maternal sensitivity, positive regard or negative regard and executive functioning for all three situations. Nor were there significant relationships with the subscales of the BRIEF-P (i.e. inhibitory self-control, flexibility index and metacognition). Table 3 shows all correlation coefficients. Variables showed either no relationship or a very weak relationship (range rs = [.01, -.12]).

**Background Variables**

Recent study showed a significant relationship between gender and executive functioning. Spearman’s rho indicated the presence of a weak negative correlation between these two variables (rs[188] = -.16, p = .032). Educational level of the mother and siblings had no significant relationship with executive functioning. No further significant relationships between gender and specific BRIEF-P subscales were found.

**Maternal Sensitivity and Executive Functioning**

Hierarchical multiple regression analysis (MRA) was conducted to further examine the relationship between, controlling for background variables: gender, educational level of the mother and whether or not the child had siblings. In step 1 of the hierarchical MRA, gender, educational level of the mother and siblings accounted for a non-significant 4% of the variance in executive functioning, $R^2 = .042$, $F(4, 156) = 1.80, p = .132$. In step 2, maternal sensitivity in all three situations were added to the regression equation, and accounted for an additional non-significant 0.7% of the variance in executive functioning, $\Delta R^2 = .007, \Delta F(3, 162) = .40, p = .756$. In combination both background variables and maternal sensitivity
accounted for 4.9% of the variance in executive functioning at 24 months, $R^2 = .049$, adjusted $R^2 = .008$, $F (7, 162) = 1.19$, $p = .314$. Unstandardized (B) and standardized ($\beta$) regression coefficient for each predictor in the regression model are reported in Table 4. As can be seen in Table 4, there are no significant predictors of executive functioning in the regression model.

A MANCOVA was conducted with inhibitory self-control, flexibility and emergent metacognition as dependent variables and maternal sensitivity in free play, diaper change and face-to-face situation as independent variables and gender, educational level and siblings as covariates. MANCOVA showed no significant effects of maternal sensitivity in all three situations (i.e. free play, $F(24, 404) = .819$, $p = .713$, diaper change $F(27, 407) = .864$, $p = .665$ and face-to-face $F (21, 340) = .683$, $p = .851$) on the dependent variables.

**Positive Regard and Executive Functioning**

To further examine the relationship between the two variables MRA was conducted, again controlling for the same background variables. In step 1 of the hierarchical regression the background variables accounted for a non-significant 4.8% of the variance in executive functioning, $R^2 = .048$, $F (4, 175) = 2.22$, $p = .069$. In step 2, positive regard in all three situations were added. This step accounted for an addition non-significant 1.3% of the variance, $\Delta R^2 = .013$, $\Delta F (3, 172) = .77$, $p = .513$. The total model accounted for 6.1% of the variance in executive functioning, $R^2 = .061$, adjusted $R^2 = .022$, $F = (7, 172) = 1.59$, $p = .141$ but was not significant. Unstandardized (B) and standardized ($\beta$) regression coefficient for each predictor in the regression model are reported in Table 5. As Table 5 shows, the only significant predictor in the final regression model was gender ($\beta = -.168$, $p = .027$).

To examine the relationship between positive regard and executive functioning subscales inhibitory self-control, flexibility and emergent metacognition a MANCOVA was conducted, again controlling for gender, educational level and siblings. MANCOVA showed
no significant effects of positive regard on the dependent variables for free play ($F(9, 399) = .914, p = .512$), diaper change ($F(9, 399) = .618, p = .782$), and face-to-face ($F(9, 399) = .418, p = .926$) situation.

**Negative Regard and Executive Functioning**

For all three situations the negative regard data did not meet the assumption of normality. After transforming the data, using logarithm, square root and inverse, the assumption of normality was still not met. It was decided not to perform MRA and MANCOVA using the negative regard data.

**Discussion**

The current study examined the relationship between mother-child interaction and executive functioning of the child. Previous studies that assessed the relationship between mother-child interaction from the age of 1 year and later executive functioning, found a relationship between the two (Bernier et al., 2010; Landry et al., 2010). This study examined the effect of mother-child interaction at a younger age (i.e. 6 months) on cognitive functioning. Previous research found a relationship between scaffolding, maternal sensitivity, mind-mindedness, and autonomy and executive functioning (Bernier et al., 2010; Laundry et al., 2010). Based on those finding, current study focused on the effect of three specific mother-child interaction domains: maternal sensitivity, positive regard and negative regard. This study shows different findings that are not in line with the results of previous studies.

It was hypothesized that mother-child interaction would have a positive effect on executive functioning. More specific it was hypothesised that high maternal sensitivity, high positive regard and low negative regard would have a positive effect on both total executive functioning and specific executive functioning domains inhibitory self-control, flexibility and emergent metacognition. In contrast with precious research, the current study found no significant relationships between any interaction domains and executive functioning. The only
significant relationship found was between gender and executive functioning, which was also found in previous research. One possible explanation for the contrast found between recent studies’ findings and previous research’ findings is a restriction of range. Current study showed only a small range in maternal sensitivity, positive regard, and negative regard scores. This may be the result of a homogenenous sample. Another explanation may be the children’s age. Previous research found that mother-child interaction at 6 months only indirectly influenced cognitive functioning. Interaction at later age directly influenced cognitive functioning (Olson, Bates, & Bayles, 1984). Executive functioning is a component of cognitive functioning and might be influenced in the same way. Recent study only measured mother-child interaction at an early age, where previous studies measured interaction at a later age. Differences in mother-child interaction at only 6 months might not yet effect executive functioning, or only have an indirect effect.

The negative regard data did not meet the assumption of normal distribution. The relationship between negative regard and executive functioning was examined using only nonparametric correlation coefficients. Almost no negative regard was found in recent study, causing a low range in negative regard. Bornstein et al. (2006) showed that negative behaviour is more common in high-risk samples. Recent study contains a low-risk population of predominantly high educated, working mothers. Conclusion that there is no relationship between the two is based on only one test and should be further examined in a more varied sample, containing both low-risk and high-risk dyads.

Inspection of the correlation matrix revealed low bivariate correlations between maternal sensitivity in the three different situations. However, positive regard in three situations showed higher, just acceptable, bivariate correlations. This may possibly effect the results of the MANCOVA by increasing the standard errors of coefficients, causing otherwise statistically significant variables to be insignificant predictors. Results of the MANCOVA
examining the relationship between positive regard and inhibitory self-control, flexibility and emergent metacognition may be decreased by the high bivariate correlations.

Some limitations of current study should be emphasised. First, a large part of the sample exists of highly educated, working woman. Only few woman with low or middle educational level were included in the study. The homogeneity of the sample may have had an effect on interaction domains such as positive and negative regard. Mother-child dyads with a higher family income-to-need ratio and high educated mothers show higher levels of maternal sensitivity and positive interaction than mother-child dyads with a lower ratio and mother with low educational level (NICHD, 1999). Current study shows low range in all three interaction domains, but specifically in positive and negative regard, with very small standard deviations. Replication of the study including sample that showed more variety in maternal educational level is recommended.

A second limitation may be a misrepresentation of the mother-child interaction. Interaction was videotaped in three situations, with a total time of only 10-15 minutes. During the videotaping a researcher was present in the room. Longer observation time may be needed to increase the generalizability of the observed mother-child interaction, as both mother and child are more comfortable with the camera’s and the observer.

Third, fathers’ influence on the children’s executive functioning was not included in recent study. Father’s also play an active role in raising their children, also affecting the development. Paternal factors can influence children’s executive functioning and should be considered in further studies (Ardila et al., 2005; Bernier, Carlson, Deschênes, & Matte-Gagné, 2012).

In sum, no significant relationship was found between mother-child interaction at 6 months and executive functioning at 24 months. The results of current study have limited implications. Because of the limitations of current study new research is needed to examine
the relationship between early mother-child interaction at 6 months and executive functioning 24 months, preferably in a varied sample containing both high-risk and low-risk dyads.
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References


### Table 1: Descriptive Statistics NICHD (n = 227)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Free Play</th>
<th></th>
<th>Diaper change</th>
<th></th>
<th>Face-to-face</th>
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<td></td>
<td>mean</td>
<td>s.d.</td>
<td>mean</td>
<td>s.d.</td>
<td>Mean</td>
<td>s.d.</td>
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<td>Maternal sensitivity Composite</td>
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<td>18.3</td>
<td>2.1</td>
<td>18.4</td>
<td>1.9</td>
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<td>Positive Regard</td>
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<td>5.7</td>
<td>1.0</td>
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<td>.9</td>
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<td>Negative Regard</td>
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<td>6.9</td>
<td>.3</td>
<td>6.9</td>
<td>.3</td>
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### Table 2: Descriptive Statistics BRIEF-P scales (n = 227)

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<td>7.2</td>
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<td>Flexibility Index</td>
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<td>Emergent Metacognition Index</td>
<td>35.7</td>
<td>6.5</td>
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<td>Global Executive Composite</td>
<td>86.2</td>
<td>13.6</td>
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Table 3: Correlations studies variables (n = 227)

<table>
<thead>
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<th></th>
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<th>Diaper change</th>
<th>Face-to-face</th>
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</thead>
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<tr>
<td>Inhibitory self-control index</td>
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<td>-.05</td>
<td>-.12</td>
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<tr>
<td>Flexibility Index</td>
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<td>-.04</td>
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<tr>
<td>Emergent Metacognition Index</td>
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<td>-.06</td>
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<tr>
<td>Global Executive Functioning</td>
<td>.01</td>
<td>-.01</td>
<td>-.10</td>
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*p < .05, **p<.01, ***p<.001

a. Tests were conducted using Spearman’s rho
Table 4: Hierarchical Multiple Regression Models Estimating Effects of Maternal Sensitivity on Executive Functioning (n = 227)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
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<th></th>
<th>Model 2</th>
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<tr>
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<td>SE</td>
<td>β</td>
<td>B</td>
<td>SE</td>
<td>β</td>
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<td>Brothers/Sisters</td>
<td>2.38</td>
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<td>2.51</td>
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<td>.09</td>
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<td>Dummy Education middle versus High</td>
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<td>Maternal Sensitivity Diaper Change</td>
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<td>.84</td>
<td>0.16</td>
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<tr>
<td>(Constant)</td>
<td>86.98</td>
<td>4.57</td>
<td></td>
<td>92.20</td>
<td>11.92</td>
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F                                           | 1.797   | 1.185    |

Adjusted R²                                   | .019*** | .008**   |

Change in Adjusted R²                          | .756    |          |

*p < .05, **p<.01, ***p<.001
Table 5: Hierarchical Multiple Regression Models Estimating Effects of Positive Regard on Executive Functioning (n = 227)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
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<th>Model 2</th>
<th></th>
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<tbody>
<tr>
<td></td>
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<td>SE</td>
<td>B</td>
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<tr>
<td>Brothers/Sisters</td>
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<td>2.21</td>
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<td>Dummy Education Low versus High</td>
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<td>-.01</td>
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<tr>
<td>Dummy Education middle versus High</td>
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<td>Positive Regard Free Play</td>
<td>-2.17</td>
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<td>Positive Regard Diaper Change</td>
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<tr>
<td>(Constant)</td>
<td>88.02</td>
<td>4.42</td>
<td>91.27</td>
<td>8.62</td>
</tr>
</tbody>
</table>

F                                       | 2.218 | 1.592   |

Adjusted $R^2$                          | .026  | .022    |

Change in Adjusted $R^2$                 | .513  |         |

*p < .05, **p<.01, ***p<.001