Maternal Scaffolding and Preterm Toddlers’ Visual-Spatial Processing and Emerging Working Memory

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Objective We examined longitudinal associations among neonatal and socioeconomic risks, maternal scaffolding behaviors, and 24-month visual-spatial processing and working memory in a sample of 73 toddlers born preterm or low birthweight (PT LBW).

Methods Risk data were collected at hospital discharge and dyadic play interactions were observed at 16-months postterm. Abbreviated IQ scores, verbal/nonverbal working memory, and verbal/nonverbal visual-spatial processing data were collected at 24-months postterm.

Results Higher attention scaffolding and lower emotion scaffolding during 16-month play were associated with 24-month verbal working memory scores. A joint significance test revealed that maternal attention and emotion scaffolding during 16-month play mediated the relationship between socioeconomic risk and 24-month verbal working memory.

Conclusions These findings suggest areas for future research and intervention with children born PT LBW who also experience high socioeconomic risk.

Key words parenting; prematurity; risk.

Introduction

With improvements in medical technology, more medically fragile infants born preterm or with low birthweights (PT LBW) are surviving their Neonatal Intensive Care Unit stays. Despite this progress, there has been no reduction in the proportion of infants who develop cognitive and other neurodevelopmental problems (Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Emsley, Wardle, Sims, Chiswick, & D’Souza, 1998). In addition to the significant cognitive deficits that can result from PT LBW births, more subtle complications that are related to socioemotional and academic impairments can also occur (Anderson, Doyle, Callanan, & Victorian Infant Collaborative Study Group, 2003; Taylor, Klein, Schatschneider, & Hack, 1998). Prior research findings also suggest that sociodemographic risks and parenting behaviors can significantly impact skill development (e.g., Farah et al., 2006; Landry, Miller-Loncar, Smith, & Swank, 2002). Thus, it is important to examine predictors of early skills such as working memory and visual-spatial processing in children PT LBW who also experience high socioeconomic (SES) risk, particularly within the early parenting context. The goal of this study is to examine longitudinal relations among neonatal and SES risks, maternal scaffolding behaviors, and 24-month working memory and visual-spatial processing in a sample of toddlers born PT LBW.

Visual-Spatial Processing, Working Memory, and Child Outcomes

Children who are born with low (<2500 g) and very low (<1500 g) birth weights and/or prior to 37 weeks gestation are more likely to obtain lower scores on cognitive tests than their normal-birth-weight peers (Bhutta et al., 2002). Differences between PT LBW and normal birth weight, term babies are most pronounced in the first years of the child’s life (Bhutta et al., 2002; Liaw & Brooks-Gunn, 1993), but children born PT LBW can continue to display skill deficits throughout childhood. For example, working memory and visual-spatial processing have been observed to be delayed or impaired among children born PT LBW (Anderson et al., 2003; Assel, Landry, Swank, Smith, & Steelman, 2003; Taylor, Minich, Bangert, Filpek, & Hack, 2004). Working memory begins to emerge around 24 months of age allows for the...
temporary storage and manipulation of information (Baddeley, 1992; Barkley, 2001). It is included with attentional control and inhibitory control as one of the core executive functions (Blair, 2002) that provides a building block for more complex cognitive skills including planning, problems solving, and hindsight (Barkley, 1997). As such, working memory is an important prerequisite for academic success, and is associated with attainments in reading, mathematics, and language comprehension (Bull & Scerif, 2001; de Jonge & de Jong, 1996).

Visual-spatial processing is among several nonverbal learning abilities that likely underlie the skills considered crucial to school readiness and academic success, particularly in mathematics (e.g., Assel et al., 2003; McGrath & Sullivan, 2002). Assel and colleagues (2003) contend that visual-spatial processing in toddlerhood provides a building block for later mathematical achievement because the skills allow children to mentally represent and interpret numerical information. These representations begin with activities such as counting on one’s fingers, but become more automatic as a child’s ability to create mental representations increase. The result of this increased ability to create mental representations of numerical information, in turn, allows for abstract thinking (Assel et al., 2003).

Maternal Scaffolding

According to sociocultural theory, cognitive development and mastery of other developmental tasks emerge over time in the context of interactions with adults and more competent individuals within the child’s proximal contexts (Rogoff, 1998; Vygotsky, 1978). Adults, especially parents, promote the child’s development through a process of guided participation (Rogoff, 1990) or “scaffolding” (Vygotsky, 1978) that can take various forms, such as prompts, modeling, discussion, joint participation, encouragement, and maintenance of the child’s attention. Scaffolding enables a child to accomplish increasingly challenging goals that would otherwise be outside of the child’s range of attainment. As the child experiences success when solving incrementally more difficult problems, the child internalizes the skills required to solve such problems independently and is no longer reliant on the support of others (Rogoff, Mistry, Goncu, & Mosier, 1993).

Successful scaffolding behaviors can take place within the context of otherwise adaptive parent–child interactions. However, not all parent–child interactions include the scaffolding of developing competencies. Mothers scaffold their young children’s cognitive and social development through explicit verbal direction and verbal and nonverbal behaviors that sustain children’s focus on objects, actions, or concepts (e.g., Landry, Garner, Swank, & Baldwin, 1996). Verbal and nonverbal maternal scaffolding with an emotional orientation can promote children’s abilities to self-regulate and persist in challenging tasks (Neitzel & Stright, 2003). Maternal scaffolding in early childhood is associated with positive developmental outcomes for children later on. For example, mothers’ efforts to maintain their two-year-olds’ attention has been positively associated with their independence in cognitive and social skills at 4.5 years, and early maternal scaffolding is related to children’s social and cognitive development as they enter school (Landry et al., 2002; Landry, Smith, Swank, & Miller-Loncar, 2000).

Maternal scaffolding behaviors can positively impact children’s cognitive abilities despite neonatal risk, with maternal verbal scaffolding, in particular, being related to global executive functioning, reading comprehension, and verbal and nonverbal problem solving (Dieterich, Assel, Swank, Smith, & Landry, 2006; Smith, Landry, & Swank, 2000). Mothers’ attempts to promote their children’s development may be, nevertheless, significantly impacted by SES factors. Compared to families that are not economically constrained, parents in low-income homes provide fewer developmentally appropriate physical and psychosocial resources and opportunities in their homes, and they engage in fewer learning-related activities (e.g., Evans, 2004; Hoff, 2003). Parenting behaviors may be particularly salient for children born PT LBW who may already be at greater risk for behavioral, cognitive, and socioemotional difficulties due to higher neonatal risk (Bhutta et al., 2002; Rickards, Kelly, & Doyle, 2001).

This study is grounded in the basic premise of the sociocultural theory, that cognitive and social development results from interactions with more competent individuals within the developmental context (Rogoff, 1998; Wood, 1989). We extend existing research by examining associations among neonatal and SES risks, maternal scaffolding behaviors, and 24-month working memory and visual-spatial processing abilities in a sample of toddlers born PT LBW. We tested three hypotheses. First, we expected that children who experience more neonatal and SES risks would display less optimal precursors of working memory and more impaired visual-spatial processing at 24 months postterm. Second, we hypothesized that higher-quality maternal attention and emotional scaffolding during mother–child play at 16 months postterm will predict more optimal visual-spatial processing and emerging working memory skills at 24 months. Third, we predicted that higher maternal attention and emotion scaffolding will mediate the relationship between early SES risk and the 24-month outcomes.
Method
Sample
The data for this study included 73 infant–mother dyads derived from a larger longitudinal study focusing on the development of self-regulation in infants born preterm or low birthweight (N = 181). Participants were recruited into the larger study using five criteria: (a) infants were born at less than 35 weeks gestation or weighing $\leq 2300$ g; (ii) infants had no known congenital malformations or prenatal drug exposures; (iii) mothers were at least 17 years old; (iv) mothers could read English; and (v) mothers identified themselves as the infant’s primary caregiver. Children who experienced grade IV intraventricular hemorrhage were excluded due to its strong correlation with developmental disability among children born preterm and/or with low birth weights (Bassan et al., 2007). Since the hospitals would not allow us to be “first contact” for families and they only provided us with information about families who signed consent forms for the study, we were unable to calculate a participation rate. Of the 186 mothers who signed consent forms, 181 (97%) participated in data collection.

Mother, child, and dyadic data were collected at hospital discharge as well as at 4-, 9-, 16-, and 24-months postterm. Although there was 14% attrition between the hospital discharge and the 24-month assessment, there were no differences in neonatal risk between infants who remained in the study and those whose families discontinued (multivariate $F(6, 172) = 1.36$, $p = .23$). However, mothers lost to attrition were younger ($F(1, 173) = 5.51$, $p < .05$), had less education ($F(1, 173) = 5.88$, $p < .05$), and a marginally higher sociodemographic risk index score ($F(1, 173) = 3.23$, $p < .08$) (multivariate $F(7, 167) = 1.90$, $p < .08$). Single mothers ($\chi^2 (1) = 4.68$, $p < .05$) and mothers who were not White ($\chi^2 (1) = 5.57$, $p < .05$) were also more likely to be lost to attrition.

This study used SES and neonatal risk data collected at hospital discharge and dyadic play interaction data collected at 16-months postterm. Abbreviated IQ scores, verbal working memory, verbal visual-spatial processing, nonverbal working memory, and nonverbal visual-spatial processing data were collected at 24-months postterm. The 24-month postterm working memory and visual-spatial processing variables were added to end of the larger study battery at about halfway through the data collection period. The analyses reported herein use data from whom these variables were available. Mean birthweights and gestational ages for this subsample were 1753.86 g ($SD = 573.20$) and 31.74 weeks ($SD = 3.07$), respectively. Mothers obtained a mean 14.47 ($SD = 2.55$) and fathers obtained a mean 13.92 ($SD = 2.62$) years of education. Average household income for the sample was $60409.78 ($SD = 38,573.65$). (Table 1 presents detailed sociodemographic and neonatal risk data for this subsample.)

Measures
Abbreviated IQ
Child intelligence was estimated with the Abbreviated Battery IQ scale (ABIQ) from the Stanford-Binet Intelligence Scales, 5th edition (SB5; Roid, 2003) and used as a control variable in regression analyses. Unlike the full-scale, verbal, and nonverbal IQ scores, the ABIQ scale does not use items from the 10 SB5 subscales. Instead, ABIQ scores are derived from the Object Series/Matrices and Verbal Knowledge routing subtests of the SB5. The Object Series/Matrices routine items provide an estimate of respondents’ cognitive flexibility, fluid reasoning, inductive and deductive reasoning, as well as their abilities to sequence and concentrate ($\alpha = .81$). The Verbal Knowledge routing subtest items assess word knowledge, verbal fluency, and conceptual thinking ($\alpha = .93$). The total ABIQ score has a coefficient $\alpha$ of .90, and correlates the full-scale IQ for 2-5-year-olds was .81 in the (Roid, 2003b). As a self-contained task, the SB5 routing allows the measure to be adapted to participants’ level of functioning and subtest administration can be tailored to assessment needs. Use of the ABIQ along with the working memory and visual-spatial processing subscales was deemed appropriate because they rely on different items (Roid, 2003b). The SB5 subtests were administered by trained graduate student research assistants who were supervised by a licensed clinical psychologist.

SES Risk
Years of maternal education, years of paternal education, and household income at the child’s birth for the subsample were standardized and summed to create the SES risk variable. Standardized scores were then reversed so that higher scores indicated higher risk (Chronbach’s $\alpha = .81$).

Neonatal Risk
Infant medical records from NICU discharge provided the data for our neonatal health risk variable. Because infant birthweight and gestational age were highly correlated ($r = .87$, $p < .001$), we standardized and combined them to create a prematurity composite. We then reverse scored the composite so that higher scores reflected more prematurity. We then created a neonatal health risk index combining the reversed prematurity composite with
10 other risk variables (scored as 1 if the risk was present): diagnosis of apnea, respiratory distress syndrome, chronic lung disease, gastroesophageal reflux; multiple birth; whether infants had 5-min Apgar scores of <6, spent more than 30 days in the NICU, were discharged with an apnea monitor, and whether they were still receiving oxygen at hospital discharge (Chronbach’s $\alpha = .72$). We did not include grades I–III IVH in the neonatal risk index due to low frequency in our sample.

### Maternal Scaffolding

Mother’s scaffolding behaviors during a 15-min free play interaction at 16 months postterm were coded using the 10-item Maternal Emotion and Attention Scaffolding – Free Play Coding Manual (MAES, Dilworth-Bart, unpublished manual). Some of the scaffolding codes were modified from the coding system used in Hoffman et al. (2006). The MAES system includes codes referring to maternal, child, and dyadic behaviors. Scaffolding codes capture maternal behaviors that support their toddlers’ attention to play activities and promote emotion understanding and regulation. The 10 items on the scale include maternal codes (e.g., play-directed attention, attention scaffolding, social engagement, and emotion scaffolding), a child code (e.g., play-directed attention), and dyadic codes (e.g., number of mother initiated task changes, child flexibility, number of child initiated task changes, mother flexibility, and joint attention). Possible scores for each item ranged from 1 (low) to 5 (high) for all MAES items, except the number of mother or child initiated task changes, which ranged from 1 to 5 or more. Three, two-member teams coded play interactions in four, two-minute segments. Play interaction data were available for 73 mother–child dyads. Intrarater reliability for eight (10.9%) tapes was 92.3%. Coded items were summed across all four segments, creating total scores ranging from 5 (lowest) to 20 (highest) on each item. This study used the Attention Scaffolding and Emotion Scaffolding items on the MAES (Table II). These codes were adapted from Hoffman, Crnic, and Baker’s (2006) emotional, motivational, and technical scaffolding codes. Using these codes, Hoffman observed less successful scaffolding among depressed mothers of preschoolers than among mothers of preschoolers who were not depressed (Hoffman et al., 2006). Intrarater reliabilities for the attention and emotion scaffolding items of the MAES were 100% and 94.9%, respectively.
Visual-Spatial Processing

Visual-spatial processing skills were assessed using the verbal and nonverbal visual-spatial processing subtests of the SB5 (Roid, 2003a). The nonverbal subtests include increasingly difficult form-board and pattern activities. The verbal subtests assess knowledge of spatial concepts using position and direction activities. Reliability coefficients for the nonverbal and verbal subtests are .87 and .82, respectively. The correlation between SB5 visual-spatial processing and the abstract reasoning subscale of the SB4 is .69 (Roid, 2003b).

Working Memory

Working memory was assessed using the standardized and normed verbal (VWM) and nonverbal working memory (NVWM) subtests of the SB5 (Roid, 2003a). The NVWM subtest includes increasingly difficult items requiring respondents to repeat a block tapping sequence. The alpha reliability coefficient for this subtest is .89. The VWM subtest includes sentence memory items in levels 2 and 3, followed by “last word” items in levels 4 through 6. The SB5 working memory subtests correlate .61 with the working memory scale of the Woodcock-Johnson III Test of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001). Items from the visual-spatial and working subtests are separate from those used in the SB5 routing scales used to calculate Abbreviated IQ.

Procedure

Mother–child dyads were invited to the Infant–Parent Interaction Lab at 16-months postterm, and mothers were instructed to play with their toddlers as they did at home prior to engaging in other assessments. Fifteen minutes of play-time interaction were videotaped and then coded in four 2-minute segments. Dyads returned to the lab at 24-months postterm and children were administered the SB5 Abbreviated IQ, verbal and nonverbal visual-spatial processing, and verbal and nonverbal working memory subtests as well as other assessments that are described elsewhere (Poehlmann et al., 2008). The assessment battery was administered by trained graduate research assistants. Mothers received $60 at the 16-month visit and $80 at the 24-month visit. Children received an age-appropriate book or toy at the end of each visit.

Analysis Plan

Data were analyzed in two stages. First, we calculated descriptive means and standard deviations followed by scale intercorrelations and data screening. Second, we tested the study hypotheses using a series of hierarchical regression models, one for each outcome variable. Child IQ was partialled in the first step of all the models in order to reduce its possible confounding effects.

Neonatal and sociodemographic risk variables were entered together in step 2 to test Hypothesis 1, that children who experience more neonatal and SES risks would display less optimal precursors of working memory and more impaired visual-spatial processing at 24 months postterm. We also used hierarchical regression models to test Hypothesis 2, that higher-quality maternal attention and emotional scaffolding during mother–child

<table>
<thead>
<tr>
<th>Table II. Description of attention and emotion scaffolding codes from the MAES</th>
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<tr>
<td><strong>Attention scaffolding:</strong> This item assesses verbal, nonverbal, and/or physical efforts to facilitate and/or maintain the child’s attention to a task, object(s), or sequence of events. This also includes the effectiveness of the mother’s attempts.</td>
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<tr>
<td>5: Mother appropriately uses verbal, nonverbal, and physical efforts to facilitate and/or maintain the child’s attention to a task, object(s), or sequence of for at least half the segment and her efforts are successful throughout the segment.</td>
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<tr>
<td>3: Mother appropriately uses verbal, nonverbal, and/or physical efforts to facilitate and/or maintain the child’s attention to a task, object(s), or sequence of for at least half the segment and her efforts are successful at least half of the segment.</td>
</tr>
<tr>
<td>1: Mother’s verbal, nonverbal, and/or physical efforts to facilitate and/or maintain the child’s attention to a task, object(s), or sequence of events minimal, unsuccessful, or inappropriate.</td>
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<tr>
<td><strong>Emotion scaffolding:</strong> This item assesses verbal, nonverbal, and/or physical efforts to help the child label her/his emotions, to help maintain positive emotions, to soothe negative emotions, or to facilitate child’s self-soothing behaviors.</td>
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<tr>
<td>5: Mother helps child identify his/her emotions, maintain positive emotions or to soothe negative emotions and/or facilitates child’s self-soothing behavior throughout the segment. Her efforts to scaffold emotion are successful.</td>
</tr>
<tr>
<td>3: Mother attempts to help child identify his/her emotions, to help maintain positive emotions, to soothe negative emotions, or to facilitate child’s self-soothing behavior for at least half the segment. About half of her efforts to scaffold emotion are successful.</td>
</tr>
<tr>
<td>1: Mother makes minimal efforts to help child identify his/her emotions, to help maintain positive emotions, to soothe negative emotions, or to facilitate child’s self-soothing behavior and/or her efforts to scaffold emotion are unsuccessful.</td>
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</tbody>
</table>
play at 16 months postterm will predict higher 24-month visual-spatial processing and emerging working memory scores. Again, we calculated one model for each of the 24-month outcome variables (i.e., verbal and nonverbal visual-spatial processing; verbal and nonverbal working memory). Neonatal risk was partialled in addition to Abbreviated IQ in step 1 of these models in order to identify the contribution of scaffolding to the 24-month outcome scores after accounting for possible differences in child risks.

We assessed the extent to which maternal scaffolding mediated the association between SES risk and the 24-month outcome variables (Hypothesis 3) using a joint signigicant test (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Similar to other causal steps methods (e.g., Baron & Kenny, 1986), the joint significance approach attempts to establish the indirect relationship between predictor and outcome through an intervening variable (MacKinnon et al., 2002). The joint significance test differs in that it entails the use of individual regression models to test each path of the mediation model. This approach preserves statistical power while controlling Type I error and has the benefit of identifying indirect effects when indirect and direct effects occur in different directions, thereby canceling each other out (MacKinnon et al., 2002). In addition to the models used to assess Hypothesis 2, the joint significance test for our analyses required a set of hierarchical models that regressed 24-month visual-spatial processing and working memory onto the 16-month postterm maternal scaffolding variables. Both abbreviated IQ scores and neonatal risk were entered as control variables in step 1.

Results

Table II presents variable means and standard deviations and scale intercorrelations for the sample. Abbreviated IQ significantly correlated all other variables except neonatal risk and the scaffolding variables. Given its small-to-moderate correlations with the 24-month outcomes, we deemed it necessary to include Abbreviated IQ as a control variable in the first step of all the hierarchical models. We observed a negative correlation between neonatal risk and verbal working memory (p < .05) and SES risk was negatively correlated with the scaffolding and 24-month working memory and visual-spatial outcome variables (all p’s < .05). Emotion scaffolding and attention scaffolding correlated .78 (p < .01); therefore, these variables were entered together in subsequent regression models. There were small, positive correlations between nonverbal visual-spatial processing and the verbal outcome scores (p’s < .05). Nonverbal working memory positively correlated verbal working memory (p < .05). The scaffolding variables did not significantly correlate with the visual-spatial processing and working memory outcome variables, most likely, due to suppression effects of IQ. We, therefore, partialled IQ in all subsequence regression models (Table III).

One participant’s SES risk index was >2 SD above the subsample mean. Because of this, subsequent regression analyses using SES risk as a predictor were run with and without this participant, with negligible differences in the findings. Therefore, that participant’s data are included in the results reported below. Twenty-four-month verbal working memory and verbal visual-spatial processing scores were transformed to reduce positive skew, but with negligible effects. The untransformed variables are reported in these analyses.

The Abbreviated IQ estimate accounted for 11% of nonverbal visual-spatial processing (p = .005; Cohen’s $f^2 = .12$) and 10% of nonverbal working memory score variance (p = .006; Cohen’s $f^2 = .11$) in step 1 of the hierarchical models used to assess Hypothesis 1. In the verbal domain, Abbreviated IQ accounted for 15%

### Table III. Pearson correlations and descriptive statistics of the control variables, neonatal and socioeconomic risk indices, 16-month maternal scaffolding, and 24-month outcome variables

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<th>6</th>
<th>7</th>
<th>8</th>
<th>Mean (SD)</th>
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<tbody>
<tr>
<td>1 Abbreviated IQ</td>
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<td></td>
<td></td>
<td>79.90 (17.15)</td>
</tr>
<tr>
<td>2 Neonatal risk</td>
<td>-.12</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.18 (2.72)</td>
</tr>
<tr>
<td>3 Sociodemographic risk</td>
<td>-.44***</td>
<td>.09</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.11 (1.68)</td>
</tr>
<tr>
<td>4 Attention scaffolding</td>
<td>.14</td>
<td>-.07</td>
<td>-.38**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13.66 (3.33)</td>
</tr>
<tr>
<td>5 Emotion scaffolding</td>
<td>.20$^*$</td>
<td>-.16</td>
<td>-.38**</td>
<td>.78**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td>12.67 (3.14)</td>
</tr>
<tr>
<td>6 Nonverbal visual-spatial processing</td>
<td>.33**</td>
<td>.01</td>
<td>-.23*</td>
<td>.08</td>
<td>-.03</td>
<td>--</td>
<td></td>
<td></td>
<td>6.88 (1.85)</td>
</tr>
<tr>
<td>7 Nonverbal working memory</td>
<td>.32**</td>
<td>-.10</td>
<td>-.26*</td>
<td>-.05</td>
<td>.05</td>
<td>.08</td>
<td>--</td>
<td></td>
<td>6.99 (2.59)</td>
</tr>
<tr>
<td>8 Verbal visual-spatial processing</td>
<td>.38**</td>
<td>-.20$^*$</td>
<td>-.31**</td>
<td>.07</td>
<td>.01</td>
<td>.38**</td>
<td>.19</td>
<td>--</td>
<td>5.25 (2.14)</td>
</tr>
<tr>
<td>9 Verbal working memory</td>
<td>.53**</td>
<td>-.26*</td>
<td>-.30*</td>
<td>.20$^*$</td>
<td>.07</td>
<td>.32**</td>
<td>.14</td>
<td>.33**</td>
<td>5.64 (2.70)</td>
</tr>
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* $p < .10; * < .05; ** < .01; *** < .001
(p = .001; Cohen’s $f^2 = .18$) and 28% ($p < .001$; Cohen’s $f^2 = .39$) of visual-spatial processing and working memory score variance, respectively. Neither risk index accounted for significant score variance for 24-month verbal visual-spatial processing ($\Delta R^2 = .05, p = .13$), verbal working memory ($\Delta R^2 = .05, p = .11$), nonverbal visual-spatial processing ($\Delta R^2 = .01, p = .61$), or nonverbal working memory ($\Delta R^2 = .04, p = .21$) when entered in step 2 of the models (Table IV).

Neonatal risk and Abbreviated IQ scores accounted for 32% ($p < .001$; Cohen’s $f^2 = .47$) of verbal working memory score variance in step 1 of the models used to test Hypothesis 2. Abbreviated IQ scores accounted for 17% ($p = .001$; Cohen’s $f^2 = .20$) of verbal visual-spatial processing score variance, 11% ($p = .02$; Cohen’s $f^2 = .12$) of nonverbal visual-spatial processing score variance, and 11% ($p = .02$; Cohen’s $f^2 = .12$) of nonverbal working memory score variance. Entry of the scaffolding variables in step 2 of the verbal working memory model accounted for an additional 8% ($p = .02$; Cohen’s $f^2 = .13$) of score variance. Higher attention scaffolding ($\beta = .44, p = .006$) and lower emotion scaffolding ($\beta = -.41, p = .01$) during 16-month free play predicted greater verbal working memory scores at 24-months (Tolerances: AS = .38, ES = .37; VIFs: AS = 2.61, ES = 2.71). The scaffolding variables did not account for additional significant score variance for nonverbal visual-spatial processing ($\Delta R^2 = .04, p = .22$), nonverbal working memory ($R^2 = .02, p = .44$), or verbal visual-spatial processing ($\Delta R^2 = .02, p = .38$) (Table Va).

The mediation analysis for Hypothesis 3 required a two-step hierarchical model that was calculated with the neonatal risk entered in step 1 followed by SES risk entered in step two. Neonatal risk accounted for a nonsignificant proportion of 16-month Attention Scaffolding variance ($R^2 = .00, p = .54$). Entry of SES risk in the second step of the model contributed another 13% ($p = .002$; Cohen’s $f^2 = .06$; B = -.54, SE = .17, $\beta = -.40, p = .002$) to the variance in Attention Scaffolding scores, with lower risk predicting higher maternal scaffolding. Similarly, neonatal risk did not predict 16-month Emotion Scaffolding scores ($R^2 = .08, p = .15$). However, SES risk contributed to Emotion Scaffolding score variance in step 2, again with lower risk predicting higher maternal scaffolding ($\Delta R^2 = .10, p = .005$; Cohen’s $f^2 = .06$; B = -.69, SE = .21, $\beta = -.37, p = .001$) (Table Vb).

In sum, higher SES risk predicted lower attention and emotion scaffolding scores at 16-month postterm. Sixteen-month maternal scaffolding, in turn, predicted verbal working memory scores assessed at 24-months, partially supporting our mediator hypotheses for that outcome. The mediation hypothesis was not supported for either visual-spatial processing outcome or for nonverbal working memory (Table V).

**Table IV. Hierarchical model assessing prediction of 24-month visual-spatial processing and working memory from early SES and neonatal risks (Hypothesis 1)**

<table>
<thead>
<tr>
<th></th>
<th>NVVSP$^a$</th>
<th></th>
<th>NWWM$^b$</th>
<th></th>
<th>VWSP$^c$</th>
<th></th>
<th>VWM$^d$</th>
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<tbody>
<tr>
<td></td>
<td>B (SE)</td>
<td>$\beta$</td>
<td>B (SE)</td>
<td>$\beta$</td>
<td>B (SE)</td>
<td>$\beta$</td>
<td>B (SE)</td>
</tr>
<tr>
<td>1 ABIQ$^e$</td>
<td>.04 (.01)</td>
<td>.33**</td>
<td>.05 (.02)</td>
<td>.32**</td>
<td>.05 (.01)</td>
<td>.38**</td>
<td>.08 (.02)</td>
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<tr>
<td>$R^2$</td>
<td>.11**</td>
<td></td>
<td>.10**</td>
<td></td>
<td>.15**</td>
<td></td>
<td>.28**</td>
</tr>
<tr>
<td>2 Neonatal Risk</td>
<td>-.02 (.05)</td>
<td>-.04</td>
<td>.05 (.08)</td>
<td>.07</td>
<td>.09 (.06)</td>
<td>.16</td>
<td>.14 (.07)</td>
</tr>
<tr>
<td>SES Risk</td>
<td>-.08 (.09)</td>
<td>-.11</td>
<td>-.23 (.13)</td>
<td>-.21$^e$</td>
<td>-.16 (.10)</td>
<td>-.18</td>
<td>-.07 (.12)</td>
</tr>
<tr>
<td>$\Delta R^2$</td>
<td>.01</td>
<td>.04</td>
<td>.05</td>
<td>.05</td>
<td>.05</td>
<td>.05</td>
<td>.05</td>
</tr>
</tbody>
</table>

$^a$Nonverbal visual-spatial processing.
$^b$Nonverbal working memory.
$^c$Verbal visual-spatial processing.
$^d$Verbal working memory.
$^e$Abbreviated IQ.

*p < .10; * < .05; ** < .01; *** < .001.

**Discussion**

This longitudinal study examined the extent to which neonatal risk, SES risk, and maternal scaffolding behaviors predicted 24-month working memory and visual-spatial processing abilities in a sample of toddlers born PT LBW. Although Hypothesis 1 was not supported, our analyses partially supported our hypothesized association between maternal scaffolding and 24-month outcome scores (Hypothesis 2) and our hypothesis that scaffolding would mediate an association between SES risk and 24-month outcomes (Hypothesis 3).

**The Importance of Maternal Scaffolding for Children Born Preterm**

Infants born PT LBW experience medical and social vulnerabilities that may make them particularly susceptible...
to parenting influences such as those that occur during day-to-day interactions with their mothers (e.g., Poehlmann & Fiese, 2001a; Smith et al., 2000). In this analysis, we found that maternal scaffolding was associated with children’s verbal working memory scores but not with their nonverbal working memory scores. Mothers who used verbal, nonverbal, and/or physical efforts to facilitate and maintain the child’s attention to a task, object or sequence of events during play had children who scored higher on the verbal working memory subtest of the Stanford-Binet. This finding is consistent with and extends previous literature linking quality of parenting interactions to preterm infants’ developmental capacities (e.g., Poehlmann & Fiese, 2001b).

However, contrary to expectation, we also found that lower maternal emotion scaffolding during 16-month play was associated with higher verbal working memory scores in children. There are at least three possible explanations for this finding. First, children whose mothers engaged in more emotion scaffolding may have had lower early executive skills more generally. Additional studies that include full executive function assessment batteries are needed to determine the extent to which this finding reflects poorer function not just in the working memory domain, but also in emerging attentional and inhibitory control. Further, longitudinal study is needed to determine the extent to which mothers’ scaffolding behaviors are driven by child neurocognitive competencies or vice versa.

Second, in addition to risk for cognitive difficulties, PT LBW infants also experience challenges engaging in interactions with their caregivers. They are less attentive, less alert, and more distressed, and they exhibit cues that are more difficult to read compared to healthy fullterm infants (Macey, Harmon, & Easterbrooks, 1987). The underlying assumption of the emotion scaffolding code was that more scaffolding, as defined in the MAES, reflected a more positive interaction. Alternatively, however, high Emotion Scaffolding scores could reflect mothers’ efforts to scaffold the emotion of a fragile child. Instead of affect and actions flowing between partners (Harrist & Waugh, 2002), PT LBW infants may be overwhelmed, overstimulated, and distressed during interactions with caregivers (Macey et al., 1987). Opportunities for synchronous interactions that promote working memory development may be reduced. Consequently, high emotion scaffolding may actually interfere with the development of certain emerging skills rather than facilitating them in this vulnerable group.

Third, although the Emotion Scaffolding code does account for mothers’ intrusiveness during the interaction,
it does not address child social engagement or responsiveness. While not assessed as part of the current analysis, children requiring more assistance with soothing behaviors may have been too emotionally reactive to benefit from mothers’ scaffolding behaviors in the same ways as less reactive children. The role of physiological arousal and emotional reactivity are especially important areas for future study given the reciprocal relationships between cognition and emotion (Blair, Zelazo, & Greenberg, 2005).

Unlike Smith et al. (2000), we did not observe a relationship between maternal scaffolding and children’s nonverbal skills. Our analyses, however, differed from the Smith analyses in two important ways. First, children in our sample were significantly younger (2- as opposed to 3-years-olds). Second, whereas Smith and colleagues assessed children’s verbal comprehension and nonverbal reasoning (Thorndike, Hagen, & Sattler, 1986), our analysis focused on verbal and nonverbal working memory and visual-spatial processing after accounting for abbreviated IQ scores. Therefore, we observed these specific effects on working memory above and beyond the effects of children’s general verbal and nonverbal skills.

We also found that maternal attention and emotion scaffolding during 16-month free play mediated the relationship between SES risk and 24-month verbal working memory for children born PT LBW. Controlling for SES risks such as lower parental educational attainment and lower family income, more attention scaffolding and less emotion scaffolding were associated with more optimal verbal working memory skills in children. Again, scaffolding was unrelated to nonverbal working memory and visual-spatial processing in our analyses.

Our finding that maternal scaffolding was uniquely associated with verbal working memory highlights the role of language in working memory (e.g., Gathercole & Baddeley, 1993) and warrants further investigation. Higher scores on the scaffolding items require the use of verbal input from mothers. Mothers who provide more verbal input while scaffolding attention, but not while scaffolding emotion, may provide better opportunities for toddlers to use maternal language to facilitate their emerging abilities. The predictive relationship between 16-month maternal scaffolding and 24-month verbal working memory that we observed may reflect children’s abilities to capitalize on mothers’ language prior to the development of their phonological loop (a component of working memory that provides short-term storage system for verbal information) (Gathercole & Baddeley, 1993). Further research that includes assessment of child language, a fine-grained analysis of how and when mothers use language during parent–child interactions, and repeated measurement of the reciprocal exchanges between mothers and children is needed to determine whether this speculation is supported.

The Importance of Early Risks for Children Born Preterm

The cumulative risks associated with economic disadvantage can impact most developmental areas, including cognitive, language, and social-emotional functioning (Conger et al., 2002) that may be particularly potent for infants born preterm or low birthweight. Nevertheless, certain developmental contexts facilitate resilience processes in individuals and families despite high SES risk (Masten, 2001). Although there are few investigations that directly examine the extent of associations between neurocognitive skills such as working memory and resilience processes in young children (Buckner et al., 2003), our findings suggest that maternal attention scaffolding promotes the skill development of young children experiencing high neonatal and/or sociodemographic risk. Thus, understanding parenting interactions that facilitate development in young children may enhance our ability to intervene. However, additional research examining the developmental trajectories of children who show early positive verbal and nonverbal working memory and visual-spatial skills is needed.

Limitations

The finding that neonatal risk did not predict any of the outcome variables is likely because our sample was composed entirely of high-risk infants, limiting the variability of our neonatal risk index. Moreover, higher sociodemographic risk dyads (characterized by lower maternal education, lower income, younger maternal age, and single parent status) were more likely to be lost to attrition. As our study focuses on the impacts of SES risk on parenting behaviors and child outcomes, the differential loss of these higher-risk dyads impacts the generalizability of the study results. Nevertheless, the fact that we observed an effect of SES risk, albeit small, suggests that this phenomenon warrants further study with a larger and more income diverse sample. Further, while the parent–child play interaction used to identify mothers’ scaffolding behaviors provides snapshot, data from dyadic interactions over several time points are needed to fully clarify the impact of mothers’ scaffolding behaviors on child outcomes.

Implications

Despite these limitations, this study provides valuable preliminary insight into how SES status and maternal
scaffolding relate to the cognitive competencies of young children born PT LBW. Our finding of a unique association between verbal working memory and maternal scaffolding, in particular, raises questions about the role of the early developmental context in the emergence of key neurocognitive skills. Future studies in this area should include measures of emerging executive functions as well as comprehensive assessment of dyadic synchrony, child arousal, and emotional reactivity to fully clarify the role of mothers’ emotion scaffolding during interactions with PT LBW infants in promoting neurocognitive development.

Should our findings be replicated by larger-scale, longitudinal study, the line of research could inform interventions that focus on training parents of medically fragile children to engage in specific verbal and nonverbal attention scaffolding behaviors that help promote working memory skills. Intervention may be especially important for children born PT LBW who also live in high-SES-risk homes due to the possible associations between SES risk and lower scaffolding competence on the part of parents. Due to the increase in PT LBW births (Hamilton et al., 2007) and because the structural aspects of children’s developmental contexts are difficult to change, creating effective interventions that directly promote development in this way may be a promising step toward reducing persistent academic and behavioral problems in this high risk group.

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