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Early working memory and maternal communication in toddlers born very low birth weight

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Abstract

Aim—Early working memory is emerging as an important indicator of developmental outcome predicting later cognitive, behavioural and academic competencies. The current study compared early working memory in a sample of toddlers (18–22 months) born very low birth weight (VLBW; $n = 40$) and full term ($n = 51$) and the relationship between early working memory, mental developmental index (MDI), and maternal communication in both samples.

Methods—Early working memory, measured by object permanence; Bayley mental developmental index; and maternal communication, coded during mother-toddler play interaction, were examined in 39 toddlers born VLBW and 41 toddlers born full term.

Results—Toddlers born VLBW were found to be 6.4 times less likely to demonstrate attainment of object permanence than were toddlers born full term, adjusting for age at testing. MDI and maternal communication were found to be positively associated with attainment of object permanence in the VLBW group only.

Conclusion—The difference found in the early working memory performance of toddlers born VLBW, compared with those born full term, emphasizes the importance of assessing early working memory in at-risk populations, while the maternal communication finding highlights potential targets of intervention for improving working memory in toddlers born VLBW.

Keywords

Early working memory; Maternal communication; Object permanence; Very low birth weight

INTRODUCTION

Infants born very low birth weight (VLBW; <1250 g) are at risk of displaying cognitive, attention and self-regulation difficulties (1,2). These difficulties can persist throughout childhood and are associated with an increased incidence of learning difficulties, attention-deficit/hyperactivity disorder and behavioural problems throughout childhood (3,4). Early working memory, defined as temporarily storing and managing information, is emerging as an important indicator of infant developmental outcome and is predictive of cognitive, behavioural and academic outcomes in children born preterm (3,5).

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Working memory deficits have been documented in school-age children born preterm (6), though few studies have examined whether such impairments are present in young toddlers. Furthermore, maternal communication has been found to influence cognitive outcomes (7) and executive functioning skills (8), but little is known about its association with working memory.

The purpose of the current study was to compare object permanence, a measure of early working memory, in toddlers born VLBW and full term as well as examine the relationship between object permanence, developmental cognitive ability and maternal communication in both groups. It was hypothesized that toddlers born VLBW would have more difficulties than toddlers born full term and that object permanence performance would be positively associated with developmental cognitive ability and maternal communication.

METHODS

Subjects and procedures

The University of New Mexico's Human Subjects Committee provided review and approval for this study. Participants were recruited by research nurses at the University of New Mexico Hospital Pediatric clinic and Newborn Intensive Care Nursery. All mothers were informed that participating in the study was voluntary and that declining to participate would not affect health care services. Forty 18 to 22 month old toddlers born VLBW and 51 toddlers born full term were evaluated. One of the toddlers born VLBW did not have a play video and was excluded from the analysis. Age at testing was adjusted for gestational age for the sub sample of toddlers born VLBW.

Development and play scales

Development was assessed with the Bayley Scales of Infant Development II, (BSID-II) with the Mental Developmental Index (MDI) as a measure of cognition (9). Items 84, 96 and 102 of the BSID-II were used together as a measure of object permanence (10). These type of items object permanence items were developed by Piaget (11), and have been used by Adele Diamond (12) as a measure of early working memory. A 5 min videotaped segment of unstructured mother-child play was coded using the Caregiver-Child Affect, Responsiveness and Engagement Scale (13). The manual for the scale was made available by the author with factor and cluster analyses that revealed consistent factors across age categories. We were interested in the maternal communication scale (one of the factors identified) that measures verbal stimulation and richness of language, quantity of language used, and the amount and type of play used by the mother towards the toddler.

Procedures

Once informed consent was obtained, a developmental evaluation of the toddler was conducted. The object permanence items on the BSID-II sequentially increased in difficulty. First, the child was asked to find a toy hidden under one of two cups (item 84). Second, the cups were reversed after the toy was hidden (item 96). Third, double visual displacement was used (item 102). The number of object permanence items correctly completed was calculated for each child and used as both an ordinal measure (0–3) and a dichotomous variable (all or less than 3 items). Next, unstructured play of the mother and toddler alone in a room for 10 min, using a uniform set of toys, was videotaped. Each tape was scored independently by two-trained undergraduate or graduate students with discrepancies settled by a master coder. For purposes of inter-rater reliability, 20% of tapes were randomly selected and coded by a master coder. Interclass correlations across mother, child and dyad scales were 0.8 or better with a master coder. Birth weight, gestational age and days on

ventilation (a measure of illness severity) were used as indicators of medical risk, while income was used to measure family socio-economic status (Table 1).

Statistics

Object permanence score was used as an ordinal scale (from 0 to 3) for Spearman correlations and Fisher's Exact Test, and as a dichotomous variable (0.1 or 2 correct vs. 3 correct) for the dependent variable, using multivariate logistic regression on groups (full term vs. preterm), with maternal communication score and MDI as independent variables. As the object permanence data for the children born full term was 0 or 3 we used the data as dichotomous for the logistic regression analysis. Effect sizes were assessed using odds ratios. Hypotheses tests were two-sided and used a significance level of 0.05. All statistical analyses were conducted using SAS version 9 (SAS Institute Inc, Cary, NC, USA).

RESULTS

Patient characteristics and medical data

As a preliminary analysis, t-test comparisons of the VLBW and full term toddler groups indicated a significant difference between children born preterm and term for birth weight, gestational age, and illness severity scores, as expected. Toddlers' age at testing was significantly higher in the preterm group ($p = 0.003$) by 0.9 of a month (Table 1). Maternal education and family income were not significantly different between the groups.

Object permanence skills and maternal communication

As hypothesized, more full term toddlers achieved object permanence ($p < 0.001$), even after controlling for age at testing (Fisher's exact test $p < 0.001$). Odds of having achieved object permanence was 4.6 times less in the toddlers born preterm than in toddlers born full term and 6.4 less when adjusted for child's age at testing (Table 1). Maternal communication scores were not significantly correlated to maternal education or family income for either group.

Object permanence and maternal communication

Object permanence scores were highly correlated with MDI ($R = 0.47$, $p = 0.003$) and maternal communication ($R = 0.50$, $p = 0.001$) for the toddlers born VLBW only. A significant interaction was found between maternal communication and birth group for the object permanence scores ($p = 0.04$). Although the two groups had significantly different scores on overall MDI score ($p = 0.006$), the interaction remained significant even after controlling for MDI score ($p = 0.02$) (Fig. 1). For the toddlers born VLBW, as their mother's communication scores increased, their object permanence scores increased (odds ratio = 1.44; $p = 0.01$). In contrast, object permanence scores for toddlers born full term were unrelated to maternal communication (odds ratio = 1.02; $p = 0.86$).

DISCUSSION

As previously noted the purpose of the current study was to compare object permanence in toddlers born VLBW and full term and examine the relationship between object permanence, developmental cognitive ability and maternal communication in both groups. Consistent with our hypothesis, adjusting for age at testing, we found that toddlers born full term were more than six times more likely to achieve object permanence, than toddlers born preterm. Interestingly, we found that in the VLBW group alone, object permanence was correlated with both the MDI and maternal communication score.

Medical research is continuously searching for medical markers predictive of developmental outcomes. Indeed, medical markers such as birth weight, ventilation and use of maternal steroids, have all been found to be correlated with later cognitive scores (14,15). The majority of outcomes studies following children born preterm have used the Bayley Scales' Mental Developmental Index as a measure of developmental outcome. Research is increasingly highlighting the poor predictive value of the Bayley Scales in explaining later developmental outcomes (16). As a result of the Bayley Scales' poor predictability, current research has shifted its focus to emphasize the importance of working memory and other executive functions in predicting developmental outcomes of children born preterm (6). Early working memory, as measured by object permanence test items in the current study, was negatively associated with prematurity, suggesting that future research warrants inclusion of these types of measures in identifying predictors and correlates of developmental outcomes. Our current findings that the children born VLBW did poorer on object permanence items compared to children born full term expanded our previous study's findings that emotional regulation was an important factor associated with object permanence items (10).

Increased maternal communication was correlated with higher object permanence scores only in the VLBW group, which could have significant implications in early intervention programs. Although numerous studies have demonstrated the importance of maternal communication in children's cognitive development (7,17), limited empirical information is available regarding how maternal communication influences more specific cognitive skills, such as early working memory. The findings that maternal communication was not simply a proxy of maternal education or family income, suggests that maternal communication may be a uniquely important variable in explaining VLBW toddlers' early working memory. This highlights a potential area of early intervention which is especially relevant given the importance of working memory in predicting later cognitive, behavioural, and academic outcomes in children born preterm (3,5). Targeting an area of early intervention, such as maternal communication, is potentially promising.

In summary, our findings indicate that achieving object permanence is negatively associated with prematurity and that developmental cognitive ability and maternal communication style are associated with performance on an object permanence task for preterm toddlers but not for full term toddlers. These findings may have implications for early intervention strategies, including the targeting of early working memory in children born VLBW, to try to improve developmental outcome over time. Strategies to enhance maternal communication in parent-child interaction, as a correlate of early working memory in preterm toddlers, could also prove beneficial.

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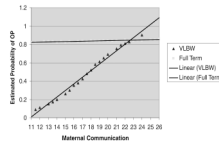


Figure 1. Estimated probability of object permanence by maternal communication score.

Table 1

Participant demographics by group – including frequencies and percentiles of object permanence scores

Demographic variables	Mean (standard deviation)	
	Very low birth weight N = 39	Full term N = 51
Child age, (months)	19.95 (1.35)	19.08 (1.31)
Birth weight (g)	949.71 (221.64)	3342.90 (420.66)
Gestational age (weeks)	27.38 (1.98)	39.23 (1.36)
Illness severity, no. of days on ventilation	24.87 (26.43)	0(0)
Family income *	3.21 (1.78)	2.82 (1.69)
Maternal education **	2.93 (1.56)	2.62 (1.78)
Maternal communication score	18.22 (3.15)	18.79 (4.16)
Bayley mental developmental index	82.95 (15.32)	91.29 (11.61)
Object permanence scores		
0 correct	8 (21%)	8 (16%)
1 correct	7 (18%)	0
2 correct	3 (7%)	0
3 correct	21 (54%)	43 (84%)

* Based on semi-continuous scores of 1: <\$10000; 2: \$10000–\$20000; 3: \$20000–\$30000; 4: \$30000–\$40000; 5: \$40000–\$50000; 6: >\$60000.

** Based on semi-continuous scores of 1: <12th grade; 2: H.S; graduate; 3: 1 year college; 4: Associate degree; 5: Bachelor degree; 6: Some graduate school; 7: Masters degree or higher.