Using Eye Movements to Assess Language Comprehension in Toddlers Born Preterm and Full Term

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Objective To assess language skills in children born preterm and full term by the use of a standardized language test and eye-tracking methods.

Study design Children born ≤32 weeks' gestation (n = 44) were matched on sex and socioeconomic status to children born full term (n = 44) and studied longitudinally. The Bayley Scales of Infant and Toddler Development, Third Edition (BSID-III) were administered at 18 months (corrected for prematurity as applicable). The Looking-While-Listening Task (LWL) simultaneously presents 2 pictures and an auditory stimulus that directs the child's attention to one image. The pattern of eye movements reflects visual processing and the efficiency of language comprehension. Children born preterm were evaluated on LWL 3 times between 18 and 24 months. Children born full term were evaluated at ages corresponding to chronological and corrected ages of their preterm match. Results were compared between groups for the BSID-III and 2 LWL measures: accuracy (proportion of time looking at target) and reaction time (latency to shift gaze from distracter to target).

Results Children born preterm had lower BSID-III scores than children born full term. Children born preterm had poorer performance than children born full term on LWL measures for chronological age but similar performance for corrected age. Accuracy and reaction time at 18 months' corrected age displaced preterm-full term group membership as significant predictors of BSID-III scores.

Conclusions Performance and rate of change on language comprehension measures were similar in children born preterm and full term compared at corrected age. Individual variation in language comprehension efficiency was a robust predictor of scores on a standardized language assessment in both groups. *(J Pediatr 2017;180:124-9).*

Children born preterm are at increased risk for delays and disorders of language development. Meta-analyses confirm lower scores on language tests in children older than age 2 years of age born preterm compared with controls born full term.[1,2] Delays in language have been reported before age 2 years,[3-8] although group differences are not found universally at these ages.[9-11] Performance on early language assessments is associated with language evaluations 1-3 years later.[12-14] Language delays can be highly detrimental to children's development because language plays a critical role in learning and reading.[15,16] Understanding the underlying processes associated with language skills may elucidate causes and shape treatments of language delays.

Studies of language in children born preterm typically rely on standardized measures of global language skills or parent-report questionnaires. These measures do not reveal underlying neuropsychological mechanisms that may accumulate to contribute to rates of development. Eye-tracking methods in tasks of word recognition,[17] lexical understanding,[18-20] and novel word learning[21] have been used in children developing typically to investigate neuropsychological mechanisms of language development and have been applied recently to examine these processes in studies of clinical populations.[22,23]

In this study of children born preterm, we administered an eye-tracking procedure to assess language-processing efficiency in addition to a standardized language assessment. The Looking-While-Listening Task (LWL)[24] monitors children's eye movements toward pictures in response to verbal stimuli directing attention to one picture. Like other eye-tracking tasks, it generates measures of preferential looking[25]; however, it also captures speed of lexical processing. We examined 3 hypotheses: (1) children born preterm would show poorer performance on the standardized language assessment and LWL measures in comparison with children born full term; (2) differences would remain when the groups were matched by age corrected for the degree of prematurity[6]; and (3) LWL measures would be strong predictors of scores on the standardized assessment of language.

Methods

The sample included 44 preterm-full term pairs (88 participants) from a larger sample that participated in a longitudinal study of early language development.

BSID-III	Bayley Scales of Infant and Toddler Development, Third Edition
LWL	Looking-While-Listening Task
SES	Socioeconomic status

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Enrollment criteria for the preterm group were gestational age ≤ 32 weeks and birth weight < 1800 g. Inclusion criteria for the cohort born full term were gestational age ≥ 37 weeks and birth weight ≥ 2495 g. Socioeconomic status (SES) was measured via the Hollingshead Four-Factor Index.[26] Each child in the cohort born preterm was matched to a child in the cohort born full term by sex and SES within 7 points. Members of both groups had to be evaluated at each of the study age points. Exclusion criteria for both cohorts were exposure to a non-English language ≥ 25% of the time and major medical conditions. The institutional review board at Stanford University approved the study protocol, and parents of participants provided written consent.

The mean gestational age (SD) was 29.8 (±1.9) weeks in the group born preterm and 40.0 (±1.0) weeks in the group born full term. The mean birth weight was 1246 g (±302) in the group born preterm and 3499 g (±465) in the group born full term. Both groups were 54.5% male. Mean Hollingshead Four-Factor Index score for the cohort born preterm was 58.2 and for the cohort born full term was 59.5 (P = NS). For participants born preterm, medical complications were 18.2% small for gestational age (defined as <10th percentile for gestational age[27]), 79.5% respiratory distress syndrome, 27.3% bronchopulmonary dysplasia or chronic lung disease, 25% patent ductus arteriosus, 11.4% necrotizing enterocolitis, 15.9% intraventricular hemorrhage (13.6% grades 1-2, 2.3% grade 4), 2.3% white matter damage, and 27.3% retinopathy of prematurity.

The timing of the assessments was structured to allow for a corrected-age comparison for the standardized language assessment and for both chronological- and corrected-age comparisons over time for the LWL measures. The study collected data at 16, 18, 22, and 24 months' chronological age from the children born full term and at 16, 18, and 22 months' corrected age from the children born preterm (**Table I**). The data collected at 16 and 22 months' corrected age in the group born preterm also were used for chronological-age comparisons (18 and 24 months' chronological age).

A standardized language assessment was performed at 18 months (corrected for prematurity where applicable) via the Bayley Scales of Infant and Toddler Development, Third Edition (BSID-III).[28] Language Composite Scores were computed with the Receptive and Expressive Communication subtests.

In the LWL,[24] each child was seated on the caregiver's lap and viewed pairs of familiar color pictures projected on a screen. Parents wore opaque eyeglasses so that they could not see the visual stimuli. On each trial, a prerecorded voice named one of the objects in a simple sentence, directing the child's attention to the target image (eg, "Look at the ball. Can you see it?"). The child's eye movements were video-recorded. Before the task, parents were presented with a list of the target nouns used in the procedure and were asked to indicate whether or not their child understood each noun. Because the LWL task measures the efficiency of familiar word comprehension, primary analyses were restricted to trials on which the parent reported that the child understood the target noun on a child-by-child basis. Additional criteria for inclusion of the trial were that the child was attentive to the task, was fixated on one of the pictures at the onset of the trial, and made an eye movement within a time window (300-1800 milliseconds) considered to be appropriate for demonstrating language comprehension in young children.[29,30]

For children at 16 and 18 months of age, 64 experimental trials were presented with simple sentences such as the example discussed previously, counterbalanced for target side. At 22 and 24 months of age, the stimulus set included the same simple sentences and additional stimuli with more complex constructions; only simple sentences were analyzed to allow for longitudinal comparisons (32 trials). Gaze patterns were coded manually offline frame-by-frame. Measures were accuracy (mean proportion of time looking to the target divided by the total looking time to either image from 300 to 1800 milliseconds after target-word onset) and reaction time (mean latency [milliseconds] measured from the onset of the target noun to the initiation of a shift in eye gaze from the distracter image to the target image on trials on which the child was looking at the distracter image at the onset of the target word).

Children who did not participate successfully in at least 25% of the experimental trials were excluded for that age point, because too few trials could yield inaccurate estimates of the child's abilities. One child born preterm was excluded from analysis of reaction time at 24 months because of fewer than 2 valid distracter-to-target shifts. Reliability coding was conducted on 20% of total LWL sessions. For accuracy, coders achieved 93%-99% reliability at all ages for the proportion of frames identified as target and distracter. For reaction time, coders achieved 97%-100% reliability for the proportion of trials on which initial-shift latency agreed within one frame.

Table I. Mean scores on the LWL as a function of corrected and chronological ages in the groups born preterm and full term

	Full term	Preterm	Full term	Preterm	Full term	Preterm	Full term
Number	**n = 43**	**n = 38**	**n = 44**	**n = 42**	**n = 44**	**n = 41**	**n = 44**
Age at test, mo*	16.3 (0.6)	18.5 (0.5) 16.1 (0.6)	18.7 (0.5)	18.6 (0.5)	22.2 (0.7)	24.5 (0.5) 22.2 (0.6)	24.6 (0.6)
Accuracy†	0.61 (0.08)	0.59 (0.09)	0.65 (0.09)	0.63 (0.10)	0.71 (0.10)	0.68 (0.10)	0.75 (0.09)
Reaction time,‡ ms	852 (164)	853 (217)	757 (139)	819 (190)	713 (182)	751 (171)	664 (174)

*Presented as the mean (SD). For preterm infants, the first line is the chronological age at test and the second line is the corrected age.
†Mean proportion of time (SE) looking at the target compared with total looking time.
‡Mean latency (SE) to shift eye gaze from distracter to target picture.

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