1. Introduction

Children born preterm (before 37 weeks gestational age, GA) are at an increased risk for language deficits. By their second birthdays, these children lag on multiple measures of linguistic competencies, including smaller expressive and receptive vocabularies as well as reduced use of complex grammatical structures (Kern and Gayraud, 2007; Vohr, Garcia Coll, and Oh, 1988). Linguistic deficits continue to be pervasive during the early school years (Ortiz-Mantilla, Choudhury, Leevers, and Benasich, 2008), suggesting early limitations may have cascading effects on subsequent language development. By age five years, preterms show a delayed and decreased emergence of verb type and token usage (Le Normand and Cohen, 1999), and by age six years, they are three to five times more likely to have issues with articulatory and pre-reading skills (Wolke and Mayer, 1999), such as phonological awareness (Guarini et al., 2009). Poor language abilities in toddlerhood have also been linked to later academic underachievement (Pritchard et al., 2009; Wolke, Samara, Bracewell, and Marlow, 2008). Together these findings suggest that preterms do not fully catch-up to their full-term counterparts. Furthermore, understanding the nature of early linguistic deficits and how they relate to later linguistic abilities could provide insight on how to mitigate poor outcomes among preterm individuals.

Precursors to preterm children’s linguistic deficits are not well understood. To date, research has primarily been clinical in nature, focusing on characterizing outcomes at and after age two years. Although such work is invaluable, it critically ignores early abilities that could predict future delays and deficits. This is problematic for early intervention services as it is considerably more difficult to intervene on a stable system than it is on one that is still developing. More generally, there is a need to identify when and how developmental trajectories diverge between those children who will develop typically and those who will experience language deficits.

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Preterm toddlers’ reduced vocabularies suggest that they have difficulties with at least some aspects of word-learning. Successful word-learning requires skills for establishing word-form representations and acquiring word meanings. Two such supporting skills are the abilities to detect mispronunciation and mapping novel objects to novel labels. Detecting small variations in pronunciation can facilitate the development of word-form representations by distinguishing familiar from novel, to-be-learned words. In typically-developing children, the ability to detect phonological change in recently habituated label-object pairings has been observed as early as 14 months (Fennell and Werker, 2003). By 18 months, recognition of familiar words is impaired by single-segment mispronunciations (Swingley and Aslin, 2000), and by 19 months, graded, adult-like sensitivities to word-initial (White and Morgan, 2000), and word-final (Ren and Morgan, 2011) single-segment mispronunciations emerge.

Toddlers’ tendency to map novel words to novel objects rather than onto ones for which they already have labels provides a basic strategy for learning unfamiliar word meanings (Markman, 1990). Termed novel name-nameless category (N³C; Mervis and Bertrand, 1994), this bias has been observed at age 17 months, with those exhibiting it having larger vocabularies than those who do not (Halberda, 2003). These findings suggest an important link between the capacity to capitalize on making novel label-novel object associations and vocabulary acquisition. Moreover, the N³C bias has been reported among typically developing (Mervis and Bertrand, 1994) and hard-of-hearing/deaf (Lederberg, Prezbindowski, and Spencer, 2000) populations, indicating that it is universally important for word-learning.

In the present study we examined whether differences in fundamental skills that support word-learning potentially account for some of preterm children’s reduced linguistic competencies. First, we compared word-initial, single-segment mispronunciation detection and the N³C bias across full-term and preterm 19-month-olds. Second, we sought to replicate previous findings showing poorer comprehension skills among preterm two-year-olds. Lastly, we investigated whether sensitivity to mispronunciations and N³C success would account for individual differences in later comprehension skills above and beyond other factors known to impact language outcomes (e.g., gestational age and sex).

Given their increased vulnerability for language deficits, we expected preterms to show reduced detection of mispronunciations and N³C abilities as well as poorer comprehension outcomes. Furthermore, we anticipated that differences in sensitivity to mispronunciations and N³C success would predict outcomes above and beyond gestational age and sex. Such findings would indicate that preterm children’s linguistic difficulties are at least partially rooted in atypical performance in early word-learning supporting skills. Unlike gestational age and sex, these skills can be targeted by early intervention. Knowing that preterm toddlers show deficits in mispronunciation detection and N³C abilities also means that strategies to prevent poor outcomes can be employed earlier in development.
2. Method

2.1. Participants

Preterm and full-term children were initially recruited at four months from Providence, Rhode Island and surrounding areas to participate in a larger longitudinal project of which the study reported here formed a part. All participants were English-learning, and had normal or corrected to normal hearing and vision. All preterm data were collected at corrected ages$^1$.

Twenty preterm (13 female; $M_{GA}=30.5$ weeks, range= 24-36; $M_{Birth-weight} = 1,399$ g, range= 640-2,750) and 40 full-term (20 female; $M_{GA}= 39.6$ weeks, range= 37-41; $M_{Birth-weight} = 3,559$ g, range= 2,778-4,423) toddlers were tested at 19 months. Of these, 15 preterms (9 female; $M_{GA}= 30.7$ weeks, range= 24-36; $M_{Birth-weight} =1,455$ g, range= 640-2,750) and 36 full-terms (17 female; $M_{GA}=39.7$ weeks, range= 37-41; $M_{Birth-weight} = 3,600$ g, range= 2,892-4,423) also provided comprehension outcome data at 26 months. Mean maternal education, as assessed by an 8-point scale quantifying highest level of education attained, was slightly higher in full-term ($M= 7.4$, SD= 0.7) than preterm ($M= 6.7$, SD= 1.7) participants.

2.2. Procedure and Stimuli: Assessing Detection of Mispronunciations and the N³C Bias

Modeled after White and Morgan (2008), the present study tested 19-month-olds using the Intermodal Preferential Looking Paradigm (IPLP). While sitting on a caregiver’s lap, toddlers were presented with 18 trials comprised of unique familiar-unfamiliar object pairs (e.g., shoe-padlock). This design, which allows observation of language processing in the presence of objects with unknown labels, is more representative of what the novice language-learner encounters on a daily basis. Object familiarity/unfamiliarity was confirmed using parental report, with familiar objects having labels known by at least 50% of the American English-learning population by age 14 months.

Trials consisted of two phases, Baseline and Test, and included three trial-types, five Correct, nine Mispronunciation, and four Novel. Objects in a pair appeared simultaneously side-by-side (see Figure 1). Pairs were first presented in silence for four seconds; this Baseline phase was intended to capture potential preferences for either object in a pair. Objects were then re-represented, and participants were directed to look at the target; this Test phase lasted nine seconds.

In Correct trials, the target was always the familiar object, with its label correctly pronounced. During these trials, participants were expected to look
longer at the familiar target object. In Mispronunciation trials, the target was again the familiar object, this time presented with a word-initial, single-segment change to its label (e.g., “shoe” was pronounced as “foo”). Mispronunciations were expected to drive decreased looking to the familiar target object accompanied by increased looking to the unfamiliar distractor object. Difference scores in target looking during Correct vs. Mispronunciation trials were used as a measure of sensitivity to mispronunciations.

In Novel trials, the target was always the unfamiliar object. These trials assessed children’s N3C bias. Participants with a strong bias were expected to look longer at the unfamiliar object after hearing a novel label.

4-Second Baseline: In Silence Object Presentation

9-Second Test: “Where’s the foo?...Find the foo!”

Figure 1. Example of a Mispronunciation trial, including the Baseline and Test phases. The familiar target and unfamiliar distractor objects appear on the right and left, respectively.

2.3. Procedure and Stimuli: Assessing Language Comprehension Outcomes

Participants’ comprehension skills were evaluated at 26 months using the Receptive Language Subscale (RLS) of the Mullen Scales of Early Learning. This standardized tool is composed of five subscales measuring motor, cognitive, and linguistic development from birth to age five years, eight months.

The RLS measures receptive language skills via 33 test items arranged in order of progressive difficulty. A child’s age and level of development determine which task s/he starts on. Test items evaluate comprehension skills by presenting children with everyday situations encountered at home or school.

3. Results

3.1. Detection of Mispronunciations and the N3C Bias at 19 Months

For each trial, proportion target looking (PTL= Target/[Target+Distractor]) was calculated by subtracting Baseline PTL from Test PTL for the first three seconds following target label onset. The resulting PTLs were then averaged for
each trial-type. Positive mean difference scores indicated greater looking to the target, while negative ones indicated greater looking to the distractor.

**Detection Mispronunciations.** Mean PTL values for Correct and Mispronunciation trials were 0.112 (SD= 0.154) and 0.00548 (SD= 0.135) for full-terms, and 0.0285 (SD= 0.252) and 0.0549 (SD= 0.0987) for preterms\(^2\), respectively (see Figure 2). An ANOVA with birth status (Full-term vs. Preterm) as a between subjects factor and trial-type (Correct vs. Mispronunciation) as a within subjects factor indicated a significant interaction between these two variable-types, \(F(1, 57)= 4.59, p= .037\), with no main effect of trial-type, \(F(1, 57)= 1.67, p= .201\). Follow-up t-tests confirmed that while full-terms looked significantly longer at the target during Correct than Mispronunciation trials, \(t(39)= 3.61, p= .001\), preterms did not, \(t(18)= -0.40, p= .692\).

![Figure 2. Mean proportion target looking after adjusting for baseline preferences and standard error for Correct and Mispronunciation trials at 19 months. Positive values indicate greater looking to the target rather than the distractor object.](image)

Individual differences in sensitivity to mispronunciations were also evaluated by computing the difference between mean PTLs for Correct and Mispronunciation trials for each participant. Specifically, mean PTLs for *one-feature* mispronunciations were used. Compared to two- and three-feature mispronunciations, these are perceptually less salient, making their detection more challenging. Thus, a decrease in target looking in response to one-feature label mispronunciations relative to correct label pronunciations are indicative of high sensitivity to mispronunciations.

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\(^2\) Group means exclude data from one female participant who failed to produce any usable Correct trials.
Mean sensitivity measures were 0.153 (SD= 0.245) and 0.00740 (SD= 0.452) for full-terms and preterms, respectively. Individual measures of mispronunciation sensitivity were used in regression analyses as predictors of language comprehension outcomes at 26 months (see Section 3.2, below).

The N³C Bias. Mean proportion target object looking values for Novel trials were -0.0388 (SD= 0.229) and -0.0807 (SD= 0.255) for full-terms and preterms, respectively (see Figure 3). T-testing indicated cross-group looking time differences were not statistically significant, $t(58)= 0.643, p = .523$.

Negative values for mean proportion target looking show that, as groups, neither full-terms nor preterms consistently demonstrated the N³C bias. However, at the individual level, full-terms were more likely to look at the unfamiliar target after hearing a novel label. Positive PTLs were observed in 23 of the 40 full-terms (~58%) compared to only 7 of the 20 preterms (~35%).

![Figure 3. Mean Proportion target looking after correcting for baseline preferences and standard error for Novel trials at 19 months. Negative values indicate greater looking to the familiar distractor than the novel target object.](image)

3.2. Language Comprehension Outcomes at 26 Months

Preterm 26-month-olds were significantly outscored on the RLS by their full-term peers, $t(49)= 2.28, p = .027$. Mean raw scores differed by 2.1 points across groups, with group scores of 27.6 (SD= 2.75) and 29.7 (SD= 3.02) points for preterms and full-terms, respectively.

3.3. Relations Between Word-Learning Skills and Comprehension Outcomes

Hierarchical regression was implemented to determine whether mispronunciation sensitivity and N³C success at 19 months predicted RLS scores at 26 months above and beyond gestational age and sex, two factors known to be of significant consequence for language outcomes (Bornstein,
While gestational age and sex alone significantly predicted comprehension, $R^2 = 0.23$, $F(2, 48) = 7.07$, $p = .002$, adding mispronunciation sensitivity and N3C success doubled the amount of variance in RLS scores explained by the regression model, $R^2 = 0.46$, $F(4, 46) = 9.62$, $p < .001$. Together, mispronunciation sensitivity and N3C success contributed to the model just as much as gestational age and sex (see Table 1 for a comparison of standardized $\beta$ values). Of the four predictors, N3C success had the highest predictive value for RLS scores.

**Table 1. Regression coefficients and zero-order correlations for model including mispronunciation sensitivity, N3C success, gestational age (GA), and sex as predictors of RLS scores.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$ unstandardized</th>
<th>SE</th>
<th>$\beta$ standardized</th>
<th>$t$</th>
<th>$p$</th>
<th>Zero-order</th>
</tr>
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<tr>
<td>Intercept</td>
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<td>7.41</td>
<td>&lt; .001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mispro. Sensitivity</td>
<td>2.64</td>
<td>1.27</td>
<td>0.25</td>
<td>2.08</td>
<td>.043</td>
<td>0.40**</td>
</tr>
<tr>
<td>N3C Success</td>
<td>4.93</td>
<td>1.47</td>
<td>0.37</td>
<td>3.36</td>
<td>.002</td>
<td>0.43***</td>
</tr>
<tr>
<td>GA</td>
<td>0.21</td>
<td>0.08</td>
<td>0.31</td>
<td>2.65</td>
<td>.011</td>
<td>0.36**</td>
</tr>
<tr>
<td>Sex</td>
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<td>0.67</td>
<td>0.31</td>
<td>2.82</td>
<td>.007</td>
<td>0.26*</td>
</tr>
</tbody>
</table>

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

4. Discussion

Our goals for this study were threefold. First, we compared mispronunciation detection and the N3C bias, two word-learning supporting skills, across full-term and preterm toddlers. Second, we sought to replicate previous research showing preterm two-year-olds are linguistically disadvantaged compared to their full-term counterparts. Third, we examined relations between early word-learning supporting skills and later language comprehension, specifically investigating whether differences in sensitivity to mispronunciations and N3C success accounted for variability in RLS scores above and beyond gestational age and sex.

Our findings indicated that preterm corrected age 19-month-olds are not sensitive to mispronunciations of highly familiar words. Unlike their full-term peers, these toddlers were not differentially sensitive to correctly and incorrectly pronounced target labels. While neither preterm nor full-term groups consistently engaged in the N3C bias, preterm individuals were less likely to employ this strategy for linking novel labels to unfamiliar objects. Interestingly, preterms’ lag in these word-learning skills was evident despite having greater
native language experience\(^3\). These findings confirm that preterm children, a population known to be at an increased risk for language deficits, have difficulties with fundamental skills that support word-learning. Insensitivities to mispronunciations can hinder the differentiation of similar-sounding words and slow word recognition, ultimately impacting the development of *word-form representations*. Deficits in the capacity to link novel labels to unfamiliar objects can affect the acquisition of *word meanings*.

As expected, preterm corrected age 26-month-olds had poorer language comprehension than their full-term peers. Critically, individual differences in mispronunciation sensitivity and N\(^3\)C success at 19 months predicted comprehension above and beyond gestational age and sex. Together, these four variables accounted for 46% of the variance in comprehension scores, 23% greater than that explained by gestational age and sex alone. Better comprehension was associated with greater mispronunciation sensitivity, higher N\(^3\)C success, longer gestational ages, and being female.

**5. Conclusion**

From previous work we know that preterm children are at risk for reduced linguistic competencies and that these are related to long-term deficits and academic underachievement. In the present study we show that preterm toddlers lag behind in skills that support the acquisition of word-form representations and word meanings, and that performance on these skills predict later comprehension abilities. These findings are consistent with additional results from our longitudinal project showing that differences in sensitivity to lexical stress and phonotactics are already evident across preterms and full-terms in *infancy*, and that these also account for variability in comprehension outcomes in *toddlerhood* (Molina Onario and Morgan, under revision). Together, these results suggest that language processing skills are persistently different among preterms from very early on in development, prior to age two years, when preterms’ linguistic outcomes are consistently reported to be poorer than those of their full-term counterparts.

Characterizing *when* and *how* development in preterms diverges from that of full-terms can have important implications for developing interventions that can target specific sources of preterms’ linguistic incompetencies. Earlier characterization of potential sources of deficits also means that prevention strategies can be implemented at younger ages, when the at-risk child is most plastic.

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\(^3\) Since preterms were tested at corrected ages they were chronologically *older* than full-terms, meaning they had longer exposure to native language speech.
References


Fennell, Christopher, & Werker, Janet. (2003). Early word learners’ ability to access phonetic detail in well-known words. *Language and Speech, 46*(2), 245-64.


