Early Prosodic Development predicts Lexical Development in typical and atypical language acquisition

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Abstract

An early sensitivity to prosody is well-documented in the language development literature and has been suggested to facilitate language learning. However, prosodic development and its relation to other areas of language development has been less studied. Some studies suggested that early prosodic development and early lexical development are related in language production \cite{1,2}. In this longitudinal study, we investigated whether early prosodic development (assessed before 19 months) predicted receptive and expressive vocabulary outcomes in three groups of children: typically developing, at risk for language impairment, and with Down Syndrome. We used data from two parental reports: a new parental report of prosodic skills (ProsoQuest, \cite{3}), and the CDI short forms for infants and toddlers \cite{4}. Data from 23 and 79 pairs of reports was analyzed respectively for receptive and expressive vocabulary, using linear mixed models. The prosody comprehension part of ProsoQuest was found to predict receptive vocabulary development, and the prosody production part to predict expressive vocabulary development. There was no interaction with group. These findings suggest that at a young age prosody predicts lexical development, and thus early assessment of prosody may play a crucial role in the screening, prevention, early intervention and diagnosis of language impairments.

\textbf{Index Terms:} Prosodic development; Lexical development; early predictors; typical development; risk for language impairment; Down Syndrome

1. Introduction

Prosody is a key component of successful communication development. Prosody is manifested by the use of phonetic features (like pitch, intensity, and duration) to establish patterns of intonation, stress, timing, and speech chunking which contribute to meaning. Thus, prosody plays an important role in the comprehension and production of speech.

An early sensitivity to prosody is well-documented in the language development literature and has been suggested to facilitate language learning \cite{5, for a review}. Infants are sensitive to rhythm, stress and prominence patterns, pitch patterns, and to the cues that signal prosodic boundaries \cite{6}. For example, \cite{7} found that by 5 months infants could discriminate the intonation patterns that signal the contrast between statements and questions in Portuguese. In \cite{8, 9} it is shown that early word segmentation abilities are initially facilitated by prosody, as words located at prosodic edges in English and Portuguese utterances are segmented earlier than words in internal utterance position. Furthermore, infants’ perception of prosodic boundaries at 9 months was related to their vocabulary scores at 18 months, and their word combination abilities at 24 months \cite{10}. Indeed, it has been suggested that early perception of phrasal prosody plays a role in the acquisition of the lexicon and syntax \cite{11}.

Studies on early prosodic development and its relation with other areas of language development are, however, scarce. Specifically, it is largely unknown whether and how the development of prosody, in language perception and in language production, might relate to the development of the lexicon and syntax. Looking at early speech production, some studies have suggested that prosodic development and lexical development are related. \cite{1} and \cite{2} have respectively shown a close relationship in time between intonation and lexical development, whereas intonation development was found to be independent of, and precede, the onset of combinatorial speech. Thus, the development of the ability to produce different sentence types and other pragmatic meanings through changes in intonation was related to the development of word production. In \cite{2} a similar pattern was found for the development of prosodic phrasing. By and large, both the perception and production of at least certain aspects of prosody seem to emerge early and to develop before other areas of language in typical development \cite{6}.

Studies on prosodic development in atypical populations are rare. \cite{12} and \cite{13} suggested that children with Down Syndrome tend to have lower scores for vocabulary production, but higher scores for the comprehension of prosody tasks, suggesting that prosody and vocabulary are not related in this atypical group. However, \cite{14} examined how prosody modulated early word segmentation abilities in infants and toddlers at risk for language impairment and infants and toddlers with Down Syndrome. They found that for both groups segmentation abilities at the prosodic edge were correlated with concurrent vocabulary scores measured with the MacArthur Bates Communicative Development Inventory (CDI). For the current longitudinal study, we were especially interested in investigating whether early prosodic skills predicted lexical development in typical and atypical populations. Using data from two parental reports, one assessing prosodic skills (ProsoQuest) and the other lexical development (CDI), we examined the relation between early prosodic development and receptive and expressive vocabulary in three groups of infants: typically developing, at risk for language impairment, and infants with down syndrome.
2. Method

2.1. Participants

For this study, we analyzed data belonging to three groups of infants. The typically developing (TD) infants and toddlers had no known risk for language impairment. The infants and toddlers at risk for language impairment (AR) included a mix of risk factors: familial risk for autism or language disorder, suspicious of late talker, preterm birth (<37 weeks), low weight birth weight (<2500g), and other factors like low Appgar score and reanimation at birth. The infants and toddlers with Down Syndrome (DS) had no severe hearing loss and no uncorrected hearing or vision problems. All participants were raised in monolingual European Portuguese homes and had no reported history of seizures, neurological sequelae or other serious medical or neurological conditions.

Parents gave written informed consent before participation in the study. The study was approved by the Ethical Committee for Research of the School of Arts and Humanities of the University of Lisbon, as part of the Predictors of Language outcomes project.

2.2. Materials

We used two parental reports to measure language skills, namely, the new parental report of prosodic skills (ProsoQuest, [3], [15]) and the European Portuguese version of MacArthur Bates Communicative Development Inventory (CDI) short forms ([4]).

2.2.1. ProsoQuest: a new parental report of prosodic skills

ProsoQuest is a new tool to assess infants’ prosodic skills and their development, which has recently been validated for European Portuguese. The parental report may be administered when the child is between 12 months and 24 months. It includes two sections respectively devoted to comprehension of prosody and production of prosody. Each of the sections includes 3 items that assess the comprehension/production of communicative functions of intonation (statement, question, command, request, call), of prosodic phrasing and of prosodic focus (i.e., the highlighting of a given element in an utterance). For each item, parents answer a 7-alternative forced choice question that corresponds to different age options of when the respective prosodic skill emerged.

2.2.2. EP version of MacArthur Bates Communicative Development Inventory (CDI) short forms

The MacArthur Bates Communicative Development Inventory (CDI) short forms are parental reports that provide measures of receptive and expressive vocabulary for assessing early language skills. Specifically, parents respond as to whether the child understands a given word and whether the child produces a given word. The EP version of the CDI short forms was used [4]. The infant short form is administered when the child is between 8 and 18 months and provides measures for receptive and expressive vocabulary. The toddler short form 2 is administered between 16 to 30 months and provide a measure of expressive vocabulary, morphology, and the development of word combinations. For the purposes of the present study only the expressive vocabulary measure is used.

2.3. Data Set

Data from 23 and 79 pairs of ProsoQuest and CDI reports were analyzed, respectively for receptive and expressive vocabulary. Five pairs of parental reports had to be excluded for not complying with the minimal interval of 15 days between the dates when the ProsoQuest and the CDI were filled in. For this study we were especially interested in the ProsoQuest reports administered before the child was 19 months, and the CDI reports administered at 18, 24 and 30 months. For assessment of receptive vocabulary skills, the mean interval between the ProsoQuest and the CDI was 2 months; for the assessment of expressive vocabulary skills, the mean interval between the two reports was 7 months.

For the ProsoQuest/Receptive vocabulary pairs, the mean age of administration of the ProsoQuest was 16 months, with a range between 13 to 18 months (11 girls). For the ProsoQuest/Expressive vocabulary pairs, the mean age was 17 months, with a range between 13 and 19 months (37 girls).

The final sample included the following pairs of questionnaires for the three groups of infants and toddlers: for receptive vocabulary, 5 for TD, 6 for AR, and 7 for DS; for expressive vocabulary, 32 for TD, 29 for AR, and 18 for DS.

2.4. Statistical Analysis

We fitted a linear mixed-effects model (lmer function) as implemented in the lme4 package [16] for R [17], with the percentile of vocabulary development of the CDI as the dependent variable, the ProsoQuest score as the prosodic predictor, and group (TD, AR and DS) as fixed factors, and participants as a random factor. We projected the model to use Maximum Likelihood estimation (ML).

First, we compared different models to determine the model with the best fit. The basic model (model 0) targeted the basic group x predictor interaction. The other models added covariables, namely, the age of the infant when the ProsoQuest report was filled in (model 1) and the time interval between the predictor and the vocabulary assessment (model 2). Once the best model was selected, we focused on interactions engaging group and predictor, which would indicate differences in how prosodic skills predict language across groups. When such interactions were non-significant, we determined the main effect of the predictor.

In order to investigate significant differences between models, we made direct comparisons with Chi-squared tests as provided by the anova function available in R. Decisions on the best model were based on the Bayesian Information Criteria (BIC, lower values indicate better fits). BIC considers the number of observations in the dataset and performs better than AIC (Akaike Information Criterion) for small sample sizes [18]. Since we had a sample size with only 18 observations for receptive vocabulary and 74 for expressive vocabulary, the Bayesian Information Criteria (BIC) was considered more adequate than AIC.

3. Results

We found that comprehension of prosody predicted receptive vocabulary (3.1) and production of prosody predicted expressive vocabulary (3.2). Comprehension of prosody was
found not to predict expressive vocabulary, and production of prosody did not predict receptive vocabulary. Therefore, we will focus on the former two findings.

### 3.1. Comprehension of Prosody and Receptive vocabulary

#### 3.1.1. Model Comparison

We performed several comparisons, contrasting model 0 (basic model) with models that included additional covariates. Model 0 targeted the basic group x prosodic predictor interaction. Model 1 considered a three-way interaction between group, predictor and age at which ProsoQuest data were collected. Model 2 considered a three-way interaction between group, predictor and time interval between reports.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Estimation Method</th>
<th>Model</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIC</td>
<td>ML</td>
<td>0</td>
<td>166.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>167.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>167.78</td>
</tr>
</tbody>
</table>

When directly comparing model 0 with model 1, we observed a significant difference ($\chi^2 (6, 18) = 15.67, p = .01$). The same procedure was done to compare model 0 with 2, where a significant difference was also observed ($\chi^2 (6, 18) = 15.60, p = .01$). According to the Bayesian Information Criteria (Table 1), model 0 showed the best fit (lowest BIC value).

#### 3.1.2. Group x predictor interactions

Figure 1 shows the regression lines for receptive vocabulary (CDI) as predicted by prosodic comprehension (ProsoQuest).

**Figure 1: Regression lines for the prediction of receptive vocabulary by comprehension of prosody.**

Since model 0 was the one that better explained our data, we focused on the group x predictor interaction as provided by this model. Comparisons between two versions of model 0 – with vs. without the interaction term – did not show significant differences ($\chi^2 2, N = 18, = 3.29, p = .19$), thus indicating a null group x predictor interaction. Therefore, we discarded the interaction term from model 0 and focused on the main effect of the predictor (Table 2).

### 3.2. Production of Prosody and Expressive vocabulary

#### 3.2.1. Model comparison

As in section 3.1., we performed several comparisons between models (0, 1 and 2), this time for data concerning the relation between production of prosody and expressive vocabulary.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Estimation Method</th>
<th>Model</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIC</td>
<td>ML</td>
<td>0</td>
<td>723.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>738.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>738.19</td>
</tr>
</tbody>
</table>

Model comparisons showed no significant differences between model 0 and model 1 ($\chi^2 (6, 74) = 10.12, p = .11$), and no significant differences between model 0 and mode 2 ($\chi^2 (6, 74) = 10.64, p = .10$). Because model 0 showed the lowest BIC value (best fit, see Table 3) and also because it was the simplest model, we analyzed group x predictor interactions without additional covariates.

#### 3.2.1. Group x predictor interactions

Figure 2 shows the regression lines for the relation between production of prosody (ProsoQuest) and expressive vocabulary (CDI).

As in 3.1, we compared two versions of model 0 – with and without the interaction term – to determine the significance of the group x predictor interaction. The interaction proved to be non-significant ($\chi^2 2, N = 74, = 0.21, p = .89$). As in the previous analysis, we looked at the main effect of the predictor in the model without the interaction term (Table 4).
Production of prosody (ProsoQuest) predicted lexical production in a significant manner. Together with the null group x predictor interaction, results indicate that the prosodic predictors are equally efficient in all three groups.

Table 4: Effects of group and prosodic production (ProsoQuest) on lexical production (CDI), considering the TD group as the default level.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Estimate</th>
<th>CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>52.08</td>
<td>40.02–64.14</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prosodic Production</td>
<td>0.70</td>
<td>0.02–1.39</td>
<td>0.04</td>
</tr>
<tr>
<td>Group (DS)</td>
<td>-43.18</td>
<td>-60.10–26.25</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Group (AR)</td>
<td>-30.87</td>
<td>-45.17–16.58</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of Sub</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 4, prosodic skills significantly predicted expressive vocabulary, now in the expected direction: participants with early high skills in production of prosody showed better expressive vocabulary later in development.

4. Discussion

In this study, we investigated how prosodic development related to other areas of language, namely lexical development. Our main goal was to verify if early prosodic development predicted receptive and expressive vocabulary outcomes in typically and atypical language acquisition, namely, in the three groups of interest: typically developing, at risk for language impairment, and with Down Syndrome.

Previous studies have shown that early sensitivity to prosody facilitates language learning [5]. Furthermore, it has been shown that in typical language development the perception and production of at least certain aspects of prosody seem to emerge early and to develop before other areas of language in typical development [1, 4, 6, 11]. Our finding that prosody production skills positively predict later expressive vocabulary is in line with the crucial role that prosody plays in language acquisition as a facilitator of the learning of language. It is also in line with suggestions that early prosodic development precedes other aspects of language development.

We also found that comprehension of prosody predicted receptive vocabulary outcomes. However, surprisingly, the better the prosodic comprehension skills, the lower the receptive vocabulary. It might be possible that the early ability to comprehend prosodic cues allows some degree of semantic comprehension and retards the need for lexical decoding, meaning that infants and toddlers survive with prosodic-based comprehension tools, relying more on prosody until later on development. Alternatively, it could be that early prosodic comprehension may work as a compensatory mechanism in infants and toddlers struggling to acquire receptive vocabulary. Another possible explanation is related to the interval between the prosodic skills assessed and the lexical abilities. In the case of receptive vocabulary, the interval was only 2 months, what may have not been enough to capture later vocabulary outcomes promoted by prosodic skills. Importantly, our sample for receptive vocabulary is small, and thus current findings need to be confirmed in a larger sample.

Interestingly, both in the case of receptive and expressive vocabulary, the predictive power of prosodic skills did not differ according to the developmental status of participants.

Therefore, the impact of prosodic skills on later lexical development was found to be similar in typical and atypical language development. Future work will examine larger samples, particularly in the case of receptive vocabulary outcomes, and extend the analysis to the relation between prosodic skills and the development of syntax.

5. Conclusion

The findings from the present study suggest that at a young age prosody predicts lexical development, and thus early assessment of prosody may play a crucial role in the screening, prevention, early intervention and diagnosis of language impairments.

6. Acknowledgements

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7. References


