Phonology of late and precocious talkers in French

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Abstract. This study examines the relationship between lexical and phonological variables in 40 French-speaking children, aged 2;5. Specifically, it examines the influence of phonetic complexity (PhC), phonological production (PhP), and neighbourhood density (ND) on vocabulary size. Children were divided into four groups on the basis of vocabulary size: late1 (<10%ile), late2 (15-25%ile), middle (40-60%ile), and precocious (>90%ile). The children's lexicons were coded in terms of PhC and ND (one-syllable words), and their PhP capacities were determined from measuring percent consonants correct (PCC) in spontaneous language samples. Results indicated significant group differences in all three variables. Children with larger vocabularies selected words with greater PhC and with lower ND values. They had superior PhP abilities compared to children with smaller vocabularies. Linear regression indicated that 71% of variance in vocabulary size could be accounted for by the three variables, with the highest percentage accounted for by ND (56%). Our findings are consistent with previous studies which show that ND plays an important role in accounting for variance in vocabulary size. They also indicate that other variables such as PhC and PhP influence lexical acquisition.

Keywords: lexical selection, phonetic complexity, neighborhood density, phonological production, late talkers

Introduction

The relationship between lexical and phonological development has been the subject of much research in recent times (see Stoel-Gammon, 2011, for a review). One line of research has focused on children's tendency to select and avoid words on the basis of their phonological characteristics, a phenomenon referred to as *lexical selection and avoidance*. Another line of research has examined the relationship between phonological production (PhP) and vocabulary size (Rescorla & Ratner, 1996; Smith, McGregor, & Demille, 2006). Yet another line of research has adopted variables from adult psycholinguistics such as neighbourhood density (ND) and word frequency (WF) to determine what factors account for vocabulary development in children (Stokes, 2010; Stokes, Bleses, Basbøll, & Lambertsen, 2012a; Stokes, Kern, & dos Santos, 2012b). The aim of the study is to bring these three themes together when examining the phonological and lexical development of French-speaking children. Specifically, we investigate the influence of phonetic complexity (PhC), PhP, and ND on vocabulary size.

Lexical selection and avoidance

Observational studies support the idea that children select and avoid words on the basis of their PhP capacities. For example, Ferguson and Farwell (1975) reported on a child who had a disproportionately high number of words containing sibilant consonants [s, z, ʃ, ʒ, ʤ] (e.g. *cereal*, *shoes*, *cheese*, *juice*, *see*, *eyes* and *sit*). Since input frequency could explain apparent lexical selection patterns, researchers have used experimental paradigms to provide evidence for articulatory effects on word learning. Schwartz and Leonard (1982) showed that children, aged 1;2 to 1;8, learned to produce nonsense words containing sounds that they could produce more easily than nonsense words containing sounds that they could not produce thus confirming the link between phonological experience and lexical acquisition.

Beyond the first word period, authors have found evidence for phonetic effects on lexical selection by examining the phonological characteristics of children's lexicons at different ages according to the MacArthur Communicative Developmental Inventory (MCDI – Fenson, Dale, Reznick, Thal, Bates,

Hartung, Pethick, & Reill, 1993). Gayraud and Kern (2007) compared the phonological composition of nouns acquired by French-speaking children at 2;0 and at 2;6. In terms of syllable structure, they observed a decrease in the proportion of CV syllables and an increase in the proportion of CVC syllables between the two ages. Words beginning with nasals decreased whereas words beginning with fricatives increased in frequency. Words beginning with bilabials decreased whereas those beginning with alveolars and velars increased. In sum, findings based on French and several other languages (e.g., Cantonese: Fletcher, Chan, Wong, Stokes, Tardif, & Leung, 2004; English: Stoel-Gammon, 1998) show phonetic differences between the vocabularies of younger and older children which match those of production data. Those features which are less frequent in the lexicons of the younger children are those which are acquired later in production.

Other studies have looked at lexical selection in children of the same age, but who vary according to vocabulary size. Kehoe, Chaplin, Mudry, and Friend (2015) observed phonetic selection tendencies in a group of late talkers. One of the ten late talkers did not select any words with initial clusters and four of them did not select any words with final clusters in comparison to their peers with medium or large vocabularies who selected words with clusters. Further information on lexical selection comes from a study by Kern and dos Santos (2016) which examined whether PhC (as defined by the Index of PhC; Jakielski, 2000) could explain variance in vocabulary size in French-speaking children, aged 2;0 to 2;6. They found that it accounted for very little variance in comparison to other variables (e.g., ND, see below). In sum, more research is needed to clarify the role of lexical selection in vocabulary acquisition.

The phonology of late and precocious talkers

There is a wealth of data supporting the association between PhP and vocabulary size. Children who have exceptionally small vocabularies such as late talkers have very limited phonological abilities. Rescorla and Ratner (1996) found that late talkers vocalized less often, had smaller consonantal and vocalic inventories and employed a more restricted set of syllable shapes than their typically developing peers. At the other end of the spectrum, Smith *et al*. (2006) found that lexically precocious two-year olds were superior to their age-matched peers in terms of the number of singleton consonants correct, the percentage of final consonants correct and in their use of phonological processes. The association between vocabulary size and PhP has been observed in a variety of languages including English, Cypriot Greek, and Cantonese (Fletcher *et al*., 2004; Paul & Jennings, 1992; Petinou & Okalidou, 2006) but, to date, there has been little research on the phonology of late talkers in French.

Adult-centred psycholinguistic studies

Stoel-Gammon (2011) contrasted two different approaches to examining the association between lexical and phonological development: child- versus adult-centred approaches. The above-mentioned themes, *lexical selection* and the *phonology of late and precocious talkers,* are child-centred approaches. In adult-centred approaches, researchers have borrowed constructs from language processing in adults to examine the role played by lexical and sub-lexical patterns in the ambient language. We are interested in those studies which have focused on the role of ND in accounting for vocabulary size in children.

Neighbourhood density (ND) refers to the number of phonological neighbours of a word whereby a phonological neighbour is a word that differs from another word by substitution, deletion, or addition of a sound in any word position. Words which contain many phonological neighbours are said to belong to dense neighbourhoods, whereas those which contain few neighbours belong to sparse neighbourhoods. A series of studies by Stokes and colleagues shows that ND accounts for an exceptionally high proportion of variance in the vocabulary size of children acquiring English, French and Danish (Stokes, 2010; Stokes *et al*., 2012a, 2012b). In all of these studies, they coded the mean ND and WF of one-syllable words appearing in two-year-old children's lexicons. The amount of variance accounted for by ND was 39% in Danish-speaking (n=894; age range 2;2-2;6), 47% in English-speaking (n=222; age range 2;0-2;6) and 53% in French-speaking children (n=208; age range

2;0-2;6). In all cases, WF accounted for a small amount of additional variance (English: 14%; French: 9%; Danish: 3%).

One salient finding from Stokes *et al*.'s research is that children with small vocabularies select words with high ND values. Stokes *et al*. (2012b) posit that words from dense neighbourhoods are less taxing on auditory-verbal short term memories than words from sparse neighbourhoods. By virtue of the fact that they share segments with many words they offer a familiar phonetic stream which facilitates word learning. They hypothesize that all children select words with high NDs at the beginning, but children with low vocabularies continue to adopt this strategy for an extended period, thus, impeding later word learning.

Current Study

This study focuses on phonological and lexical associations in French-speaking children, aged 2;5. We seek to confirm Stokes *et al*.'s findings that children with small vocabularies have significantly higher ND values than children with large vocabularies, and that ND accounts for a large percentage of variance in vocabulary size. We extend previous research by including other phonological variables, such as PhC and PhP alongside ND (see Kern & dos Santos, 2016, for PhC).

The first aim is to examine whether children, separated into groups according to vocabulary size, differ in the phonological and lexical characteristics of their lexicons and in their PhP abilities. We predict that children with small vocabularies select words with phonetically simpler forms and with higher ND values than children with large vocabularies. We also predict that they will have inferior PhP skills compared to children with large vocabularies.

The second aim is to examine how much variance in vocabulary size is accounted for by PhC, ND and PhP. We predict that the highest percentage of variance will be accounted for by ND, but given the frequently cited correlation between vocabulary size and PhP, some additional variance will be accounted for by PhP. Given the lack of research on PhC, we make no specific predictions, although the findings of Kern and dos Santos (2016) suggest that PhC does not play a strong role in accounting for vocabulary size.

Method

This study is part of a larger project whose main purpose was to examine the association between early language comprehension and later language and literacy development. The larger study involved testing 65 French-speaking children longitudinally from the ages of 1;4 through to 5;0 years. In this study, we focus on a sub-sample of these children at a single age-range.

Participants

Participants included 40 monolingual French-speaking children, aged 2;5 (+/- 15 days). Children were selected from the larger data-base on the basis of vocabulary size as determined by their percentile scores on the *Inventaire Français du Développement Communicatif* (IFDC) (Kern & Gayraud, 2010) (the French adaptation of the MCDI). Four groups were formed: 1. Late 1 (n=8; 3 girls) were children whose IFDC scores were at or below the 10th percentile (range=40-221); 2. Late 2 (n=9; 6 girls) were children whose IFDC scores were between the 15th and 25th percentile (range=268-353); 3. Middle (n=11; 5 girls) were children whose IFDC scores were between the 40th and 60th percentile (range=372-474); and 4. Precocious (n=12; 6 girls) were children whose IFDC scores exceeded the 90th percentile (range=572-677). All children had normal hearing, were reported to be in good health and were developing normally.

Procedure

Children attended a single session of 60 minutes in the speech laboratory at the University of Geneva in which they received a battery of tests designed to measure executive functions and comprehension and production of vocabulary and morpho-syntax. They also participated in a play session (20 minutes

duration) with Fisher Price farm toys while interacting with one of their parents. The play sessions were recorded using a portable digital tape-recorder (Marantz PMD620). The parents completed the IFDC following the session.

Data-coding

A restricted set of the IFDC was coded for PhC and ND (see Stokes *et al*., 2012b). The restricted set included 12 categories of items considered to represent core vocabulary. **All** of the items in the restricted set (n=518) were coded for PhC using the Index of PhC (Jakielski, 2000). A word received a point if it contained: a dorsal consonant (e.g., *camion* [**k**amjɔ̃] 'truck'), a fricative or liquid (e.g., *avion* [a**v**jɔ̃] 'plane'; *balle* [ba**l**] 'ball'), a final consonant (e.g., *balle* [ba**l**] 'ball'), three-syllables or more (e.g., *animal* [**animal**] 'animal'), two or more consonants with different places of articulation (PoA) (e.g., *balle* [**b**a**l**] 'ball' which has labial and coronal PoAs), a tautosyllabic cluster (e.g., *crayon* [**kʁ**ejɔ̃] 'pencil'), or a heterosyllabic cluster (e.g., *tracteur* [tʁa**kt**œːʁ] 'tractor'). Once coding was completed, we determined the mean PhC value for each child. **One-syllable words** of the restricted set of the IFDC were coded for ND (Stokes *et al*., 2012b) using the values generated by the Lexique3 database, a corpus of adult language (New, Brysbaert, Veronis, & Pallier, 2007). The most frequent phonological form was chosen when two word choices (e.g., *beau*/***belle***) were provided. Once coding was completed, a mean ND values was obtained for one-syllable words in each child's lexicon.

We analyzed children's spontaneous language samples using Phon, a software program designed for the analysis of phonological data (Rose, MacWhinney, Byrne, Hedlund, Maddocks, O'Brien, & Wareham, 2006). Each child's language sample was segmented into utterances, glossed, and phonetically transcribed. Three French-speaking students, who had experience in phonetic transcription, performed the analyses. Calculations of PCC were computed automatically for each child using the Query function in Phon. Three participants were re-transcribed by a second transcriber using the Blind Transcription function in Phon. Point-to-point agreement in terms of consonant transcription was high (ranging from 88% to 93%).

Results

Figure 1 shows a box-plot representation of mean PhC for the French-speaking children separated according to vocabulary size. A one-way analysis of variance (ANOVA) revealed a significant group

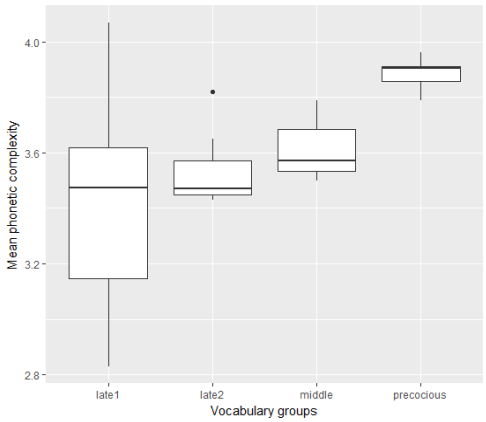

Figure 1. Box plot display of mean PhC for the French-speaking children separated according to vocabulary size

effect ($F(3,36)=10.84$, $p<.001$). Children with larger vocabularies had higher PhC values than children with small vocabularies. Tukey HSD multiple comparisons indicated that the precocious group differed significantly from late1 ($p<.001$), late2 ($p<.01$), and middle groups ($p<.01$) but there were no significant differences between the two late and the middle groups.

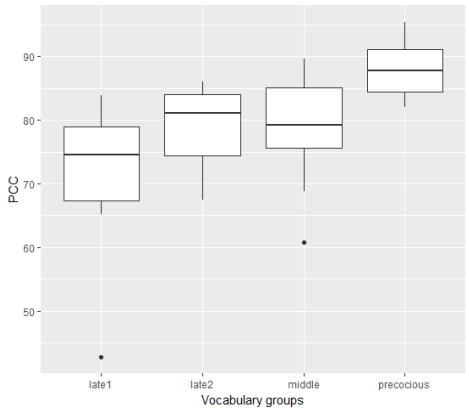

Figure 2. Box plot display of PCCs for the French-speaking children separated according to vocabulary size

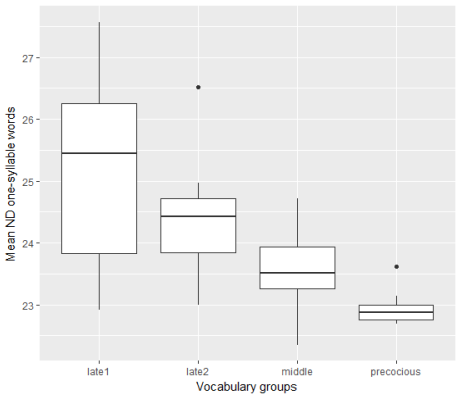

Figure 3. Box plot display of mean ND for the French-speaking children separated according to vocabulary size

Figure 2 provides a box-plot representation of PCCs for the French-speaking children separated according to vocabulary size. A one-way ANOVA revealed a significant group effect ($F(3,36)=7.34$, $p<.001$). Children with larger vocabularies had superior PCCs than children with smaller vocabularies. Tukey HSD multiple comparisons indicated that the precocious group differed significantly from late1 ($p<.001$) and middle groups ($p<.05$) and was marginally different from the late2 group ($p=.06$). There were no significant differences between the other groups.

Figure 3 shows a box-plot representation of mean ND values for one-syllable words in the lexicons of the four groups of French-speaking children. A one-way ANOVA revealed a significant group effect ($F(3,36)=10.93$, $p<.001$). Children with smaller vocabularies had higher ND values than children with larger vocabularies. Tukey HSD multiple comparisons indicated that the precocious group differed significantly from late1 ($p<.001$) and late2 ($p<.01$) but not from the middle group. The middle group differed significantly from the late1 ($p<.01$) but not from the late2 group. The two late groups did not differ significantly from each other.

Finally, we conducted a linear regression entering the three independent variables PhC, ND and PCC as predictors and using vocabulary size at 2;5 as the dependent variable. Together the variables accounted for 71% variance in vocabulary size (adjusted $R^2=.71$). The t values suggested that ND accounted for the most variance in vocabulary size followed by phonetic complexity and PCC. To determine the unique variance of each predictor variable, we entered them in a stepwise fashion starting with ND (see Table 1). ND accounted for 56% unique variance; phonetic complexity, an additional 13% unique variance ($F(1,37)=16.22$, $p<.001$) and PCC, an additional 2% unique variance ($F(1,36)=4.26$, $p<.05$).

Table 1. Coefficients for predicting vocabulary size

Model	B	SE	t	p value
1. Intercept	3064.67	371.41	8.25	p<.001
ND	-111.42	15.52	-7.18	p<.001
2. Intercept	1357.41	527.38	2.57	p<.05
ND	-84.26	14.75	-5.71	p<.001
PhC	290.92	72.22	4.03	p<.001
3. Intercept	1155.38	514.94	2.44	p<.05
ND	-77.7	14.49	-5.36	p<.001
PhC	215.89	78.19	2.76	p<.01
PhP	3.98	1.92	2.06	p<.05

Discussion

The purpose of the study was to examine the influence of lexical selection (measured by PhC), PhP (measured by PCC) and ND on the vocabulary sizes of French-speaking children, aged 2;5. Our results showed significant group differences in all three variables. Children with larger vocabularies selected words with greater PhC and with lower ND values. They had superior PhP abilities compared to children with smaller vocabularies. Multiple comparison tests did not reveal significant differences between all four groups, however. The precocious group, which was characterized by low intra-group variability, differed from the other three groups whereas the late1 group, which was characterized by high intra-group variability, tended to have similar scores to the late2 and middle groups. The lack of significant differences amongst the children with smaller vocabularies could have resulted from reduced power related to sampling effects: the number of items used to determine PhC, ND and PCC was reduced in the late talkers in comparison to the other groups.

Our findings are consistent with those of Stokes and colleagues (2010; 2012b) which show that children with low vocabulary sizes select words from high density neighbourhoods. They studied a group of children ranging in age from 2;0 to 2;6, whereas we focused on children, aged 2;5 only. Thus, our results indicate that even at the outer limits of the age range 2;0 to 2;6, the effects of ND appear to be strong. Our results are also consistent with numerous studies showing that late talkers have inferior PhP abilities and precocious talkers have superior abilities compared to their typically developing peers (Rescorla & Ratner, 1996; Smith *et al*., 2006). As for lexical selection, there has been less research focusing on the PhC of words selected by late and precocious talkers. Our findings, nevertheless, go in the direction of studies which have examined the phonological characteristics of children's lexicons at different ages (Fletcher *et al*., 2004; Gayraud & Kern, 2007; Stoel-Gammon, 1998). These studies showed that older children's lexicons contain more phonetically complex words than younger children's lexicons. Our results indicate that the lexicons of lexically advanced children contain more phonetically complex words than the lexicons of less-advanced children.

Linear regression models revealed that all three variables accounted for a high proportion of variance in vocabulary size (71%). Nevertheless, the bulk of the effect was carried by ND. The value of 56% is not very different from the one reported by Stokes *et al*. (2012b) for French-speaking children (53%) and is higher than the ones reported for English (47%) and Danish-speaking children (39%), suggesting that ND plays a particularly strong role in French in comparison to other languages. The next most important variable was PhC which added 13% unique variance, implying that children with low vocabularies seek phonetically simple words regardless of the density of the neighbourhoods in which these words are found.

Finally, we found that PhP plays a role, albeit a small one, in accounting for children's vocabulary sizes. Many authors have pondered the nature of the relationship between the two variables: whether having larger vocabularies leads to greater experience in producing sounds or whether greater experience producing sounds leads to increased ability to learn new words (Smith *et al*., 2007). Although the relationship is likely to be reciprocal, our findings support the fact that poor production skills are a limiting factor in the development of a lexicon. In sum, our findings confirm those of previous studies in pointing to a central role of ND in accounting for variance in vocabulary size. They extend research by implicating the role of other phonological variables such as PhC and PhP in lexical acquisition.

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