

Phonological complexity and vocabulary size in 30-month-old Swedish children

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Abstract

This study addresses the relationship between phonological complexity and vocabulary size in fifteen 30-month-old Swedish children, selected to cover a wide range of reported lexical development. It is in line with earlier studies indicating a relationship between phonological and lexical development in children and how it is affected by the ambient linguistic input. Phonological complexity of content words uttered by the children was computed by using a Swedish adaptation of Stoel-Gammon's Word Complexity Measure [1]. Speech data from recordings of parent-child conversations were related to parent-reported vocabulary size data collected with the Swedish version of McArthur-Bates CDI [2]. The results indicate that phonological complexity increases with vocabulary size. Implications for parent-based intervention to children with language impairment are discussed.

Index Terms: phonological development, lexical development, phonological complexity, parental input, parent-child interaction

1. Introduction

Language acquisition in early childhood is known to be influenced by the amount, the frequency and the diversity of the parental speech to which the child is exposed [3, 4]. From a functional developmental perspective, the relationship between language acquisition and the exposure to parental speech is viewed as an inevitable outcome of general multi-sensory information processing leading to the emergence of basic linguistic functions [5]. Under this assumption, the child's acquisition of basic linguistic abilities is determined by the hierarchical establishment of different levels of linguistic referential functions. It starts off with immediate concrete entities and progresses thereafter towards increasingly more abstract levels of representation that build upon already acquired levels.

A direct consequence of this type of approach is that the typical timeline of language acquisition in early childhood may also be expected to be affected by the linguistic structure of the child's ambient language. In the particular case of languages like Swedish or English this information-based account of language acquisition in childhood suggest that young children can be expected to acquire first the basic linguistic referential function conveyed by simple object naming (nouns) before acquiring linguistic functions involving relationships between objects, as in the case of transitive verbs. The rationale is that a multi-sensory associative process is sufficient for the establishment of the sound-object relationship characteristic of object naming, whereas inferring a verb from a sound string demands the previous establishment of object categories in order to be able to

associate the verb's sound string with the relationship between the objects that the verb captures. In line with this information-content perspective, grammatical categories like adjectives may be expected to require even more language exposure than the verbs, because they refer to object properties whose importance rises with the need of more fine-graded descriptions of those objects [5]. Additionally, the phonological representation can be seen as an emerging consequence of the increasing numbers of lexical items [6] under the constraints of a limited memory capacity. According to this view, the granularity of the phonological representations will necessarily go from crude to fine-grained representations in the course of the language acquisition process, as a consequence of the expansion of the lexical representation needs, reaching an optimal theoretical granularity limit that is dependent on the lexical information pressure [7]. Once the principles of phonological representation are established, the short term memory – with the phonological loop – is suggested to have an important role in further phonological development, specifically when acquiring new phonological forms. Children with large phonological store capacity have been found more likely to learn new words, suggesting that phonological memory is a predictor to vocabulary [8]. Non-word-repetition is often used as a measure of working memory [e.g.9], and it is found to correlate positively to the time which the child has been producing consonants [10]. However, language development is not an incremental process – it appears to be triggered by processes that are clearly non-linear. Once the child has produced the first word, this linguistic discovery triggers a new process that generates more words with a subsequent explosion of lexical inventory. At the same time, from the target language perspective the phonological accuracy in production is decreased and more similar word forms will appear which can be interpreted as the first steps in the phonological organization of the child [11].

In general, children with phonological difficulties in production will also have difficulties in acquisition of lexicon [1], but phonological problems are not a homogeneous class. For a meaningful interpretation of phonological deviations, their underlying acoustic and aerodynamic phonetic aspects have to be taken into account. For instance, an error in place of articulation of a stop consonant may disclose a much poorer phonological representation than the substitution of a fricative by a homorganic stop consonant. In the first case the substitution error may reveal an incorrect underlying phonological representation because, in principle, the child might have been able to produce both stop consonants but picked up the wrong place of articulation, perhaps because of lack of phonological awareness. However, substituting a fricative with a homorganic stop consonant may be due to lack of articulatory skills to control the aerodynamics of the fricative production.

In this study, phonological complexity in word production of children aged 30 months is related to vocabulary size. It is expected that large vocabulary size would be associated with increased phonological complexity.

2. Method

2.1 Speech material

In the current study, data from the Swedish language intervention project SPRINT¹ was used. Pre-intervention recordings of fifteen conversations between parents and their 30 month old children were analyzed. All parent-child conversations were recorded during story time based on the text-less picture book “Frog Where are You?” [12]. The audio files were selected according to vocabulary size of the child, measured by the Swedish version of McArthur-Bates Communicative Development Inventory, SECDI [2]. They were from children whose vocabulary scores of the word list in SECDI were in the top, middle and lowest ranges of SPRINT data from the relevant age, ranging 329-707 word items of 710 possible.

2.2 Complexity measures for Swedish

Phonological complexity was measured by the Word Complexity Measure (WCM) [1], which targets later acquired structures in child phonology. Stoel-Gammon’s WCM was adjusted to fit Swedish. For sound classes, no points were given for any affricates (voiced or un-voiced) or syllabic liquids as they are not relevant in Swedish phonotax. Additionally, liquids were not considered as they in Swedish often are acquired earlier and replace the alveolar tremulant [r] that tends to be acquired later. However, long, front, rounded vowels, the typically Swedish [ɥ:], [y:] and [ø:] were considered. The measures of word patterns and syllable structure were the same used as for English. The eight following characteristics representing word patterns, syllable structures and sound classes were measured in each word:

- Any syllable in excess of two syllables
- Stress on any syllable but the first
- Word-final consonant
- Consonant clusters
- Long, front, rounded vowels: [ɥ:], [y:], [ø:]
- [r]
- Fricatives
- Velar consonants

Word pattern characteristics given points were words with more than two syllables and production with stress on any syllable but the first syllable. For syllable structure characteristics, points were given to productions with a word final consonant and productions with a consonant cluster. Sound

classes given points were productions including a velar consonant, an [r], a fricative and/or any of the long, front, rounded vowels [ɥ:], [y:], [ø:]. Each word was given one point per characteristic detected.

2.3 Procedure

Ten minutes of child speech from each recording were transcribed in Wavesurfer, version 8.4.2.9 [13]. Quasi-phonemic transcriptions based on the assumptions of the underlying phonemic structure of the target language were used. Transcriptions were made on speech material selected from the beginning of the fourth minute from start. Utterances stretching over the starting point at the fourth minute were not transcribed, and the next utterance was the first transcribed. Additionally, utterances stretching over the ten minute mark from start were excluded. All vocalizations classified as having a communicative intent were transcribed. Coughing, singing and laughing were not transcribed; however, word-like utterances were, and adult interpretations of target words were inserted whenever necessary. Utterances adjacent to gaps longer than 300 milliseconds were counted as separate. Content words (nouns, verbs and adjectives) were extracted and analyzed in terms of phonological complexity. Both complexity of target word and the actual pronunciation were computed, and the results for child production were compared to target. A complexity ratio – defined as the total complexity of the produced utterances vs. the total complexity of the corresponding target words – was calculated for all participants. In addition to the grouping of children based on the SECDI scores, the children were also grouped in three equal categories according to the number of word types observed in the selected speech materials.

3. Results

A one-way ANOVA revealed significant differences in mean complexity ratio between the three vocabulary groups ($F(2,12)=6.589$, $p<0.012$). The group with low vocabulary score had a mean ratio of 0.53, while the medium- and high-scoring groups had mean ratios of 0.81 and 0.79 respectively (See Figure 1). Figure 2 shows the number of types produced by children within each of the vocabulary groups. Figure 3 displays the complexity ratios per group based on the number of detected types. A one-way ANOVA revealed overall significant differences between the complexity ratios of the children in three NoType-groups ($F(2,12)=22.426$, $p<0.0005$). There is also a significant contrast between the complexity ratio of children in the “low” NoType-group and the complexity ratio of the children in the “medium” NoType-group ($p<0.012$) as well as between the “low” and the “high” NoType-group ($p<0.0005$).

4. Discussion

The results show that children in the small vocabulary range produce more often words with lower complexity compared to the children in the other two groups. Additionally, the results show that the complexity ratio is higher among the children producing more types in the recordings, suggesting that their pronunciations are closer to the target words as compared to the other children. The results also show that the children with high vocabulary scores produce more types in the recorded speech material than the other children, which supports earlier findings indicating that phonological development goes together with lexical development.

¹ SPRINT is a Swedish research project on the “Effects of enhanced parental input on young children’s vocabulary development and subsequent literacy development”, a collaboration between the Department of Linguistics and the Department of Special Education at Stockholm University, funded by the Swedish Research Council from 2008 to 2011 (VR 2008-5094).

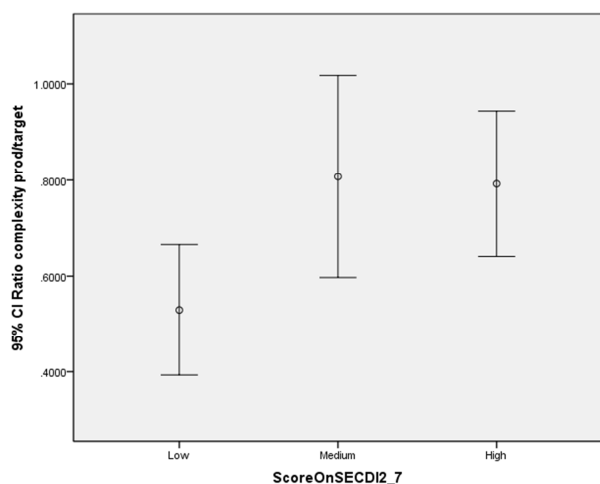


Figure 1: Mean complexity ratios for children with low, medium and high vocabulary scores in SECDI.

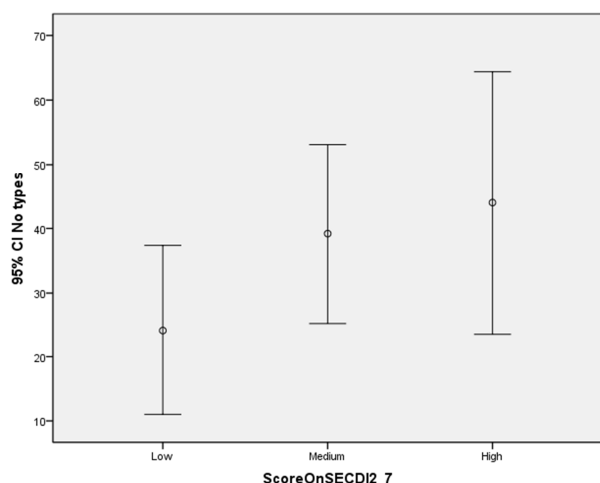


Figure 2: Number of types in the selected speech material produced by children with low, medium and high vocabulary scores in SECDI.

The parental linguistic input to the child can vary in several ways, like speech- and communication styles. In turn, the parental input is contingent on the parent's interpretation of the child's linguistic competence, both in terms of language comprehension and production. The child's comprehension feedback may limit the complexity of the linguistic environment [14]. For example, it has been shown that mothers may respond differently to infants' pre-linguistic vocalizations depending on the syllable structure produced by the infant [15].

Since parent-reports of child vocabulary are based on the parent's knowledge about the child's communicative-linguistic performance, the reporting is necessarily affected by interpretation of child performance. For example, if the parent has knowledge about the child's language comprehension and the parent is sensitive to the child's communicative initiatives (e.g. non-verbal communicative behavior), utterances far from target pronunciation may be reported as words. On the other hand, if the parent is more conservative when analyzing child

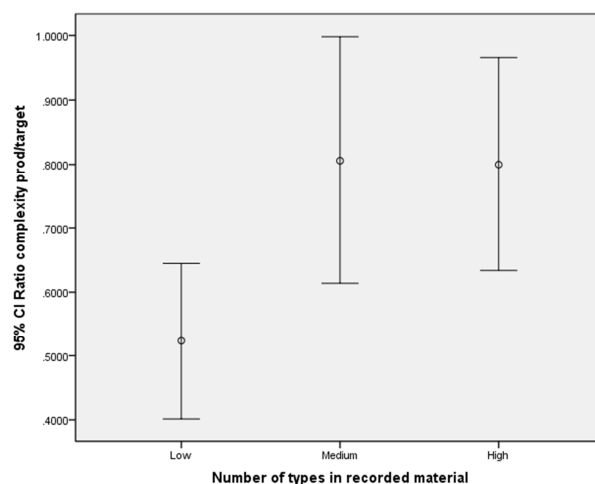


Figure 3: Mean complexity ratios for children with low, medium and high number of types in the analyzed speech materials.

communication and focuses on words in child speech, fewer items in child vocabulary may be reported because of the parent's more stringent pronunciation demands. At any rate, it is the parent's interpretation of the child's linguistic behavior that will determine the parental feedback, which implies that it is always with the reference to an external phonological system that the child's phonological complexity in speech is assessed.

A crucial difference between parental interpretation and the quasi-phonematic transcriptions used in this material is that the former are spontaneous online reactions to the child, whereas the transcriptions are non-interactive, "objective", phonological classifications colored by the underlying language system. Thus, whereas parent's interpretations provide an adaptive ecological communicative response, the "expert" transcriptions reflect stereotypical interpretations of the child's performance.

To be sure, phonological complexity is not a direct measure of accuracy in production but it can give both qualitative and quantitative information about phonology in child speech production, and can be used to characterize children's phonological difficulties. In particular the production of the child can be assessed over time and the increase in phonological complexity may be used to characterize the child's path towards the adult production patterns. In addition, because the measurement is based on spontaneous speech, it may be more suited to disclose speech difficulties that are truly representative of the child is higher than standardized phonological tests with elicitation strategies. Furthermore, the total phonological complexity sum of a child's speech sample gives more useful information about the child's phonological maturity than a traditional assessment based on single item elicitation, because the child's spontaneous speech may disclose unstable structures that would not be detected in formal assessments.

The current results are compatible with the outcome of a previous study using a similar measure [16], which indicated low phonological complexity in most SECDI reported words when the child was 18 months old, and a subsequent increase in the proportion of words medium complexity levels within the following three months. This agreement between the current and the former results supports the notion that lexical growth is linked to phonological development. This notion is further supported by the fact that children with delayed phonological

development often have difficulties in establishing lexical representations, as well as associations between lexical and semantic representations, when learning common sound sequences [17]. An association between phonologically based production and perception difficulties has also been observed and phonemic perception training has been shown to improve phonological awareness skills [18].

Taken together, the current results suggest that increasing parental awareness on the relevance of language exposure may have beneficial consequences with regard to the child's lexical growth and, by extension, the child's phonological development.

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