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THE USEFULNESS OF PHONOLOGICAL INFORMATION FOR THE ACQUISITION OF GRAMMATICAL STRUCTURE IN CHILD LANGUAGE DEVELOPMENT[1]

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ABSTRACT

During the process of language development, one of the most important tasks that children must face is that of identifying the grammatical category to which words in their language belong. This is essential in order to be able to form grammatically correct utterances. How do children proceed in order to classify words in their language and assign them to their corresponding grammatical category? The present study investigates the usefulness of phonological information for the categorization of nouns in English, given the fact that it is phonology the first source of information that might be available to prelinguistic infants who lack access to semantic information or complex morphosyntactic information. We analyse four different corpora containing linguistic samples of English speaking mothers addressing their children in order to explore the reliability with which words are represented in mothers' speech based on several phonological criteria. The results of the analysis confirm the prediction that most of the words to which English learning infants are exposed during the first two years of life can be accounted for in terms of their phonological resemblance.

Keywords: language acquisition, grammatical categories, phonology, child-directed speech, English nouns

INTRODUCTION

Grammatical categories are the groups to which individual linguistic elements are assigned. Knowledge of the grammatical category membership of words is an important and essential part in

language development, since it is a prerequisite to know how to use words in the language and produce grammatically correct sentences. But how do children learn the basic grammatical categories of their language?

Previous work which analyses cues that are effective in identifying the grammatical category of words has focused on properties that are either internal or external to words. External properties are those that determine the use or function of the word from its context (i.e. distributional or semantic information). In contrast, effective information for the same purpose can also be found within the word itself. Such internal cues include phonological or prosodic information. Young language learning infants have no access to word meaning, especially prelinguistic infants at the first stages of development. Thus, during the onset of the language learning process, phonological cues are the only ones from which young infants might start building a linguistic system.

A number of studies have provided evidence for the usefulness of phonological information as a key element for the access to grammatical properties of language (e.g. Brooks et al., 1993; Cassidy & Kelly, 1991; 2001; Cutler, 1993; Jusczyk, 2001; Morgan 1986; Peters, 1997). Phonological cues might also be a useful source to help children determine the distinctions between grammatical categories. The present study aims at investigating the actual relationship between the English noun category and phonological cues. If there is a neat mapping between a given set of phonological features and nouns in English, then children might take that relevant phonological information from parents' speech and use if for the purpose of noun categorization.

OBJECTIVES

A range of phonological cues have been proposed in the literature to correspond to particular syntactic categories in English. On the one hand, some of the proposed cues are related to distinguishing open class words (i.e. nouns, verbs, adjectives, etc.) from closed class words (i.e. prepositions, determiners, conjunctions, etc.). Such an initial broad categorization might help children establish a distinction between lexical items and function words (Monaghan, Christiansen & Chater, 2007; Monaghan, Chater & Christiansen, 2005; Morgan, Shi & Allopenna, 1996). This might help them further categorize lexical items in further subcategories more accurately.

Additionally, some other phonological cues have been found to be relevant to distinguish some open class words from others (Kelly 1992, 1996; Monaghan, Chater & Christiansen, 2005; Monaghan, Christiansen & Chater, 2007). Furthermore, empirical studies reveal that young language learners as well as adults are aware of such cues and their correlation to grammatical categories (Cassidy & Kelly, 2001; Farmer, Christiansen & Monaghan, 2006; Fitneva, Christiansen & Monaghan, 2009; Monaghan, Chater & Christiansen, 2003). These are the cues which are particularly relevant to the topic under consideration, since they have been reported to be especially useful in the noun *versus* verb distinction. Among the set of highly reliable cues, the following are the most relevant ones:

Stress: disyllabic nouns tend to be stressed on the first syllable, while disyllabic verbs tend to be stressed on the last syllable.

Syllables: nouns contain more syllables than verbs.

Vowel height: nouns tend to have more low vowels, while verbs tend to have more high vowels.

Consonant quality: if a word finishes in a consonant, it is more likely to be voiced if the word is a noun rather than a verb.

The individual magnitude of each cue is not the same, as some cues are weaker than others. Besides, the literature suggests that, taken individually, each phonological cue is not very powerful

on its own, in the sense that each cue alone does not successfully categorize a significant sample of nouns or verbs. However, taken together, they yield an accurate and successful categorization of nouns and verbs. Thus, provided the constellation of cues outlined above is available in the input, it will significantly reflect the overall phonological shape of broad grammatical categories.

Furthermore, as initial broad categorization and analysis proceeds, the child will be able to deal with smaller linguistic samples to be analyzed, where correlations between cues and categories might be stronger. Besides, as their development proceeds, learners will be able to cope with other sources of information in combination with phonology.

The aim of this paper is to test the availability of phonological cues for grammatical categorization by analyzing samples of English child-directed speech and examining the regularities of the language used by mothers when addressing their children. More specifically, we will work out: (a) the degree of successful categorization (i.e. the percentage of nouns which are correctly categorized as nouns); (b) the degree of non-categorization (i.e. the percentage of nouns which lack the cues under consideration and which would, therefore, fall out of the noun category); (c) the degree of miscategorization or overcategorization (i.e. the percentage of lexical items other than nouns which, bearing any of the cues under consideration, would be incorrectly classified as nouns on the basis of their phonological form).

The initial prediction is that the linguistic environment to which children are exposed does, in fact, contain a series of systematic, coherent and consistent phonological regularities that would allow children to cluster English nouns together in their corresponding category. Thus, a given set of sound cues alone will be enough to account for most of the nouns to which English learning children are exposed. Taken individually, phonological cues might not reach high completeness scores, but when taking them together, completeness scores might improve while noun categorization will still be accurate.

METHODOLOGY

3.1. Data source

The data used for this study comes from the Manchester corpus (Theakston et al., 2001), available from the CHILDES database (MacWhinney, 2000). In particular, a subsample of four children was randomly selected from the whole corpus for the present analysis. Only adult language was taken into account, and utterances spoken by the child were not analyzed.

Within the individual corpus of every child, we selected and considered those transcriptions in which the child was approximately 2;6 years old and younger, and we discarded all those transcriptions in which the children were older than 2;6. This was done in contrast to other more recent studies where all the speech by adults from all the English corpora in the database were extracted, regardless the age of the child to whom the utterances were addressed (i.e. Monaghan, Chater & Christiansen, 2005; Monaghan, Christiansen & Chater, 2007). Previous research on the acquisition of nominal elements by children shows that, by the age of 2;6, children have already formed a grammatical category for nouns, as they have been shown to generalize and apply nominal morphology productively to novel nouns they have not heard before (Tomasello et al., 1997; Tomasello & Brooks, 1999). Since the aim of the study is to test the accuracy and reliability with which the nominal category is represented in children's input, we considered it necessary to select all the transcriptions in which the child is potentially young enough so as to fulfill the requirement of not having formed a noun category yet.

PROCEDURE

Words were then classified into two different categories to be analyzed separately. One category included all nouns, and the other category, which was labelled as "other", included elements from all other open class word categories (i.e. verbs, adjectives and adverbs). Individual words were then analyzed to see the degree to which they matched the requirements of a selected set of phonological cues which were said to identify the grammatical category of English nouns. If the group of selected nouns obtained a high score in the analysis, that would indicate that the selected set of cues classified most English nouns (i.e. high completeness). The same procedure was carried out with the list of verbs, adjectives and adverbs obtained, but with the opposite expectation. Thus, a low score in the analysis of verbs, adjectives and adverbs would indicate that the set of cues considered were deficient for the classification of these words (i.e. high completeness scores for non nominal elements and, therefore, high accuracy scores for nouns).

A total of four different cues were considered and each one made reference to one of the features that are said to characterize English nouns *vs*. verbs (see section 2). They were labelled as *Phon1* (word length), *Phon2* (consonant quality), *Phon3* (vowel quality) and *Phon4* (stress position). Thus, for the *Phon1* classification, words with two syllables or more scored 1, and monosyllabic words scored 0. Under the *Phon2* criterion, words ending in a voiced consonant scored 1, while words which finished in a vowel or a voiceless consonant scored 0. For the *Phon3* classification, words from the corpus whose stressed vowel was low (i.e. /æ/, / /, / / or / :/) scored 1, words whose stressed vowel was mid (i.e. /e/, / :/ or / :/) or high (i.e. /u:/, / /, /I/ or /i:/) scored 0, and words whose stressed syllable contained any of the English diphthongs equally scored 0, even if one of the vowels in the diphthong was also low. Last, under the *Phon4* description, disyllabic words from the corpora that had a trochaic stress pattern scored 1. Monosyllabic words or disyllabic words with an iambic stress pattern scored 0.

The set of English nouns obtained from the children corpora were tested against the selected phonological cues in order to see the accuracy with which such cues categorized English nouns. Similarly, the set of English verbs, adjectives and adverbs obtained from the corpora were analyzed under the same criteria, in order to test the likelihood with which the selected phonological cues might overcategorize other elements which are not nouns. So, unlike previous studies (cf. Monaghan, Chater & Christiansen, 2005; Monaghan, Christiansen & Chater, 2007; Kelly, 1996), not only verbs but also adjectives and adverbs were checked against nouns.

A further advantage of this study is that phonological cues were carefully selected so that each made reference to a different phonological property of the word and every cue was not incompatible with the rest. That would make it possible for tokens to get a gradable score (from 0 to 4). Thus, if a token scored 4, this means it fulfilled all four phonological criteria under consideration, which would describe that token as highly marked with nominal features as fas as phonology is concerned. On the contrary, if a word scored 0 or 1 in the phonological test, this would indicate that such word fulfilled either none or just one of the four phonological criteria that were selected. This would make that particular word weakly marked as a noun in terms of phonology. Therefore, even if individual cues are not powerful enough by themselves and a constellation of phonological cues is necessary to distinguish word classes, combinations themselves have a gradable nature that can distinguish between strongly marked tokens and weakly marked tokens. With the cues under consideration, a limited set of twelve possible combinations arose:

NoPhon: words which scored 0 in all 4 *Phon* categories.
OnlyPhon1: words which scored 1 in *Phon1* and 0 in the rest of *Phon* categories.
OnlyPhon2: words which scored 1 in *Phon2* and 0 in the rest of *Phon* categories.

OnlyPhon3: words which scored 1 in *Phon3* and 0 in the rest of *Phon* categories.
PhonComb12: words which scored 1 in *Phon1* and *Phon2* only.
PhonComb13: words which scored 1 in *Phon1* and *Phon3* only.
PhonComb14: words which scored 1 in *Phon1* and *Phon4* only.
PhonComb23: words which scored 1 in *Phon2* and *Phon3* only.
PhonComb123: words which scored 1 in all four *Phon* categories except *Phon4*.
PhonComb124: words which scored 1 in all four *Phon* categories except *Phon3*.
PhonComb134: words which scored 1 in all four *Phon* categories except *Phon2*.
PhonComb1234: words which scored 1 in all four *Phon* categories.[2]

Thus, words which fell into the *PhonComb1234* group or any of the *PhonComb* groups with a constellation of three out of four phonological features were considered to be strongly marked as a noun as far as phonology is concerned. On the contrary, words which fell within the *NoPhon* group or any of the three possible *OnlyPhonX* groups were considered to be weakly marked as nouns regarding phonology.

RESULTS

Table 1 shows the total size of the corpus from all transcriptions that fell under the span of time under consideration before the target items were selected, the total number of open class words once function words had been eliminated, and the total amount of nouns and other open class words that resulted from the classification. These numbers include all the words from the corpora of all four children together.

Table 1: Total size of all corpora and total size of subsample selected for the present analysis.

	Total Types	Total Tokens	Type/Token Ratio	Proportion of Types	Proportion of Tokens
Total corpus	10,681	364,196	0.029	--	--
Total selected	9,641	143,272	0.067	0.90	0.39
Total nouns	5,388	51,577	0.104	0.56	0.36
Total other	4,233	88,047	0.048	0.44	0.61

In order to test the significance of phonological cues, a Mann-Whitney U-test was performed on the difference between all of the noun types and tokens as well as all the of the types and tokens from other open class words obtained from the corpora of all four children together. The results of the tests are found in table 2.

Table 2: Mann-Whitney U-test for the 12 phonological variables.

	Types			Tokens		
	Noun Means	Other Means	*Z*	Noun Means	Other Means	*Z*
NoPhon	0.14	0.19	-6.947**	1.67	7.76	-7.460**
OnlyPhon1	0.04	0.04	-0.130	0.16	0.35	-0.102
OnlyPhon2	0.16	0.17	-1.111	1.68	4.51	-1.296
OnlyPhon3	0.06	0.08	-2.630*	0.69	2.08	-2.707*
Phoncomb12	0.05	0.05	-1.096	0.18	0.38	-1.114
Phoncomb13	0.02	0.01	-3.263*	0.09	0.11	-3.256*
Phoncomb14	0.09	0.07	-3.731**	0.97	0.72	-3.746**
Phoncomb23	0.05	0.03	-5.837**	1.01	1.00	-5.770**
Phoncomb123	0.03	0.01	-5.443**	0.20	0.09	-5.440**
Phoncomb124	0.18	0.22	-4.391**	1.12	3.08	-4.680**
Phoncomb134	0.06	0.03	-6.501**	0.83	0.20	-6.567**
Phoncomb1234	0.11	0.09	-2.614*	0.97	0.54	-2.761*

* $p < .01$; ** $p < .001$.

As the table shows, most of the phonological variables that were used in the analysis were highly significant among types as well as tokens ($p<.001$ for seven of the twelve phonological variables). Those highly significant variables mostly corresponded to "absence of phonological cues" (i.e. *NoPhon*), most clusters made up of two cues (i.e. *Phoncomb13*, *Phoncomb14* and *Phoncomb23*), as well as all the clusters which were made up of three cues (i.e. *Phoncomb123*, *Phoncomb124* and *Phoncomb134*). The variable which contained the cluster of all four phonological features (i.e. *Phoncomb1234*) was equally significant (i.e. $p<.01$) and so was *Phon3*, which grouped all words that contained a stressed low vowel.

Previous studies which employ a similar methodology to the present study (i.e. Monaghan, Chater & Christiansen, 2005; Shi, Morgan & Allopenna, 1998) show that, although a given variable might not be significant in terms of its mean differences, it might nevertheless contribute to the discriminant function in a multivariate linear discriminant analysis. This only suggests that, in spite of not being significant, this variable combines with the other variables towards accurate classification of a given set of words.

Thus, correct classification of all types and tokens from the four corpora was also assessed for the twelve phonological variables together using a multivariate linear discriminant analysis. For the type analysis, 40.1% of nouns and 71.6% of other open class words were correctly classified. Overall, 53.9% of types were correctly classified. This was highly significant (Wilks = 0.980, ^{2} = 197.638, $p < .001$). Thus, as far as types are concerned, the results suggest that phonological cues are successful at categorizing English nouns in terms of accuracy (i.e. as shown by the high percentage of correctly classified "other" words), although phonological cues are less successful in terms of completeness, given the low percentage of correctly classified nouns. In the token analysis, 84.9% of nouns and 22.1% of other open class words were correctly classified. Overall, 57.3% of tokens were correctly classified, Wilks = 0.982, ^{2} = 178.169, $p < 0.001$.

Thus, overall correct classification among tokens using phonological cues is very similar to the

percentage of correct classification among types using the same cues, with a slight improvement in the token analysis (i.e. 53.9% for types and 57.3% for tokens). However, the type and token analyses differ in that the opposite pattern is found from one analysis to the other. Thus, while there was good accuracy but low completeness among types (i.e. 40.1% of correctly classified noun types versus 71.6% of correctly classified other open class word types), the reversed pattern was obtained in the token analysis, with very high completeness scores (i.e. 84.9% of the nouns were correctly classified) and very low accuracy scores (i.e. only 22.1% of other open class tokens were correctly classified in their appropriate category, and most of them were wrongly misclassified as nouns).

DISCUSSION AND CONCLUSIONS

The results obtained from the present analysis confirm the initial predictions that were outlined. Significance tests revealed that the variable which subsumed all four phonological features (i.e. *Phoncomb1234*) was found to be significant in all cases. All variables with three-feature combinations (i.e. *Phoncomb123*, *Phoncomb124* and *Phoncomb134*) were also found to be highly significant, with nouns being more likely than other open class words to contain three or four of the selected phonological features simultaneously. However, the variables with only one phonological feature appear to be equally relevant for nouns as well as for other open class words, since no significant differences were found in most of the cases.

Furthermore, the mean proportions obtained from the noun group and the other open class word group for each of the variables revealed that nouns are more likely than other open class words to be described by clusters of three or four features, while other open class words are more likely to contain just one of the selected features or none of them. This indicates that, when combined, the four phonological features selected in the present study tend to account for a greater proportion of nouns than any other word group in the English lexicon, while the opposite is true of a situation where none of the selected features are present.

Regarding the successfulness with which the selected variables classify words to which young English learning children are exposed, overall correct classification in discriminant analyses reached scores above chance levels with types as well as with tokens. However, the distribution of correct classification was uneven among both groups under examination (i.e. nouns vs. other open class words). Thus, the analysis with types gave an overall correct classification above chance levels mainly because there were relatively high accuracy scores, but there were quite low completeness scores. The opposite pattern was true of tokens, which reached an overall correct classification above chance levels mainly because there were very high completeness scores, but there were very low accuracy scores.

However, as mentioned before, despite the low accuracy scores among tokens or the low completeness scores among types, overall correct classification using phonological information was always above chance levels. Therefore, on the basis of the results obtained in the present analysis, phonological information can be claimed to be useful for the grammatical categorization of English nouns.

The main conclusion that can be drawn from the present study is that, as far as phonological features are concerned, the linguistic input to which English-learning children are exposed contains information which is reliable and sufficient enough so that children can group together most of the nominal elements they hear based on their phonological resemblance. The data presented here suggest that the nouns in the linguistic subsamples analyzed in this study contain enough inherent internal phonological properties that bind them together and that make them significantly different from other open class words in English. Therefore, given a learner who is sensitive to all these features,

a rudimentary nominal grammatical category can be formed on the basis of this source of information.

Nevertheless, these results do not seem to indicate that phonology might be the only source of information which young language learners might use to bootstrap grammatical structure in the course of language development. On the contrary, the low accuracy scores among tokens or the low completeness scores among types provide evidence for the fact that analyses of the input based exclusively on phonological correlations between words might very often lead to incorrect classifications on the part of naïve language learners. Thus, complementary sources of information, such as the morphosyntactic regularities of words or their semantic content, might be equally useful for children's word categorization tasks.

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[2] Since *Phon1* subsumes *Phon4*, it is impossible to have *OnlyPhon4* words, or *PhonComb24* words, or *PhonComb34* words or *Phoncomb234* words. In any case, these would be *Phon14* words, *Phon124* words, *Phon134* words and *Phon1234* words, respectively.

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