Possible phonological cues in categorial acquisition: Evidence from adult categorization

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Abstract

This paper reports an experiment in which adult native speakers of Dutch were asked to categorize nonce stems. These were presented without any morphological or other information about their potential class-membership. We expected that subjects would be able to categorize these words solely on the basis of phonological information. Nouns in Dutch have a richer possible syllable-structure than verbs (Trommelen 1989) and therefore, we expected that stimuli with a 'nominal' syllable make-up could be identified by the subjects as nouns where the other stimuli were ambiguous between nouns and verbs. The results show that this is indeed the case, adding to the evidence that native speakers of a language are able to use phonological information to categorize the words of their language.

Phonological cues for lexical categories *

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0. Introduction

In this paper we report an experiment on the abilities of native Dutch speakers to determine the category of nonce words solely on the basis of phonological information. Research in the domain of language acquisition has proven that both the semantic and syntactic properties of words play an important role in the acquisition of word categories. In these studies it is proposed that certain correlations exist between syntactic properties of a word and its semantic properties, and it is demonstrated that children make use of these correlations in order to arrive at the correct meaning of a word, or to acquire certain syntactic properties (such as argument structure, category). In a famous study on language learnability, Pinker (1987) elaborates on a 'bootstrapping' mechanism of this type, claiming that children use the semantic properties of a word as a bootstrap to the syntactic structure. A bootstrapping mechanism such as Pinker's would enable the child to infer the syntactic category of a word from a rough semantic categorization like 'thing', 'causal agent', and 'true in the past'. Although this proposal has received a lot of criticism over the years, the basic idea that the semantic and syntactic properties have correspondences that the child may use to start its syntactic categorization has survived.

Our ultimate goal is to investigate whether language-learning children also make use of phonological information to arrive at the proper categorization of the

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words of the ambient language. Before embarking upon such a methodologically complicated and potentially impossible undertaking, we wanted to establish that adult speakers are able to categorize words solely on the basis of their phonology. Although Cassidy and Kelly (1992) already provide experimental evidence that 3-4 year old English-learning children make use of phonological information to distinguish nouns from verbs, the idea of phonological bootstrapping has so far received only little attention in the literature. Recently, some investigations into the relationship between phonology and syntax have revealed that phonology indeed may play a role as a tell-tale of categorial information. Kelly (1996) draws attention to the fact that phonological cues have more predictive power in relation to lexical category than often has been thought.

More specifically, recent work by Shi, Morgan and Allopenna (1998) and Durieux and Gillis (2001) shows that learning algorithms are able to quite successfully distinguish function words from content words and verbs from nouns on the basis of phonological information only. Shi, Morgan and Allopenna (1998) conclude on the basis of research on Mandarin Chinese and Turkish that phonological information has predictive power for determining whether a certain word belongs to the class of function words or to the class of lexical words. Thus, lexical categories can be distinguished from functional categories in these languages on the basis of their phonological properties only. In mother-child dyads, it was found that a combination of different phonological cues, such as duration, vowel height and consonant quality (taken from Kelly 1996) could predict the super-ordinate category (i.e. lexical or functional) of words. To test the predictive power of these cues Shi, Morgan and Allopenna (1996) trained a self-organizing neural network and tested the performance on category prediction of novel items. The network succeeded in

correctly predicting whether a given item was lexical or functional in more than 80% of the test cases. These results indicate that, even across typologically distinct languages, children's input contains sets of phonological cues sufficient to support the categorization of words.

Similarly, Durieux and Gillis (2001) studied the discrimination of three different lexical categories: verb, noun and adjective. They used an artificial learning system (constructed on Instance-Based Learning) that had to predict the lexical category of a word, on the basis of phonological and prosodic information. Several experiments were conducted, varying in target language and cue-combination. The overall results show that both in English and Dutch, the learning system predicted the lexical categories most successfully if learning was done on the basis of a combination of raw segmental data. This means that the most useful bootstrapping information is given not so much by phonological cues like those presented by Kelly (1996), but rather by simple segmental encoding in onset, nucleus, coda and stress pattern. Durieux and Gillis (2001) conclude that the link between phonology and lexical category is suitable for use in acquisition. The fact that learning mechanisms of this type were able to make correct predictions for the vast majority of new words does not tell us, however, whether humans are also able to make use of such phonological cues. To establish such a conclusion, we need experimental data with human subjects.

On the basis of a corpus analysis, Monaghan et al. (2005) show that phonological cues may be especially useful in categorizing low frequency items. This corpus-based prediction was corroborated in an artificial language learning experiment, showing that learners indeed may use this kind of information to categorize items.

Furthermore in a series of experiments Farmer et al. (2006) show that subjects are sensitive to the word-class typicality of a phonological form in processing (English) words: a noun which has the typical phonological form of nouns is more easily processed than a noun which does not have a typical noun-like phonology. Typicality was expressed as the 'phonological distance' to other members of the same category. Their results show that humans are indeed sensitive to such phonological typicality. The experiment reported here confirms these results but method and language (Dutch) differ. Moreover, we do not reason on the basis of typicalities but on the basis of linguistic impossibilities, which were first brought to light by Trommelen (1989).

In this study Trommelen observes that there are several generalizations in Dutch that relate the phonological form of a (content) word to its lexical category. The studies mentioned above indicate that it is not coincidental that Trommelen found such relations. We therefore conducted an experiment in which we tested if adult native speakers of Dutch are able to use the phonological cues that we can deduce from Trommelen's generalizations in assigning lexical categories to (nonce) words.

The organization of the paper is as follows. First, in section 1 we will go into the generalizations found by Trommelen (1989) and formulate several cues that we can use in our experiment. In section 2 we will sketch the experiment. Section 3 discusses the results, from which we conclude that adults are indeed able to make use of phonological information in deciding on the category of nonce-words. In section 4 we draw some conclusions and sketch a perspective on further research on phonological bootstrapping in language learning children.

1. Form and Category: generalizations

Trommelen (1989) states that in Dutch the interaction of phonological, morphological and syntactic behavior of a word can give cues to the category of that word. She describes the way in which a word class is connected to, or derivable from, certain phonological properties of the word in Dutch. By analyzing all possible clusters in verbs and nouns she shows that the complexity of final rhymes in underived words can be an indication for word class. With respect to verbs, Trommelen observed that, generally speaking, they conform to a set of phonological restrictions: many phonological forms which would make perfect nouns in Dutch, are simply not possible as verbs. Based on her observations Trommelen formulated the following generalizations about Dutch underived verbs:

- verbs are monosyllabic;
- verbs do not end in a monophthongal vowel (including schwa)[1]. We do find *brei* [**breɪ̯**] 'to knit', *brouw* [**braʊ̯**] 'to brew', etc. but not #kra [**kra**], #bro [**bro**], or #made [**madə**];
- rhymes larger than three elements do not occur in verbs, apart from *peins* 'to consider', and *veins* 'to pretend' both with the diphthongue [**eɪ̯**];
- verbs ending in schwa, followed by [**n**] or [**r**] and [**l**] do occur, but verbs ending in schwa, followed by [**m**] do not occur.

Some exceptions to these phonological restrictions exist, but those words are either denominal, foreign, or extremely rare. The possible phonological form of an underived verb thus forms a proper subset of the possible phonological form of Dutch

[1] Trommelen's second generalization is also confronted with the following counter-examples: *ga* [x**a**] 'go', *doe* [**du**] 'do', *sta* [**sta**] 'stand' and *zie* [**zi**] 'see'.

(underived) words. Only nouns can make use of the full range of possible phonological forms.

For ease of exposition, we will henceforth refer to the set of possible phonological forms of an underived verb, as the phonological **frame** of a verb.

The first of Trommelen's generalizations requires some explanation. With respect to their phonological make-up, typical Dutch verbs come in two types: monosyllabic, or bisyllabic with schwa as the kernel vowel of the final syllable. Kager & Zonneveld (1986) argue at length that phonologically speaking 'bisyllabic with schwa' in fact means 'monosyllabic'. Adopting this analysis, we can confirm the monosyllabicity generalization above, albeit that a small number of counterexamples exist.[2]

It is important to note, as Trommelen did, that there are in fact many verbs that apparently do not obey the above-mentioned generalizations. These verbs come in two types. First, there are verbs ending in the affix *–eer* (*argument-eer* 'argue'; *public-eer* 'publish'). These verbs are clearly derived, while the phonological generalizations only hold for *underived* verbs. Second, there are seeming counter-examples like *olie* [**oli**] 'to oil' and *ruzie* [**ryzi**] 'to quarrel', but these verbs all have phonologically identical and semantically related nominal or adjectival counterparts. Therefore, these verbs can be safely assumed to be conversions of these 'underlying' adjectives, or nouns. For example, the verb *olie* is evidently derived from the phonological identical noun *olie* [**oli**] 'oil', and we can safely assume that the same holds for *ruzie*. Moreover, there are other types of independent evidence which show

[2] So far we have found the following counterexamples to the generalization that Dutch underived verbs exist only in a single syllable: bakkelei [**bɑkəlɛ͡ɪ**] 'fight', plavei [**plɑvɛ͡ɪ**] 'pave', ravot [**ravɔt**] 'romp about', krioel [**kriul**] 'teem', kidnap [**kɪtnɛp**] 'kidnap', soebat [**subɑt**] 'pester', poleist [**polɛ͡ɪst**] 'polish'.

that the seeming counter-examples can safely be regarded as ‘conversions’ (cf. Don 1993).

Turning now to nouns, the first observation is that they allow for all the possibilities that verbs have in Dutch, and many more. Hence, the phonological frame of verbs is a proper subset of the phonological frame of nouns in Dutch. To illustrate, let us give several examples. ‘True’ polysyllabic nouns, that is nouns with more than a single full vowel, freely exist (*gordijn* [**xɔrdɛ͡ɪn**] ‘curtain’, *banaan* [**banan**] ‘banana’, *antenne* [**ɑntɛnə**] ‘antenna’, *cement* [**səmɛnt**] ‘cement’ etc.), as well as nouns ending in monophthongal vowels (*zee* [**ze**] ‘sea’, ra [**ra**] ‘yard’, *dominee* [**domine**] ‘vicar’, *knie* [**kni**] ‘knee’, *po* [**po**] ‘potty’, etc.), and nouns that have rhymes with more than three elements (*angst* [**ɑŋst**] ‘fear’, *herfst* [**hɛrfst**] ‘autumn’, *oogst* [**oxst**] ‘harvest’). Furthermore, there are several nouns ending in schwa (*kade* [**kadə**] ‘quay’, *commune* [**kɔmynə**] ‘commune’) or in schwa followed by a labial nasal (*bezem* [**bezəm**] ‘broom’). Therefore, words having one (or more) of the following phonological characteristics can be classified as a noun:

- true polysyllabic words (with more than one full vowel)
- words ending in a long vowel
- words with ‘more than super-heavy’ rhymes (VVCC, or VCCC)
- words with a final schwa
- words with a final syllable consisting of schwa, followed by a labial nasal.

Summarizing, one could say that in Dutch only three types of phonological forms do not give any clue about the category of a word: monosyllabic words ending in a single consonant, monosyllabic words ending in a consonant cluster with an

obstruent as the second consonant and monosyllabic words that end in a diphthong.[3] All other rhymes can be categorized as nominal.

The fact, that certain phonological patterns are possible in one and not in the other lexical category, obviously is a necessary but not a sufficient condition to argue that phonology plays a role in the discrimination of nouns and verbs. We need to establish that language users, whether consciously aware of this knowledge or not, are actually able to make use of this knowledge once they are asked to.

2. Method

We designed a decision task to test if adult Dutch speakers are able to use phonological information in the categorization of content words: participants had to decide whether certain nonce stems are nominal or verbal. Using nonce stems in isolation is a good way to test phonological awareness only. The participants' semantic, morphological and syntactic knowledge is ruled out because nonce stems have no meaning, morphological structure or sentential context. Of course, we cannot exclude the possibility that subjects interpret some nonce forms as being morphologically complex. However, the phonological form of the nonce forms was chosen in such a way that no existing affix could be recognized in these words. We further assumed that, although many nouns in Dutch can be 'converted' to verbs without any overt phonological affix, subjects would still be inclined to immediately recognize such words as nominal rather than verbal.

The stimuli used in the experiment are based on the generalizations made by Trommelen (1989). Since the relation between the nominal and the verbal frame in

[3] As an anonymous reviewer points out, it might be the case that even within this group there are tendencies such that certain combinations of phonemes are more or less reliable indicators of category-membership. Testing this remains a task for future research.

Dutch is a superset (nouns) – subset (verbs) relation, we could only design stimuli as either *nominal* or as *ambiguous* between nominal and verbal. The specific properties that define a particular stimulus as 'nominal', as discussed in the previous section, are the following:

- nouns can have more than one syllable
- nouns can end in a monophthongal long vowel
- nouns can have more than super-heavy rhymes
- nouns can end in a schwa
- nouns can end in a schwa followed by a labial nasal

We created a set of 20 nonce stems, which are all phonologically possible stems in Dutch. Of these 20, 11 were designed as nouns, according to the generalizations made by Trommelen. The other 9 stems were designed as being ambiguous between nouns and verbs. In appendix 1 the stimuli are listed together with the design principles.

The participants of the experiment were 28 adults whose native language was Dutch. The stimuli were presented on paper with a brief introduction. The participants were asked to choose for each of the presented words, whether they were stems of nouns or stems of verbs. In order to make sure that our subjects understood the notion of a 'stem', we gave an example of both a nominal and a verbal stem in Dutch. Moreover, the terms 'nominal' and 'verbal' were briefly introduced and the task was explained. The task itself was presented as a three-column sheet. In the first column all stimuli were listed. The second and the third column were headed by 'nominal' and 'verbal' respectively. The participants were asked to tick a mark for only one of the columns for each stimulus; the nominal column if they thought the stimulus was a nominal stem, and the verbal column if they thought it was a verbal stem. All participants understood the task.

Our expectations were that subjects would answer ‘nominal’ more often on the stimuli that were designed as ‘nouns’, and that they would perform at chance level for the ambiguous stimuli.

3. Results

Now that the background and the method of the experiment have been set out, we can turn to the results. First, we will sketch the general picture of the outcomes of the decision task. Then, we will analyze the results in some more detail to see which phonological generalization is the most reliable predictor of word class in Dutch.

A first look at the data shows that there are some general patterns observable across the participants. In figure 1 we depicted for each stimulus the number of participants judging the stimulus as either being nominal or verbal.

<<Figure 1 about here>>

We ordered the stimuli in such a way that, read from left to right, we can observe a decreasing percentage of subjects that regarded the stimulus as a potential noun. For example, at the left half of the figure, we see that a large majority of the participants categorized the stimuli ‘riele’, ‘giveno’, ‘strempa’, and ‘donkam’ as nominal, but on the right hand, the stimuli ‘pluig’, ‘drauf’, and ‘krei’ were considered verbal by a majority of the subjects. This first look at the data indicates that participants judge the stimuli as being different with respect to word class. This proves to be true (χ^2 (19) = 117,1; $p < .01$).

However, the fact that this observation is true does not yet tell us anything about its nature. Therefore, the more interesting question is where this significant difference comes from. In other words: did the participants indeed respond ‘nominal’ more often to the stimuli that we designed as nominal? And did they respond at

chance level to the stimuli we designed as ambiguous? Table 1 shows the relationship between the design of the stimuli and the responses. In figure 2 we visualized these data.

<< Table 1 about here>>

<< Figure 2 about here>>

The scores in table 1 show that, for the stimuli designed as ambiguous, the participants slightly preferred a verbal response. The pattern for the stimuli designed as nominal clearly shows the expected asymmetric pattern: the subjects categorize almost 80% of the nominally designed stimuli as nominal stems. Subjects used the response 'noun' significantly more often for stimuli which were designed as nouns (χ^2 (1) = 102,0 ; p < ,001), but for the stimuli designed as ambiguous, the difference was not significant (χ^2 (1) = 6,4 ; p = ,025).

Since 11 items were designed as 'nominal', subjects could give the answer 'noun' 11 times for the items of that design. On average, subjects gave the answer 'noun' 8.64 times (range 5-11, SD = 1.97) and the answer 'verb' 2.32 times (range 0-7, SD = 2.02). There was some individual variation across subjects: 3 subjects gave the answer 'noun' only 5 times, 3 subjects 6 times, and 1 subject 7 times; the other 21 subjects answered 'noun' 8 times or more.

We have now established that, taken together, the principles that we used to design stimuli as nominal in general indeed lead participants to categorize stimuli as nominal stems. However, we also would like to know whether all principles have contributed equally to these results. The remaining question then is whether the different principles determining the noun-hood of the stimuli have different predicting

values. There are five different types of nominal stimuli: bisyllabic ones, stimuli ending in a long vowel, stimuli with superheavy rhymes, stimuli ending in a schwa, and stimuli ending in a schwa followed by a labial nasal (see appendix 1 for an overview of the stimuli). In table 2 and figure 3 the scores for the stimuli falling into one of these five types are listed and visualized.

<< Table 2 about here>>

<< Figure 3 about here>>

Every design principle, each corresponding to one of the generalizations found by Trommelen, triggered the participants to judge the corresponding stimuli as nominal in more than 80% of the cases, except for the principle of 'more than superheavy' rhymes. The stimuli designed according to this principle were categorized as nominal in only 55% of the cases. Overall we found a statistically significant difference in response patterns for all stimuli designed as phonological nouns. These 11 stimuli can be subdivided according to the five principles (bisyllabic, final long vowel, heavy rhyme, final schwa, final schwa + [m]). A one-way ANOVA of response*design principle shows a significant effect of design principle on the responses ($F_{(5,19)} = 13.3$, $p < .001$). Post hoc comparisons show that the response pattern for the stimuli based on four of the five principles differs significantly from the response pattern on stimuli designed as ambiguous (Tukey's HSD procedure). Only the principle of heavy rhyme does not cause a significant difference and hence does not contribute to the overall significant effect.

We may conclude from these results that, of the five phonological principles presented by Trommelen, four principles do indeed give enough cues for adult Dutch speakers to categorize stems as nominal. Three questions remain at this point,

however. First, it is not exactly clear why one of the Trommelen generalizations did not trigger the expected responses. The conclusion would have to be that this generalization does not belong to the speakers' competence and that the observations on which Trommelen based this generalization are coincidental. Second, we may wonder if and to what extent lexical information available to the native speakers somehow plays a role in the determination of category. It cannot be excluded that some of the stimuli remind the subjects of existing words in their lexicon and that the decision for noun or verb is influenced by this resemblance. It could be that precisely in the case of the 'more than superheavy rhymes' this potential lexical effect plays a role. Note that more than superheavy rhymes have a quite specific form segmentally since the phonology of Dutch does not allow just any range of final consonants. The possibilities are quite limited and therefore remininscence to existing lexical forms might be more obvious in these cases than in those forms where the lexical space is much larger. A follow-up study in which such lexical effects are better controlled for could possibly shed light on this issue. Third, our assumption that 'conversion' would not disturb the behavior of our subjects turned out to be true. Remember that almost all nouns in Dutch have the ability to become verbs through a morphological process of conversion that does not change the phonological form of the stems. Still, the stimuli designed as 'nominal' were indeed recognized as such by most subjects. Therefore, the subjects respond as if the stimuli are not cases of conversions but truly underived stems.

The results of this experimental study allow us to conclude that adult speakers of Dutch are able to make use of phonological cues in the discrimination of nouns and verbs. This result strengthens the idea of phonological bootstrapping as a plausible strategy to follow for children acquiring words. Of course, whether this is indeed the

case can only be established once we have some experimental results on children. In the next section we will present some material which bears on the question whether children make use of the phonological cues available to them in Dutch.

4. Conclusion

Trommelen's cues except for one ('more than superheavy rhymes') are reliable predictors of the nominal word class in Dutch. Adults can use their phonological knowledge to classify stimuli that are designed according to these cues, correctly.

What do these results say about the generalizability of Trommelen's cues to other languages? If we recall the results of the study conducted by Durieux and Gillis (2001), we see that the bare segmental information of words was at least as good a predictor of word class as the cues presented by Kelly (1996; duration, vowel height, nasality of consonants, number of phonemes) for English. They concluded that Kelly's cues might be too narrow. Probably the universality of the relationship between phonology and word class is not in the kind of phonological cues, but in the fact that structural relations exist between the possible phonological make-up of a noun versus the possible phonological make-up of a verb. The same suggestion is made by Farmer et al. (2006:12207), who state that "Analyses of languages, such as Dutch, French, Japanese, Mandarin and Turkish […] suggest that phonological cues to lexical categories are not unique to English but may be a universal property of language".

To conclude, although the phonological cues presented by Trommelen are probably specific for Dutch (modulo genetic correspondences to other languages), the fact that phonological information is available for adults in classification is a very interesting finding. If adults can actively use the link between phonology and category

membership, the idea that language-learning children may use this information to get at the proper categorization becomes more promising.

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Appendix 1 stimuli

Stimulus		Designed as	Principle
donkam	**dɔnkam**	Noun	Bisyllabic
meliens	**melins**	Noun	Bisyllabic
giveno	**xiveno**	Noun	final long vowel
strempa	**strɛmpa**	Noun	final long vowel
smoza	**smoza**	Noun	final long vowel
boogst	**boxst**	Noun	heavy rhyme
pierst	**pirst**	Noun	heavy rhyme
riele	**rilə**	Noun	final schwa
krile	**krilə**	Noun	final schwa
fallem	**fɑləm**	Noun	final schwa + m
wirfem	**wɪrfəm**	Noun	final schwa + m
book	**bok**	Ambiguous	
pluig	**plœ͡ɪx**	Ambiguous	
diel	**dil**	Ambiguous	
drauf	**drɑ͡uf**	Ambiguous	
blaap	**blap**	Ambiguous	
nort	**nort**	Ambiguous	
krei	**krɛ͡ɪ**	Ambiguous	
balter	**bɑltər**	Ambiguous	
kleest	**klest**	Ambiguous	

Appendix 2 Responses of all subjects per stimulus

Stimulus	Nominal	Verbal
Kleest	18	10
Book	13	15
boogst	16	12
giveno	22	5
strempa	22	5
donkam	23	5
pluig	6	22
riele	26	2
fallem	25	3
balter	16	12
wirfem	21	7
smoza	24	4
meliens	25	3
diel	12	16
pierst	15	13
drauf	9	19
krile	23	5
blaap	9	17
nort	13	15
krei	9	19

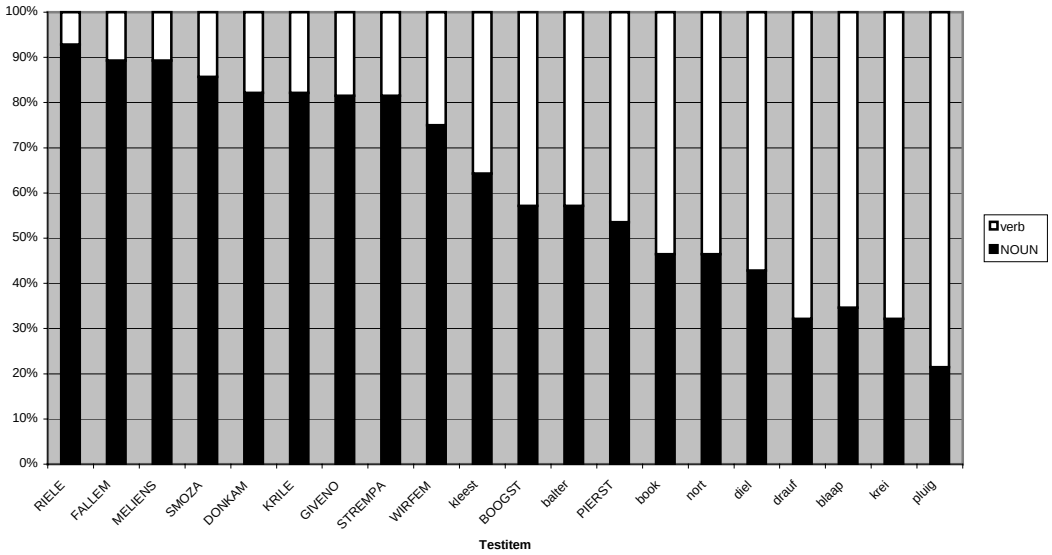

Figure 1. Responses per stimulus

Design / Category	Noun	Verb
Ambiguous	105 (42%)	145 (58%)
Nominal	242 (79%)	65 (21%)

Table 1. Responses of all subjects per stimulus design

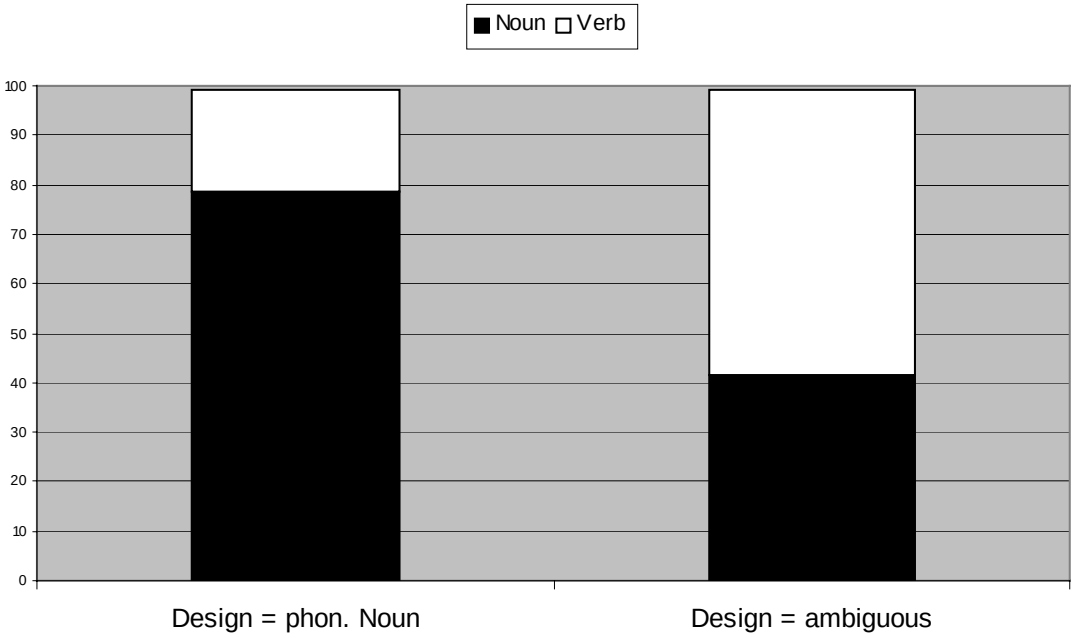

Figure 2. Percentages of responses per stimulus design

Principle	Noun	Verb
bisyllabic	48 (85 %)	8 (15 %)
final long vowel	68 (83 %)	14 (17 %)
more than superheavy rhyme	31 (55 %)	25 (45 %)
final schwa	49 (88 %)	7 (12 %)
final schwa + nasal	46 (82 %)	10 (18 %)

Table 2. Responses of all subjects per design principle

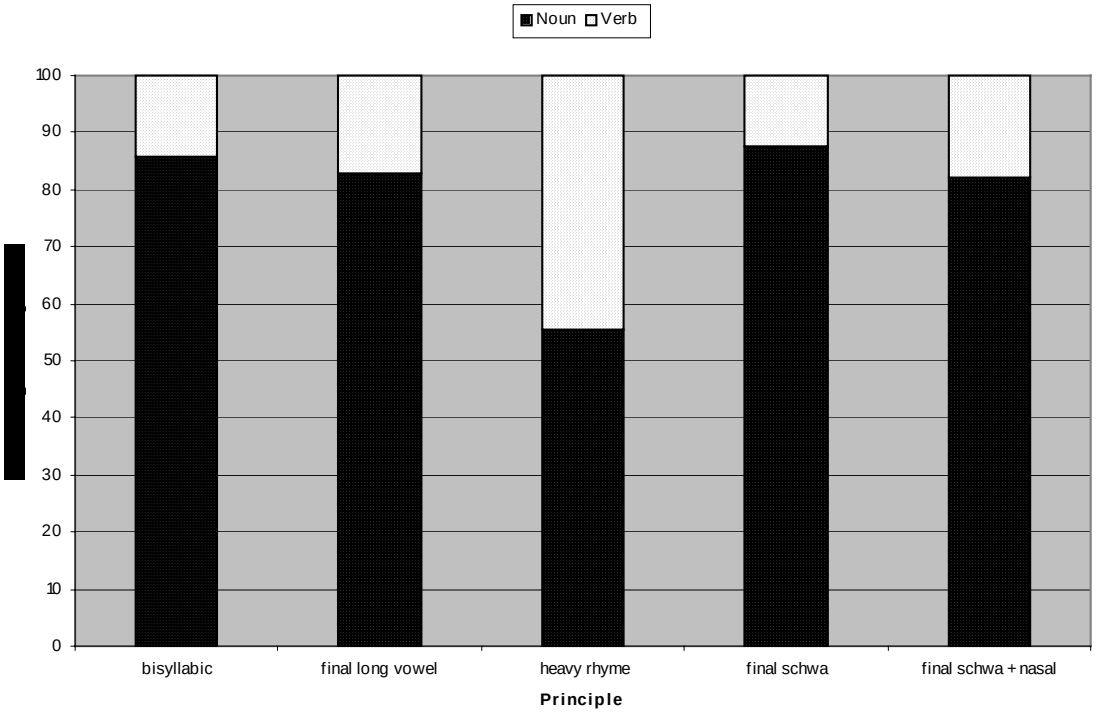

Figure 3. Percentage of responses per design principle