

## INFLUENCE OF MORPHOLOGY ON PHONEME IDENTIFICATION IN SPOKEN CROATIAN

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### ABSTRACT

The representation of morphological structures in the mental lexicon constitutes the inevitable topic in the investigation of cognitive aspects of the language data processing. In the present paper the influence of the noun case functions of the phoneme identification in Croatian language is investigated within the framework of the spoken word recognition. By means of the gating paradigm 36 subjects listened to and identified 24 words. The results showed strong influence of the morphological component, especially of the nominative case, on the word recognizability, regardless of the suffix phoneme (/a/ for feminine and /e/ for neuter gender). The results also showed the dynamics of the word identification process because it was possible to determine the decision-bias point position. Finally, the results could be interpreted in terms of the decompositional storage of morphological information of the regular complex Croatian nouns in the mental lexicon.

### INTRODUCTION

The representation of morphological structures in the mental lexicon constitutes the inevitable topic in the investigations of cognitive aspects of the language data processing [1], [2], [3], [4]. The basic models of the complex word representation assume the existence of the full form listing in the word identification process (holistic full form based models [5]) on the one side and complete morphological decomposition of the word on the other side (decompositional model [6]). According to the latter model, the components of the word are stored in the memory and the word identification implies the activation and combination of the corresponding morphological segments. The effects of the morphological structure on the spoken word identification are explained by two basic approaches. According to the first one, the morphological structures are activated before the full information about the word is accessed (prelexical influence [7], [8]) while the second one claims that the influence of the morphological structure is realized on the previously

activated full word representation (postlexical influence [9]). The main characteristic of spoken word identification (compared with written word identification) is determined by its sequential nature. Accordingly, the morphemes in spoken realization are perceived in a sequential manner. If the phonetic/acoustic realization of the particular morpheme is a speech sound (or a phoneme at the language level) it is possible to investigate the characteristics of the morphological component of language processing in the identification of phoneme/sound by which a particular inflectional form is marked. Croatian as a fleective language offers a great variety of morphological structure investigation in nouns, verbs, adjectives, numbers and pronouns. The lexical effect was investigated in Croatian and it was shown as a favorable factor of the within-word phoneme identification in various contexts: sentences, isolated words and non-words [10]. The influence of the whole word on the identification of the constituent elements is explained in terms of the amount of information gathered from the linguistic and phonetic sources. Noun words in Croatian have a very rich and diverse case paradigm. The cases are expressed by various suffixes marking the grammatical functions of the word or the syntactic relations of the word in the sentence. Besides the cases, the grammatical gender (masculine, feminine, neuter) and number (singular and plural) are also morphological categories of the nouns. The real forms of these morphological categories are amalgamated in the same morpheme which makes the case suffix of the noun ("kos-a", nom., sg., fem.; "per-o" nom., sg., neut.). The case usage frequency of the nouns in Croatian which can influence the word identification processes varies (nom. 39.9%, gen. 18.4%, dat. 5.0%, acc. 24.4%, voc. 2.8%, loc. 6.0 and inst. 3.0% [11]). The aim of this research was to show the degree of connections between the morphological processor and the phonetic/ phonological level of speech/language processing. The perceptual experiment was designed to reveal the dynamic characteristics of the spoken noun case processing in Croatian. So the different morpheme functions that are expressed by the same vowel phoneme are investigated (The same phoneme /e/ has two different morphological functions: a) nom., sg., neut,

“polj-e” and b) gen., sg., fem. “žen-e”). It was expected that the influence of the morphological component would show up in spite of the identical sounds of compared case suffixes. So it was expected that the sound which carries the function of the nominative case will be better identified than the same sound in the function of the oblique case. The identification effectiveness of the investigated sounds was specially regarded depending on the noun gender.

## PROCEDURE

The sample of 24 two-syllable feminine and neuter nouns in different case forms (nominative, genitive, dative and accusative singular) was selected. The investigation of multiple relations was possible because the same sound can have different case morpheme function. The list of stimuli is shown in Table 1.

Table 1. The list of stimuli.

Gender	Case	Suffix	Words
female	nom.	- a	sil-a, žab-a, vod-a, sov-a
neuter	gen.	- a	sel-a, neb-a, čud-a, tkiv-a
female	acc.	- u	sil-u, volj-u, žab-u, lađ-u
neuter	dat.	- u	sel-u, polj-u, neb-u, sud-u
female	gen.	- e	volj-e, bor-e, ovc-e, lađ-e
neuter	nom.	- e	polj-e, mor-e, sunc-e, sud-e

The chosen words were randomized and recorded by a female speaker in laboratory conditions on a CD so that each word was read three times in a row, and the second pronunciation was taken for further manipulation and perceptual testing. In total, 16 words in 48 different case forms were used in the word recognition procedure. The recorded words were digitized (16-bit converter, sampling frequency 20 kHz) and then manipulated by means of LSI software according to the gating paradigm. In the gating paradigm the stimulus is prolonged before each listener's response by a fixed increment, yielding progressively more acoustic information at each subsequent point (gate). Starting from the beginning of the word each subsequent gate was 20 ms longer. As the duration of the words was different so was the number of gates for a particular word. The number of gates varied from 11 (for word "sudu") to 26 (for word "lađe").

The subjects (36 female university students) listened to each stimulus word from the shortest (20 ms) to the longest (the whole word) duration of the gates through Hi-fi loudspeakers in quiet room in three groups of 12 subjects each. The listening procedure lasted

approximately 40 minutes. The interstimulus interval was 5 s during which the subjects had to write the word they thought was uttered and the degree of their confidence on a seven-point scale (from 1 for the lowest to 7 for the highest).

## RESULTS

The indicator of word recognizability (WR) for each word form was calculated by the formula that takes into account the correctness of subject's answer and the degree of confidence [12], [13], [14]:

$$WR = \frac{\sum E_{dc}}{n_{pro} \cdot \max_{dc}}$$

where  $E_{dc}$  = sum of degrees of confidence for each word,  $n_{pro}$  = number of possible occurrences (number of subjects) and  $\max_{dc}$  = maximum degree of confidence. The results are plotted in graphs showing the relations of word recognizability expressed in percentage and the reversed gate ordering number in 20 ms increments (counting from the end of the word until zero percentage of word recognizability).

a) The relations of word recognizability and the noun case

In Fig. 1 it is shown that the percentage of word identification is greater for nominative case than for genitive case of both genders. The third position is held by the accusative case of female and dative case of neuter nouns. For the nominative and genitive cases it is possible to conclude that the morphological form is more influential than the nature of the phoneme in the particular case (/a/ or /e/). The accusative of the female and the dative of the neuter show not only lower recognizability but also the influence of the suffix /u/: this is evident in the fact that 100% identification is not reached even after the presentation of the whole word. Though the usage frequency of the accusative case (24.4%) is significantly greater than of the dative (5.0%) the percentage of the dative recognizability is higher and requires further explanations. It is also shown that the same phoneme with a different morphological function (phoneme /a/ for the nominative case of female and genitive case of neuter nouns, and phoneme /e/ for the nominative case of neuter and genitive case of feminine nouns, phoneme /u/ for the accusative of feminine and dative of neuter nouns) have different recognizability. Namely, nominative morphemes are stronger than genitive and dative neuter morpheme is stronger than the accusative female one. The comparison of genders shows that the cases (nominative and genitive) manifest themselves similarly in both genders.

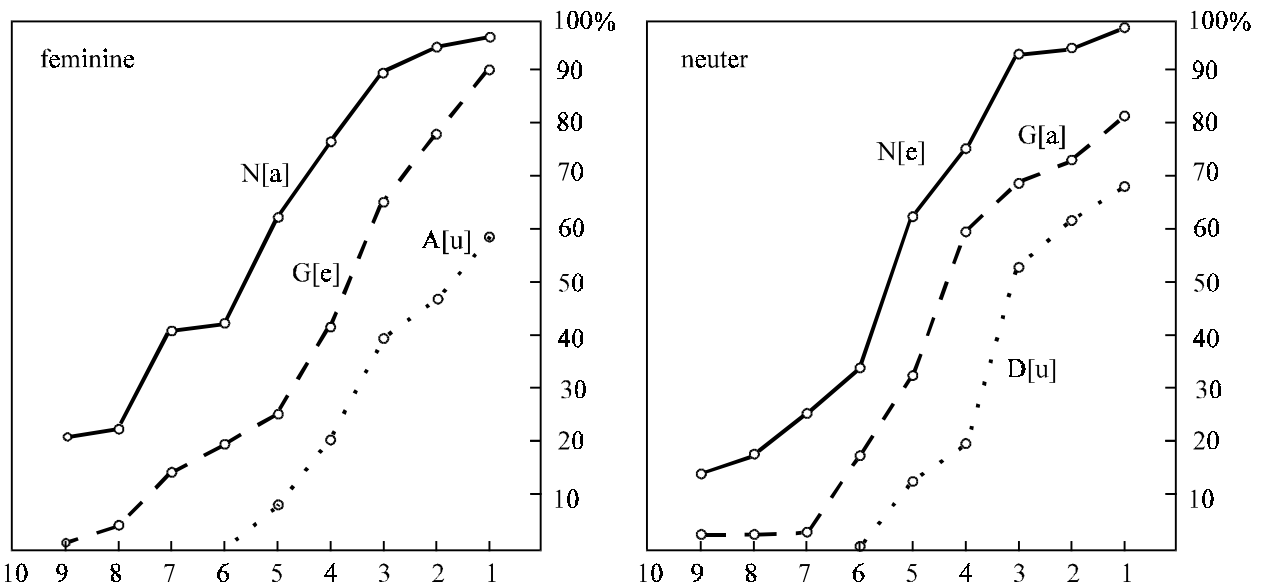


Figure 1. The relations of the percentage of word recognizability and the reversed gates for feminine and neuter nouns in nominative (N), genitive (G), dative (D) and accusative (A) cases and their suffixes [a], [e] and [u].

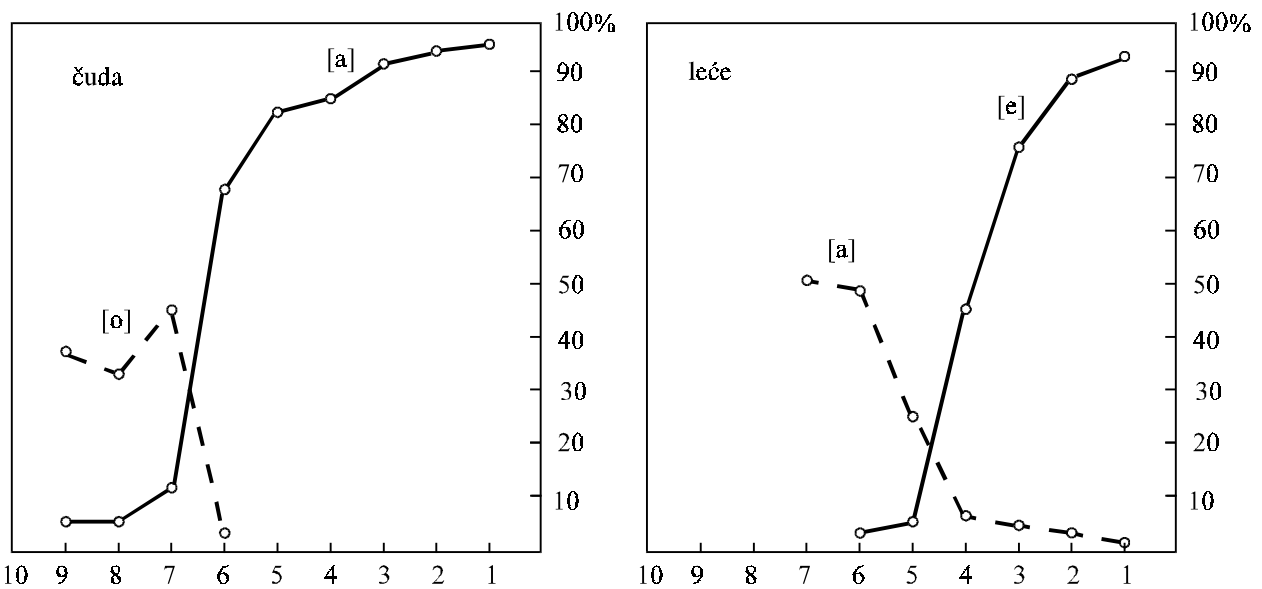


Figure 2. The decision-bias point for the words "čuda" and "leće" plotted as the crossing point of the word recognizability for the genitive case "čuda" and "leće" and for supposed by subjects nominative case "čudo" and "leća".

## b) The decision-bias point

Fig. 2 shows at which point of the word duration the auditory information (bottom-up) overcomes the conceptual morphological information (top-down). It shows at which point the subject turns from the expected nominative case to the actually presented genitive case.

## DISCUSSION AND CONCLUSION

The interpretation of the results contributes to the knowledge about the storage of morphological information in the mental lexicon and to the relations between morphological and phonetic/phonological processing of the word identification in general. Because all the results show that different morphemes (case suffixes) influence the identification of the concrete

vowel which is their phonetic realization it is possible to suppose that the morphemes as constitutive elements of a complex word are represented in decomposed form. The investigated words represent the regular inflection paradigm so this conclusion refers only to them. By the gating-paradigm procedure it is possible to follow the dynamics of the identification effectiveness of the spoken word final sound/phoneme depending on the case function. That is a new procedure in the investigation of the morphological structure bearing in mind that in the majority of investigations the procedure of lexical decision and naming task were used, i.e. only the final decision was recorded and the process of decision making was not measured at all. The regularity of word recognizability curves shows the same relations between different cases regardless of the nature of vowel morpheme. As expected, the results show that the

nominative was the strongest case in inflectional paradigms of both the feminine and neuter gender. The results of the “oblique” cases (dat. and accus.) with the same sound morpheme /u/ manifested “weak” identification power because after the full signal was presented their word recognizability was less than 70%. The gating paradigm enables us to detect the moment in the word duration at which the phoneme decision is changed, namely it is possible to determine the decision bias point. At that point the nominative form expected in the top-down information mechanism is changed by the form which was really presented in the oblique case, when the bottom-up processing starts. Finally, it may be concluded that in the declension paradigm of regular nouns in Croatian the effects of morphological processing are activated in the prelexical period of mental processing of the word, that is before the expiration of the total acoustical duration of the presented word.

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