EFFECTS OF STRESS AND SEGMENT POSITION WITHIN A WORD ON SPEECH ERRORS IN CROATIAN

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ABSTRACT

One of the major findings based on the investigation of speech errors in English is that more interaction errors occur if two segments share stress than if they do not. Another finding is that more interaction errors occur if two segments share their position within a larger unit. The aim of this study is to investigate these findings in Croatian using tongue twisters as a method for eliciting mutual substitutions of consonants, as one type of speech errors. The results show that in Croatian more substitutions of consonants occur if they are in the unstressed syllable if compared to the stressed ones, thus, the results are not in line with the findings of speech errors in English. Still, the results confirm the claim that two segments interact more frequently if they share the position within a word. The effects of these findings on phonological encoding were discussed.

Keywords: Speech error, substitution, stress, position within a word, Croatian.

1. INTRODUCTION

One of the well-known ways to investigate many aspects of speech production is analysing speech errors, also called slips of the tongue. Thus, phonological speech errors are an important source of information about the phonological encoding – the instance of speech production which refers to the retrieval of target phonemes, their sequencing within an utterance, and preparing for articulation [4, 8, 14]. The role of stress in this process is still not completely understood. Based on the research of experimentally elicited phonological errors, Shattuck-Hufnagel [13] concluded that more interaction errors occur if two segments share stress than if they do not, specifically, if they precede a stressed vowel in a word. The claim is supported by [12]. Still, the results of previous research are contradictory. While most of the studies [3, 5, 11] carried out on the English speech corpus confirm the finding that segments interact more often if they are in a stressed than in an unstressed syllable, Berg's [2] analysis of errors in Spanish showed that there is an equal possibility that segmental errors occur in a stressed or unstressed syllable. Considering this inconsistency between different languages, the aim of this study is to investigate the role of stress in mutual substitutions of target consonants in Croatian, using the tongue twister technique for eliciting errors. Croatian is a pitch-accent language [10] in which a stressed syllable is distinguished from unstressed syllables within the same word by pitch, length, and intensity which are simultaneously realized. Thus, four types of word stress can be distinguished: long rising, short rising, lang falling and short falling [1, 7]. The vowel following the stressed syllable within a word can also be short or long. The stress position in Croatian is relatively free. In polysyllabic words, any syllable except the last one could be stressed, and monosyllabic words can only have a falling accent [1, 7]. Based on the literature on the role of stress in English and Spanish, it could be expected that stress would have an effect on mutual substitutions of target consonants in Croatian as well. Still, since there are no studies that have investigated the role of stress in phonological encoding neither in Croatian nor in other Slavic languages, the kind of effect is difficult to predict, or which direction it goes, that is, whether stress will increase or decrease the number of substitutions.

Another aim of this research is to find out whether two segments interact more frequently if they do or do not share the position within a word in Croatian, using the same tongue twisters. In addition, the experimental design allows testing whether a syllable or word position similarity causes more segmental substitutions. Previous research showed that two segments interact more often if they share the same position in the syllable than if they do not [3, 4, 5, 9], which is known as position similarity constraint. Shattuck-Hufnagel [13] noted that all reported evidence for position similarity constraint is compatible with both syllable and word unit. Furthermore, her experiment, designed to investigate the effect of word position on interactions of segments, showed that more interactions occur if segments share word position than if they do not [13]. Similar experiment was conducted by [12], where this finding is confirmed. In light of the previous research, it could be expected that word position similarity would have an influence on the frequency of substitutions of segments in Croatian as well.

2. METHOD

2.1. Materials

The experimental design used in this research is based on the design used by [13], but adopted for Croatian and for the specific requirements of this research. Stimuli consisted of 18 quadruple sets of Croatian tongue twisters, making a total of 72 tongue twisters. Tongue twisters were presented one by one in a written form on the computer screen, using Arial font size 80, in lowercase, according to standard Croatian orthography rules. The presentation was in the PowerPoint. Each word of the tongue twister was presented in a separate line on the screen. Tongue twisters were constructed of four three-syllable Croatian words, and they had two target consonants (TCs), A and B, which were arranged into the following patterns:

- BO-BS – *both* TCs were in the word-*onset* position in the *stressed* syllable of the word.
- BO-SU – *both* TCs shared word-*onset* position, but they differed in the stress position: one was in the *stressed* syllable, and the other one in the *unstressed* syllable of the word.
- BO-BU – *both* TCs were in the word-*onset* position in the *unstressed* syllable of the word.
- OT-BS – *both* TCs were in the *stressed* syllable of the word, but they differed in the word position: one was in the word-*onset* position, and the other one was in the *third* position within the word.

Each quadruple set contained all four types of TC patterns (for an example, see Table 1).

Table 1: Example of one quadruple set of stimuli in Croatian, along with phonetic transcription and translation in English. TCs /ʒ/ and /z/ are in italics, the stressed vowel is underlined (the target consonant and the stressed vowel were not marked on the presentation to participants).

TC pattern	Stimulus
BO-BS	žalostan zubarski žetveni zidati ['ʒalostan 'zubarski 'ʒetʋeni 'zidati] (eng. sad dental of harvest build)
BO-SU	žalostan zubari žetveni zidari ['ʒalostan zu'bari 'ʒetʋeni zi'dari] (eng. sad dentists of harvest bricklayers)
BO-BU	žalostiv zubari žetoni zidari [ʒa'lostiv zu'bari ʒe'toni zi'dari] (eng. piteous dentists coins bricklayers).
OT-BS	ložači zubarski težina zidati [lo'ʒaʧi 'zubarski te'ʒina 'zidati] (eng. stoker dental heaviness build)

It is important to note that TCs in all types of TC patterns always shared the syllable-onset position. There were nine pairs of TCs. Based on the system of three different articulatory features, i. e. place of articulation, manner of articulation, and voicing, eight pairs differ only in one feature: /l–r, z–ʒ, s–ʃ, s–ʦ, ʃ–ʒ, n–m, k–x, l–ʎ/, and one pair differs in two features: /ʋ–f/ [6]. For the sake of reliability of the results, the intention of the author(s) was to conduct an experiment using real words. In order to meet this requirement, it was impossible to control all aspects of stressed syllables in designing the tongue twisters, that is, pitch and length were not consistently controlled. Still, wherever possible, these two features were controlled as well. The target pair in all four types appeared in two different word orders:

- ABAB: for example, *ž*^{A}*alostan z*^{B}*ubarski ž*^{A}*etveni z*^{B}*idati*.
- BAAB: for example, *z*^{B}*agađen ž*^{A}*utica ž*^{A}*irovi z*^{B}*emljani*; ['zagaʥen 'ʒutiʦa 'ʒiroʋi 'zemʎani]; eng. *polluted jaundice acorns earthlings*.

2.2. Participants

Twenty native Croatian speakers, drawn from the Faculty of Humanities and Social Sciences, University of Zagreb, participated in this experiment. They were all right-handed females, with age ranging from 19 to 38 years old. None reported any history of speech, language, or motor deficits. They did not receive compensation for their participation.

2.3. Procedure

The procedure is similar to the one described in [13] and [14], but also adopted for the purpose of this research. The testing was performed individually in a soundproof studio. The participants were instructed to read each tongue twister aloud, as long as it was presented on the computer screen (reading condition). Then the utterance showed up again on the screen for two seconds. The appearance of the green dot in the middle of the screen was a signal to the participant to begin to repeat the utterance from the memory and to continue doing it as long as the green dot was presented (recall condition). In rare cases when the participant forgot the item, the whole procedure in the recall condition was repeated. The presentation of the items (tongue twister or the green dot respectively) lasted for nine seconds. The utterances were presented in two random orders: half of the participants was given one order (Group 1), and the other half another one (Group 2). The rate of reciting the stimulus was self-paced. The only instruction for the participants was to speak a little bit faster than usual. Before the experimental session, each participant was given four trial runs. To avoid fatigue, the experiment was divided into four equal sessions and conducted in two days, with a 15-minute break between the sessions on the same day.

2.4. Data analysis

The produced utterances were audio recorded with a microphone and later transcribed by two trained transcribers. In cases where the transcriptions did not match, a third transcriber was engaged. A word was classified as incorrect if it contained at least one erroneous phoneme, i.e., that was not given by the stimulus. Only substitutions of TCs in the first four repetitions of each participant in the reading and recall condition were included in the analysis. For example, if the participant instead of *žalostan* produced *zalostan*, the substitution of /ʒ/ for /z/ was counted as one substitution. The statistical analysis was carried out using the SPSS software package. The Friedman test was conducted to test for differences between TC patterns, followed by six Wilcoxon rank sum tests for individual group comparisons.

3. RESULTS

The participants produced a total of 46 080 words: 23 040 in reading, and the same number during recall. There are 2.73% erroneous words in reading and 5.15% in recall, which is in line with the number of erroneous words in some other similar experiments [14]. This small number of erroneous words indicates that the experimental requirements were not too difficult to meet. In the following sections we will present the mutual substitutions of target consonants, i. e. the cases where one target consonant is replaced with another one, in reading and recall.

3.1. Mutual substitutions of target consonants in reading

A total of 339 mutual substitutions of TCs (TC substitutions) were produced in reading. The difference between participants in the number of TC substitutions in all four types of stimuli is high, which can be seen from the minimum and maximum number of TC substitutions per participant (see Table 2). Such discrepancy in the number of errors between participants has already been noted in [13, 14]. The lowest total number of substitutions (3) has the participant 5 (P5), and the highest number (33) has the participant 8 (P8). Still, the similar error ratio between four patterns was found in the recall condition (see Table 3), which indicates that this ratio has not been accidental.

Table 2: Descriptive statistics in reading: the number of participants (N), minimum (Min) and maximum (Max) number of TC substitutions per participant, total (Sum) number of TC substitutions in all four types of TC patterns in tongue twisters. The percentages indicate a type's percentage of all TC substitutions in reading.

Pattern type	N	Min	Max	Sum	%
BO-BS	20	0	11	99	29.2
BO-SU	20	1	10	91	26.84
BO-BU	20	1	12	117	34.51
OT-BS	20	0	5	32	9.4

As can be seen from Table 2, the highest number of TC substitutions is in the BO-BU. The fewest substitutions are in the OT-BS, and this result is observed in 18 participants. The test shows that the difference in the number of TC substitutions between the four types is significant ($\chi^2 = 24.933$, $p = 0.00$). Post-hoc tests show that the difference between OT-BS and all three other types is reliable (OT-BS vs. BO-BS: $z = -3.558$, $p = 0.00$; OT-BS vs. BO-SU: $z = -3.630$, $p = 0.00$; OT-BS vs. BO-BU: $z = -3.526$, $p = 0.00$). The difference in the TC substitutions between other three pairs of TC patterns is not significant (BO-SU vs. BO-BS: $z = -0.885$, $p = 0.38$; BO-BU vs. BO-BS: $z = -0.852$, $p = 0.39$; BO-BU vs. BO-SU: $z = -1.510$, $p = 0.13$). Bearing in mind that OT-BS is the only type where TCs do not share word position, these results indicate that the position of segments in a word has a greater influence on segmental errors than stress. In other words, if two segments share a position within a word, they are more likely to interact with each other.

3.2. Mutual substitutions of target consonants in recall

Participants produced a total of 646 TC substitutions during recall, which means that the number of TC substitutions is almost twice as many in this condition than in reading. Since the working memory in recall is much more loaded than in reading, this result is expected, and it is in line with [13]. As in reading, individual differences in the number of TC substitutions are high (Table 3). The lowest total number of substitutions (10) has the participant 18, and the highest number (71) has the participant 15. The number of TC substitutions in recall follows the same pattern as in reading: the highest number is in BO-BU, then in BO-BS, followed by BO-SU, and the fewest substitutions are in OT-BS (Table 3).

Table 3: Descriptive statistics in recall. Symbols are the same as in Table 2.

Pattern type	N	Min	Max	Sum	%
BO-BS	20	3	21	188	29.1
BO-SU	20	1	21	172	26.62
BO-BU	20	3	24	231	35.75
OT-BS	20	0	8	55	8.5

The lowest number of substitutions in the OT-BS as compared with other four pattern types is observed in 18 participants. The Friedman test shows that the difference between the four conditions is significant ($\chi^2 = 36.703$, $p = 0.00$). Again, the difference between OT-BS and all three other types is reliable (OT-BS vs. BO-BS: $z = -3.837$, $p = 0.00$; OT-BS vs. BO-SU: $z = -3.665$, $p = 0.00$; OT-BS vs. BO-BU: $z = -3.924$, $p = 0.00$). The result confirms the findings that the position of segments in a word has a greater influence on segmental interactions than stress. Contrary to the reading condition, the difference between BO-BU and the remaining two conditions in recall is significant at the level of 0.05 (BO-BU vs. BO-BS: $z = -2.079$, $p = 0.04$; BO-BU vs. BO-SU: $z = -2.268$, $p = 0.02$). Considering that only in BO-BU both target consonants were in the unstressed syllable, this result suggests that substitutions of two segments are more likely to occur if they are in the unstressed syllable than if they are in the stressed one, as far as recall is concerned. This result is not consistent with similar research studies in English [3, 5, 11, 12, 13]. Finally, the number of TC substitutions in BO-SU and BO-BS was not significantly different in recall (BO-SU vs. BO-BS: $z = -0.907$ $p = 0.36$), and in reading as well. This suggests that sharing a position in a stressed syllable does not significantly increase the possibility of mutual segmental interactions.

4. DISCUSSION

One aim of this study was to investigate the role of stress in mutual substitutions of target consonants in Croatian, using the tongue twisters in two conditions – reading and recall. The results show that in both conditions the highest number of TC substitutions occurs when both TCs are in the unstressed syllable (BO-BU). In the recall condition the difference between the number of TC substitutions in BO-BU and BO-BS (where both TCs are in the stressed syllable at the same position – word-onset), is significant. These results are not in agreement with the literature on English speech errors, which reported that segments interact more often if they are in a stressed than in an unstressed syllable [3, 5, 11, 12, 13]. The results are not completely in line with Berg's [2] finding either, according to which there is an equal possibility that errors occur in a stressed or unstressed syllable in Spanish. Still, as the difference in reading between BO-BS and BO-BU is not significant, Berg's [2] finding is confirmed in this condition. Altogether, the present results suggest that prosodic features of language could influence phonological encoding and that this process is not universal. It is possible that in pitch-accent or tone languages less attention is concentrated to segmental planning in unstressed than in stressed syllables, due to the additional demands of pitch processing in stressed syllables. This lack of attention will result in more errors in unstressed syllables. Another aim was to check whether two segments interact more frequently if they share the position within a word than if they do not. The results show that the fewest TC substitutions occur if target consonants do not share the word position (OT-BS), as compared with the results in other three pattern types, in which TCs share their word position. Furthermore, the difference in number of TC substitutions between OT-BS and other patterns is significant. These results are in line with [13], which revealed that sharing the position within a word increases the possibility of segmental interaction in English. The obtained results seem to support the Shattuck-Hufnagel's [13] claim that word structure plays an active role in phonological encoding, not just in English but in Croatian as well. Moreover, it seems that a word structure has a greater influence on segmental interactions than a syllable structure. The evidence for this claim comes from the fact that significantly more TC substitutions occur in BO-BS than in OT-BS. It should be remembered that in both BO-BS and in OT-BS pattern, TCs shared the syllable position, but only in BO-BS they shared the word-position, not in OT-BS. Regarding the results in reading vs. recall, a greater number of TC substitutions in recall than in reading is expected and in line with [13], who gave an acceptable explanation for this – in reading, the memory load is minimal, as opposed to recall where it is significantly higher, which will consequently result in more errors. Still, a similar error ratio in all four TC patterns in reading and writing indicates that errors in both conditions have the same source within the process of phonological planning, as [13] already noticed in the interpretation of her own results.

In summary, the present results suggest that Croatian, as prosodically different from English, may differently affect the processes of phonological encoding, although some aspects of these processes are common to both languages, for example the role of word structure.

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