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IMPROPER ACTIVATION AND MONITORING FAILURES IN SPEECH PLANNING

SUMMARY

During speech production, not only currently spoken fragments of utterances but also both their past and future portions are being monitored. Errors in which sounds or words are either spoken ahead of their time (anticipations), or produced later than they should be (perseverations), evidence that speech planning activates the present, deactivates the past, and prepares to activate the future. The aim of this research was to study the frequency and phonetic characteristics of anticipations and perseverations in Hungarian. Altogether 227 serial order errors of spontaneous speech samples by twenty-seven native speakers were analyzed (using Praat). Our data revealed that higher-organized units could drift away from their planned position to a relatively longer distance in time than lower-organized units while the latter tended to do so more frequently than the former. The self-inhibitory turn-off mechanism seems to be slower than the pre-planning mechanism in the case of speech sounds and word parts. Temporal patterns confirmed that the speech production mechanism controls pre-planning more successfully.

Key words: *anticipation, perseveration, measured distances, spontaneous speech*

INTRODUCTION

The speech production mechanism consists of a number of processes, most of which work in parallel with one another; this results in overlaps between the individual processes. As soon as we decide on our intention to communicate, lexical selection and grammatical transformation start taking place. These processes are still going on when phonological planning begins. Articulatory planning starts well before phonological planning is over. The mental lexicon is also activated while all the levels of speech production are still active. Speech planning activates the present, deactivates the past, and prepares to activate the future of speaking. When the language production system works well, it looks into the future and does not dwell on the past. Briefly, according to Levelt's aphorism, speakers transform their ideas and feelings into speech through a "mystical" process (1989).

Errors in which sounds or words are either spoken ahead of their time (anticipations like *reek long race* instead of *week long race1*) or re-produced later after their first appearance (perseverations like *Chomsky and Challe* instead of *Chomsky and Halle*) or show exchange within or across words (like *teep a cape* instead of *keep a tape*) evidence serial order problems in speech planning. Serial order errors can be used to determine whether behavior is focused on the past or on the future (Dell et al., 1997; Howell 2007). These errors are called 'contextual errors'; they occur during the manipulation of grammatical and phonological representations and reflect cases where the correct phonemes are spoken but their order is incorrect in some way (Vousden & Maylor, 2006). Specifically, sound errors are associated with the phonological representation, and most word errors are associated with the grammatical representation (e.g., Garrett, 1975; Stemberger, 1985).

Speakers plan a series of syllables in an utterance hierarchically from lexical access to articulatory planning; encoding thus does not proceed from unit to unit, and does not take place according to the place of units in the utterance (Gordon & Meyer, 1987; Vousden et al., 2000). There are plenty of hypotheses and models trying to explain serial order errors of speech (for a summary, see Dell et al., 1997). Although these errors seem to be timing problems of speech planning on the surface, this does not explain the reason for their occurrence. One type of hypotheses considers serial errors as an entirely timing problem while others consider them either as consequences of activation problems or as monitoring failures (e.g., Dell, 1984, 1986, 1988; Stemberger, 1985; Postma & Kolk, 1993; Dell et al., 1993; Postma, 2000; Keller et al., 2000; Howell & AuYeung, 2001; Howell, 2007). Timing depends on the complexity of the process including the linguistic task, and the extent of

[1] The English examples are from Fromkin 1971.

overlap between the different levels of speech production changes accordingly. During speech production, not only currently spoken fragments of utterances but also both their past and future parts are being monitored. Timing is controlled by the speaker in a way that such overlaps do not cause any disruption in the fluency of speech, at least as far as possible. However, proper timing and/or appropriate controlling do not always function smoothly. Dell's speech production model is based on activation spreading (Dell, 1986; Dell & O'Seaghdha, 1991). This is a network of linguistic rules and units in which decisions about what unit or rule to choose are based on the activation levels of the nodes representing those rules or units. An important element of his theory is that in the course of speech production we create an internal representation of the planned gestures, and these internal representations are accessible before the appearance of articulatory gestures. The existence of anticipations and perseverations supports this theory. The serial order errors can be explained by bidirectional activation spreading (Dell et al., 1997; Vousden et al., 2000).

Self-monitoring is responsible for identifying potential speech errors both during speech planning and execution. Speakers monitor their own speech through two routes, an external and an internal monitoring route. The perceptual loop theory explains both internal and external monitoring on the one hand, and provides explanations for monitoring failures, on the other (Levelt, 1983, 1989, 1992; Caramazza et al., 1985; Postma, 2000; Gósy, 2007). During speech planning, linguistic units for the present are activated, then deactivated, making sure that past units do not remain active for a longer period than needed. If deactivation, for some reason, fails, perseveration takes place (Stemberger, 2009). Priming activates upcoming language units and is responsible for the linguistic future in speech. If this activation is too intensive for some reason, then the overactivated linguistic unit occurs earlier in time than it is needed, resulting in an instance of anticipation.

Anticipations occur more frequently than perseverations do in typically speaking adults' speech; however, perseverations are more frequent in young children's spontaneous speech (Stemberger, 1989; Wijnen, 1992). There were also more perseverations found in aphasic patients' speech where the proportion of anticipations was 32% (Schwartz et al., 1994; Prather et al., 1997). More perseverations than anticipations were found in Thai or in Mandarin among tone errors (Gandour, 1977; Wan, 2007).

Since serial order errors are relatively not too frequent in spontaneous speech, various experiments have been carried out to obtain data using tongue twisters, manipulated sentences, perceived (collected) errors, etc. (cf. Fromkin, 1971; Shattuck-Hufnagel, 1979; Meijer, 1997; Wilshire, 1999; Nooteboom, 2005; Nooteboom & Quené, 2008). To our knowledge, there are no results based on spontaneous speech data and reporting on the time that elapses between the two productions of the linguistic units in serial order errors. The aims of the present paper were to (i) study the frequency and nature of

anticipations and perseverations in Hungarian and (ii) seek answers for the temporal properties of monitoring, and to (iii) find evidence for an explanation involving either an activation or timing planning problem or a monitoring failure (or possibly all of these) behind the errors analyzed. Our hypothesis was that improper activation spreading and failure of the inhibitory mechanism of activation can be shown by a temporal analysis of the errors.

MATERIAL, METHODS, SUBJECTS

Anticipations and perseverations were analyzed in the spontaneous speech samples of 27 native speakers of Hungarian (12 females and 15 males, mean age 40). The speech samples were randomly selected from BEA, the Hungarian Spontaneous Speech Corpus. BEA (*BEszélt nyelvi Adatbázis* 'spoken language data base') has been designed to record the state of present-day spoken Hungarian by collecting large amounts of recorded spontaneous speech produced by various speakers in Budapest. Each subject was recorded in the same sound-attenuated room using a unidirectional high-quality microphone and a digital recorder connected to a computer. The recording environment and the technical facilities were the same in all cases. Recorded speech materials contain various types of spontaneous speech (narratives, story recalls, comments on a particular topic, repetitions of sentences of various lengths, reading aloud, and a three-member conversation in each case (for further information see http://www.nytud.hu/adatb/bea/index.html)).

An average of 25 minutes of spoken language of each participant, altogether 13.5 hours of recordings were analyzed. Speakers addressed a variety of topics, including everyday life, work, hobbies, and opinions on current affairs.

The criteria of identification of anticipations and perseverations were as follows: (i) two productions of the same word or part of a word occurred in the utterance, (ii) the identified serial order errors had a clear directionality, (iii) one of the productions was unequivocally triggered by the other one. If the two productions met these criteria on the surface, they were identified as a serial error appropriate for our analysis. If the first production seemed to be unintentional considering the syntactic, morphological, prosodic and semantic structures of the utterance, the error was identified as anticipation. If the second production seemed to be unintentional (considering the syntactic, morphological, prosodic and semantic structures of the utterance again), then the error was identified as perseveration. All the three authors identified the serial order errors separately, and in cases of rare disagreement (less than 5% of all cases) two other colleagues were asked to judge the actual item. The recordings contained 150 anticipations and 77 perseverations. Single speech sounds, sequences of speech sounds, syllables and words will collectively be called 'linguistic units' in the text below.

There were three aspects to our analysis: (i) the nature of the linguistic unit in anticipations and perseverations (whether they were single speech sounds, fragments of words, or words), (ii) the word class of the anticipated or perseverated unit, and (iii) the temporal patterns of anticipations and perseverations. Word classes of linguistic units were classified based on the Hungarian word class system (Keszler, 2000), irrespective of whether the whole word or only a part of it was involved in anticipations or perseverations.

The distances between the intended and the actual locations of the linguistic units involved in the two types of errors were analyzed. Two methods were used for determining the distance, using the number of speech sounds and the time between the two productions. The distance in speech sounds was determined by counting them between the originally intended place of the linguistic unit and its earlier or later occurrence. In the case of anticipations, the first sound counted was the first sound following the preposed element. The last sound of the distance counted was the sound preceding the intended location of the element. For example: ***műsz*** *így van* ***műsz****akilag* '**tech** this is the case **tech**nically'. There is a distance of 5 speech sounds between the actual and the intended location of the unit involved. In perseverations the first sound counted was the first sound following the original unit while the last sound counted was the first speech sound of the reappearing unit. For example: *tehát ez* ***rende****s nyúlvadászat de* ***rende*** *igazi nyúlszőrrel* 'well this is a **norma**l rabbit shooting but with **norma** real rabbit hair'. Here, there are 13 speech sounds produced between the two units.

The temporal distance was determined by means of the measured data. The duration of the distance between the two productions in anticipations was measured between the last speech sound after the first realization of the anticipated unit and the beginning of the first speech sound of the unit in its intended location. The duration of the distance between the two productions in perseverations was measured from the end of the last speech sound of the first (intended) occurrence of the unit to the beginning of the first speech sound of the re-occurring unit. The distance between the two productions in anticipation will be called anticipatory distance while in perseverations it will be called perseveratory distance (cf. Figures 1 and 2 where *öh* marks filled pause /FP/, P = pause).

One of the authors initially identified anticipations while another one identified perseverations. All the three authors subsequently checked the data according to the criteria. Speech samples were annotated using the Praat 5.1 software (Boersma & Weenink, 2009). Linguistic units and anticipatory and perseveratory distances were defined manually by means of parallel visual control. To test statistical significance, an analysis of variance (one-way ANOVA) and *Chi*-square test were used (SPSS, version 14.0) as appropriate. In all cases, the confidence level was set at the conventional 95%.

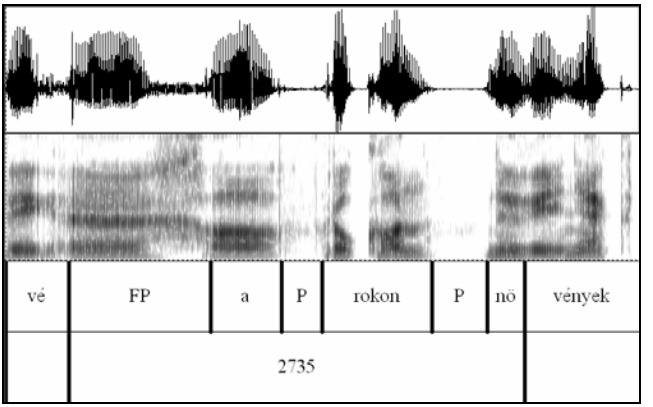

Figure 1. Determining the anticipatory distance in the example ***vé*** *öh a rokon nö****vé****nyek* [veː øh ɔ rokon nøveːɲɛk] '**an** er pl**an**ts in kinship'

Slika 1. Utvrđivanje anticipacijske udaljenosti na primjeru ***vé*** *öh a rokon nö****vé****nyek* [veː øh ɔ rokon nøveːɲɛk] '**an** er pl**an**ts in kinship'

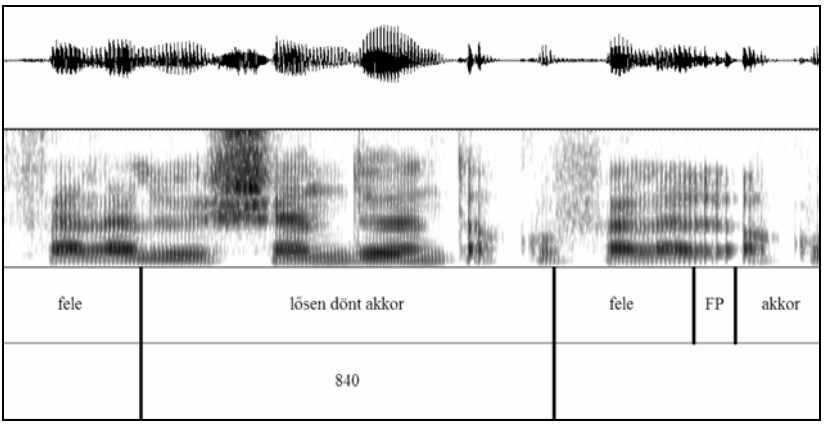

Figure 2. Determining the perseveratory distance in the example ***fele****lősen dönt akkor* ***fele*** *akkor* [fɛlɛløːʃɛn dønt ɔkːor fɛlɛ ɔkːor] '/he/ then decides with **resp**onsibility **resp** then'

Slika 2. Utvrđivanje perseveracijske udaljenosti na primjeru ***fele****lősen dönt akkor* ***fele*** *akkor* [fɛlɛløːʃɛn dønt ɔkːor fɛlɛ ɔkːor] '/he/ then decides with **resp**onsibility **resp** then'

RESULTS AND DISCUSSION

There were 5.5 anticipations and 2.7 perseverations on average in the individual speakers' spontaneous speech samples analyzed. Subjects showed a wide range of producing serial order errors (occurrences from 1 to 15). All speakers produced anticipations; however, there were 4 speakers who did not produce any perseveration at all. Taking the whole corpus into consideration, anticipations occurred every 5 minutes while perseverations occurred every 10.5 minutes. Anticipations were more frequent than perseverations, in agreement with previous data on Hungarian and other investigations (cf. Nooteboom, 1973; Garnham et al., 1981; Shattuck-Hufnagel, 1983; Dell et al., 1997; Gósy, 2003; Horváth, 2004).

Linguistic units in anticipations and perseverations

Three main categories were defined as to the nature of linguistic units: single speech sounds, fragments of words and one or more whole words. Single speech sounds can stand alone in the utterance irrespective of being anticipated or perseverated, or they can be inserted into a word. Seven of the speech sound anticipations (8.6%) took place within a word but only two (2.5%) word-internal cases were found among single-sound perseverations.

Examples for speech sounds standing alone:

Anticipation: *és őket* ***r*** *szak****r****endelő látja el* 'and they are attended to by a **k** special **c**[k]linic'

Perseveration: ***p****ohár borral vagy egy* ***p*** *korsó sörrel* 'with a **g**lass of wine or a **g** pint of beer'. Here, the consonant *p* was the initial speech sound of the word *pohár* 'glass' so it was classified as (part of) a noun.

Examples for speech sounds inserted into words:

Anticipation: *megoldható* ***j****a za****j****szűréssel* 'it can be solved by **l**oise fi**l**tration'

Perseveration: *t****á****t a sz****á****kt szakterületen belül* 'in sh**o**rt, within the sp**o** speciality'

Consonants were involved in perseverations in 42.6% while vowels were involved in 57.4% of all cases where single speech sounds were the linguistic units concerned. The proportion of consonants involved in anticipations was 62.02% while the proportion of vowels was 37.98%. Vowels seem to remain more active than consonants resulting in more perseverations of vowels than of consonants while consonants occur more frequently in anticipations than vowels do. More than half of the anticipations (53.3%) and even more of the perseverations (71.43%) involved single speech sounds. This means that a speech sound is executed earlier than planned in the anticipations while a speech sound is pronounced again somewhat later in the utterance in perseverations. Word initial speech sounds are supposed to be more controlled during covert monitoring than in overt monitoring (Wheeldon & Morgan, 2002). Initial speech sounds were found to be repaired to a greater extent in Spanish disfluencies as

opposed to non-initial ones (Pérez et al., 2007). The analysis of the participation of initial and non-initial speech sounds in serial order errors shows that there is a great difference depending on the items being either anticipated or perseverated. Anticipations involve a similar amount of initial (50.6%) and non-initial speech sounds (49.4%). However, non-initial speech sounds occur in perseverations more frequently, in 72.7% of all cases in our material. This means that non-initial speech sounds are more likely to be perseverated while there is no such difference in the occurrence of initial vs. non-initial speech sounds in the anticipations. If we accept the hypothesis that initial speech sounds are more controlled, then we can conclude that covert monitoring inhibits the re-articulation of the initial sounds more successfully than those of non-initial ones. However, this is not the case with anticipated speech sounds. We can assume that covert monitoring is more sensitive to what has been articulated than to what is going to be articulated.

Speech was halted after articulating a single speech sound similarly in anticipations (45%) and in perseverations (41.7%). The proportion of word fragments was somewhat larger in anticipations (33.3%) than in perseverations (22.09%) in our corpus. The majority of all word fragments in both types of analyzed errors preserved the initial parts of the words (92% of all word fragments in anticipations and 88.2% of all word fragments in perseverations). 66.7% of all initial parts perseverated were the first syllables or parts of the first syllables while 65.2% of all initial parts anticipated were the first syllables or parts of the first syllables. These data suggest that the initial parts of the words either are more activated or their monitoring is more successful (or both) than the non-initial or final parts of the words.

Word fragments were divided into two subgroups based on the completeness of their syllables. One subgroup contained a complete syllable or string of syllables of the intended word while the other subgroup contained a syllable that did not follow the syllabification of the word in question. The proportion of word fragments that did not follow syllabification was lower in anticipations (56% in anticipations and 70.6% in perseverations). This difference shows that anticipation errors follow the so-called 'mental syllabary' more precisely (cf. Levelt & Wheeldon, 1994). Based on experimental results it is assumed that articulation cannot start before the completion of phonological word encoding, but it can start after phonetic encoding of the first syllable of a disyllabic word (Cholin et al., 2006). In line with this assumption, the large proportion of incomplete syllables in anticipations and particularly in perseverations can be explained by the process of covert monitoring. Covert monitoring spots the serial order error before phonetic encoding is completed, and arrests the articulation independently of the syllabification of the phonological word.

Examples for subgroups of word fragments:

Anticipation (i) respecting syllabification: *jön a **szon** a kollégája az autótól a **szon**dával* 'comes the **breth** his colleague from the car with the **breath**alyzer'

(ii) contra syllabification: *akkor **kirúga** hát most egyszerűbb **kirúga**tni magadat* 'then **lay off** well now it is easier to get yourself **laid off**'. (The form ending in a complete target syllable would be *kirúgat*.)

Perseveration (i) respecting syllabification: ***kö**zépiskolában van magyar iskola igen a barátom az végig **kö** magyar iskolába járt* 'among the **sec**ondary schools there are Hungarian schools yes my friend learned in a **sec** Hungarian school',

(ii) contra syllabification: *be kellett volna **fordu**lni és hát még a lámpánál le**fordu** fulladt* 'we should have **tur**ned and well at the traffic light he **tur** throttled down'. (The form ending in a complete syllable would be *fordul*.)

In our corpus there was no suffix among perseverations while one suffix could be found among anticipations: *magá**ról** a békávé**ről*** 'about the BKV itself' (BKV is the abbreviation of Budapest Public Transport Company). In this example, vowel harmony is disrupted; the required suffix for *magáról* would have been *-ról* (the suffix alternant with the velar vowel instead of the one with the palatal vowel). The speaker did not repair the apparent error. It is likely that listeners are sensitive to moving suffixes although they are not really frequent in spontaneous speech.

Words are more prone to occur (and go unnoticed) in anticipations than in perseverations. An anticipated linguistic unit may better escape the monitoring system if it is a word. Figure 3 shows the proportions of various linguistic units occurring in anticipations and perseverations.

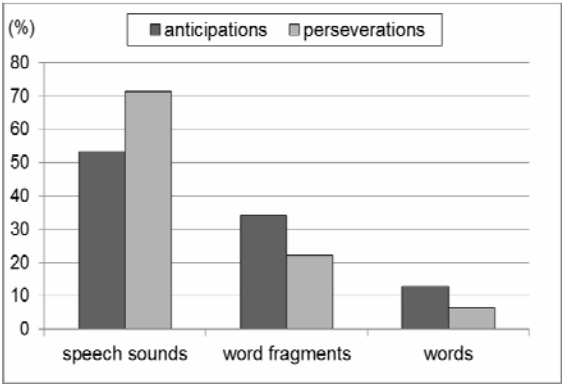

Figure 3. The distribution of linguistic units in anticipations and perseverations in spontaneous speech samples

Slika 3. Distribucija jezičnih jedinica u anticipacijama i perseveracijama u uzorcima spontanoga govora

One single word was anticipated or perseverated in general while there were some cases when more than one word moved ahead. There were no items involving several words in perseverations. Words may occur as units of serial order errors for another reason: when the anticipated or perseverated items result in meaningful words. Coincidentally meaningful words were found in 12.7% of the cases in anticipations and in 15.2% of the cases in perseverations.

Examples of word anticipations and perseverations.

Anticipation: *ha látod **rögtön** aki mondjuk bliccelni szokott az **rögtön** leszáll* 'if you see **at once** who say often dodges the fare gets off **at once**'

Perseveration: ***még** beszéljek-e vagy ennyi **még** elég ennyi már elég volt* 'shall I **still** go on speaking or this was **still** enough this was enough already'

The various classes of words were analyzed both in anticipations and perseverations in terms of whether they show similar occurrence depending on the direction of the serial errors. Only the content word classes are given in Figure 4 (with the exception of numerals because of their low rate of occurrence).

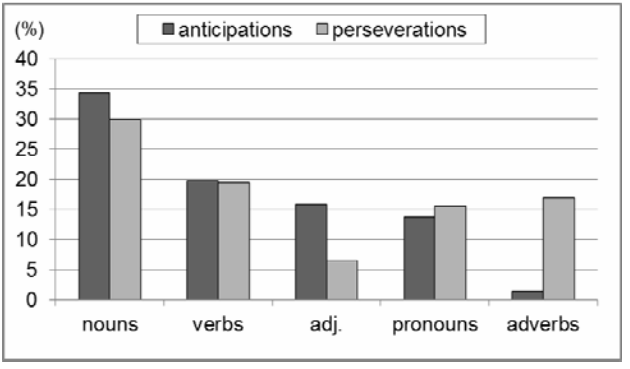

Figure 4. Word class distributions in anticipations and perseverations
Slika 4. Distribucija vrsta riječi u anticipacijama i perseveracijama

The most frequent word class both in anticipations and perseverations was that of nouns, followed by verbs, pronouns, adjectives, and adverbs. There were three word classes for which large differences were found between anticipations and perseverations. Adjectives occurred twice as frequently in anticipations than in perseverations while adverbs and conjunctions were involved in perseverations more frequently than in anticipations (conjunctions in anticipations: 0.7%, conjunctions in perseverations: 5.2%). Analyzing the occurrences of content and function words, we found no differences in this respect between anticipation (content words: 76.6%, function words: 23.4%) and perseveration (content words: 72.6%, function words: 27.4%). These findings suggest that the words being content or function words does not affect the occurrence of serial order errors.

Anticipatory and perseveratory distances

We assume that the time elapsing between the two productions of the same linguistic unit shows the activation of the intended unit. In the case of anticipations this is the effect of the retrieved phonological word on speech planning resulting in its earlier appearance. In the case of perseverations, on the other hand, this is the effect of the pronounced word on speech planning resulting in its re-appearance. These effects were expressed (i) in the number of intervening speech sounds and (ii) in measured durations. Independently of the type of linguistic unit involved, anticipated elements moved forward by an average distance of 10.02 speech sounds (std. dev.: 9.67), while perseverated elements re-appeared at an average distance of 11.81 speech sounds (std. dev.: 10.43). The shortest distance contained one speech sound, the longest contained 61 speech sounds in anticipations while immediate repetition (0 speech sounds) as shortest and 53 speech sounds as longest distance were found in perseverations (Table 1). There was no significant difference in the distance values between anticipations and perseverations expressed in the number of speech sounds.

Table 1. Anticipatory and perserveratory distances of the linguistic units measured in speech sounds

Tablica 1. Anticipacijske i perseveracijske udaljenosti jezičnih jedinica mjerene brojem glasnika

Descriptive data	Speech sounds		Word fragments		Words	
	anticipa-tion	persevera-tion	anticipa-tion	persevera-tion	anticipa-tion	persevera-tion
mean	7.51	8.81	11.28	19.64	17.42	* (19.64)
minimum	1	0	2	6	2	14
maximum	28	41	61	53	61	25

*Low number of items.

Perseverated linguistic units have larger effects expressed in speech sounds than anticipated linguistic units do. We assumed that in speech planning longer linguistic units or even words were capable of bridging longer distances than speech sounds. Our assumptions were supported by the data. In speech sound anticipations, the anticipatory distance was 7.51 speech sounds on average while the distance in perseverations was 8.81 speech sounds, on average. Both anticipatory and perseveratory distances increased when word fragments were involved. The distance here was 11.28 speech sounds on average in anticipations and 19.64 speech sounds on average in perseverations. Anticipatory distances in word anticipations were the longest (17.42 speech sounds on average). The distance of words was not longer than that of the word fragments in perseverations (19.64 speech sounds on average) but there were only a very low number of items for word perseverations.

Both in anticipations and perseverations, the higher the level of planning involved the longer the anticipatory and perseveratory distances. From the aspect of monitoring this means that the more speech sounds are involved in the anticipations and in the perseverations, the longer the distance is between the two productions of the linguistic unit. Statistical analysis confirmed that both anticipatory and perseveratory distances expressed in speech sounds show significant differences depending on the linguistic units involved (one-way ANOVA for anticipations: $F(2, 149) = 3{,}712$; $p = 0.0004$; for perseverations: $F(1, 73) = 10{,}067$; $p = 0.001$). Due to the low number of words, the statistical analysis was conducted in perseverations for speech sounds and word fragments only.

The average duration of anticipatory distance was 837 ms (std. dev.: 758) while that of perseveratory distance was 1083 ms (std. dev.: 1017). The shortest distance in anticipations was 50 ms while the longest one was 3451 ms. The shortest distance in perseverations was 24 ms while the longest one was 4884 ms. The durational data of distances between anticipations and perseverations showed significant differences ($F(1, 226) = 4{,}225$; $p = 0.041$). Perseverations seem to show larger ranges than anticipations (see Fig. 5 and Table 2).

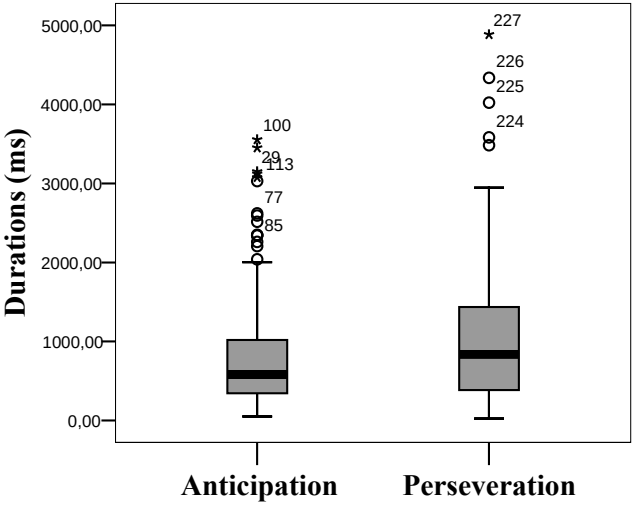

Figure 5. Durations of the distance between two productions of the same linguistic unit in anticipations and perseverations

Slika 5. Vremenska udaljenost između dvaju ostvarenja iste jezične jedinice u anticipacijama i perseveracijama

Table 2. Anticipatory and perseveratory distances of the linguistic units measured in ms

Tablica 2. Anticipacijske i perseveracijske udaljenosti jezičnih jedinica mjerene u milisekundama

Descriptive data	Speech sounds		Word fragments		Words	
	ant.	pers.	ant.	pers.	ant.	pers.
mean	640	911	1050	1751	1467	*(1522)
std. dev.	578	911	142	290	1825	465
minimum	50	24	148	532	146	991
maximum	3149	4884	4495	4336	3451	1630

*Low number of items.

Both the durations of speech sound anticipations and perseverations as well as word fragment anticipations and perseverations differed significantly from each other (in the case of speech sounds: $F(1, 130) = 4{,}322$; $p = 0.040$ and in the case of word fragments: $F(1, 66) = 5{,}372$; $p = 0.021$), cf. Figure 6. Perseverations have greater effects than anticipations.

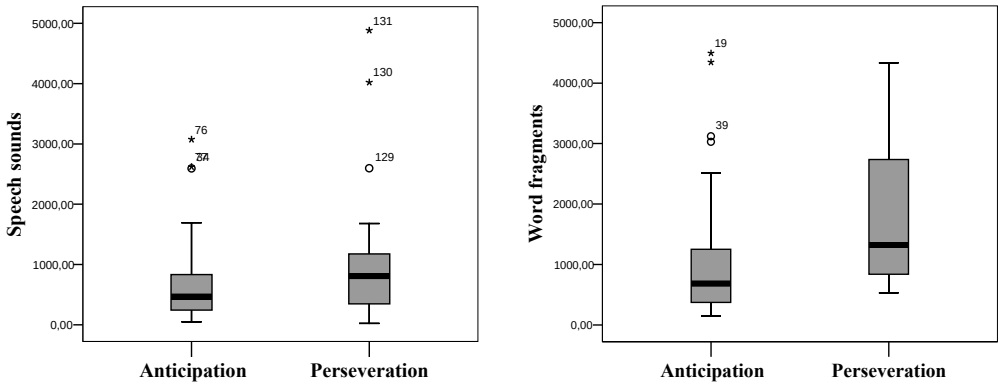

Figure 6. The means and ranges of the anticipatory and perseveratory distances of speech sounds and word fragments (in ms)

Slika 6. Srednje vrijednosti i rasponi anticipacijskih i perseveracijskih udaljenosti glasnika i dijelova riječi (u milisekundama)

The measured data support the claim that word fragments have a greater anticipatory effect than speech sounds, and words have greater anticipatory effects than word fragments. The more complex a linguistic unit, either formally or semantically, the longer the distance it can bridge. A speech sound can be anticipated about 700 ms earlier than planned (on average), whereas a whole

word can move forward about 1400 ms, on average. Statistical analysis showed a significant difference depending on the durations of the linguistic units in anticipations (one-way ANOVA: $F(2, 149) = 6{,}493$; $p = 0.002$); however, post-hoc Tukey's tests revealed significant differences only between the durations of speech sounds and words ($p = 0.001$). In the case of perseverations, the distance between the two productions of speech sounds and word-fragments was analyzed. One-way ANOVA revealed a significant difference in the perseveratory durations between these two linguistic units ($F(1, 72) = 11{,}073$; $p = 0.001$). A single speech sound can reappear at a distance of about 900 ms (on average) after its first production, whereas a word fragment can be re-pronounced about 1700 ms later (on average).

The durations of the two subtypes of word fragments (complete syllables and incomplete syllables) were analyzed depending on their syllabification. The results are similar in anticipations and in perseverations. Complete syllables show longer anticipatory distances (mean = 1140 ms, std. dev.: 243) than incomplete syllables (mean = 898 ms, std. dev.: 170) but the difference between them is not significant. The perseveratory durations are longer in the case of complete syllables (mean = 2505 ms, std. dev.: 1429) while they are shorter in the case of incomplete syllables (mean = 1340 ms, std. dev.: 799) but the difference is not significant here, either.

The mean duration for the anticipatory distances for nouns is 682 ms, for adjectives 566 ms, for pronouns 1049 ms, for verbs 1173 ms, and for articles 2068 ms. (Other word classes had a low number of items.) The mean value of perseveratory distances for nouns is 1140 ms, for adverbs 715 ms, for pronouns 998 ms, and for verbs 1487 ms. The ranges are large in all cases (Fig. 7).

Statistical analysis revealed that word class is a significant factor in relation to anticipatory distance (one-way ANOVA: $F(12, 149) = 2{,}008$; $p = 0.028$). Detailed analysis was carried out in groups where the number of elements made it possible. Significant differences were found between nouns and verbs ($F(2, 71) = 6{,}714$; $p = 0.012$), between nouns and pronouns ($F(2, 68) = 7{,}009$; $p = 0.010$), and between verbs and adjectives ($F(2, 46) = 6{,}345$; $p = 0.014$). In the case of perseverations there were no significant differences in durations depending on word classes. However, the distribution of the data was confirmed not to be random (*Chi*-square $(8, 77) = 45{,}610$; $p = 0.001$). The distances between the two productions of the intended linguistic units in perseverations were longer for nouns and verbs while they were shorter for pronouns and adverbs. Comparing the distances of word classes between anticipations and perseverations, only nouns turned out to be significantly different ($F(1, 56) = 5{,}247$, $p = 0.026$). Although there was no statistical difference in the distances of the two productions of function words between anticipations (mean: 804 ms, std. dev.: 846 ms) and perseverations (mean: 831 ms, std. dev.: 700 ms); statistically confirmed difference was found in the case of content words (mean for anticipations: 857 ms, std. dev.: 781 ms; mean for perseverations: 1160 ms, std. dev.: 1089 ms; one-way ANOVA: $F(1, 168) = 4{,}336$, $p = 0.039$), cf. Dell 1986, Howell 2007.

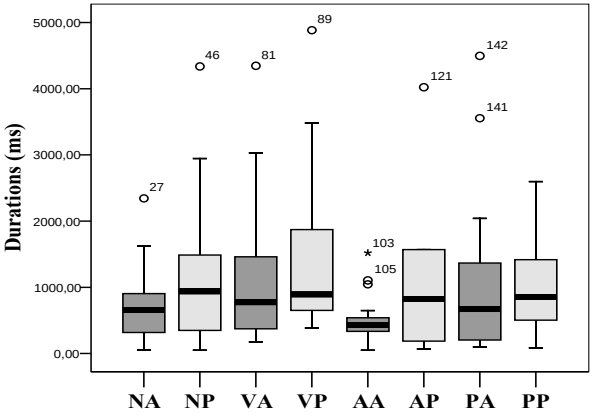

Figure 7. The durations of anticipatory and perseveratory distances as a function of word classes

Slika 7. Trajanja anticipacijskih i perseveracijskih udaljenosti s obzirom na vrstu riječi

(NA = anticipated nouns, NP = perseverated nouns, VA = anticipated verbs, VP = perseverated verbs, AA = anticipated adjectives, AP = perseverated adjectives, PA = anticipated pronouns, PP = perseverated pronouns)

(NA = anticipirane imenice, NP = perseverirane imenice, VA = anticipirani glagoli, VP = perseverirani glagoli, AA = anticipirani pridjevi, AP = perseverirani pridjevi, PA = anticipirane zamjenice, PP = perseverirane zamjenice)

Speech production models offer a variety of assumptions for both the reasons and sources of serial order errors (Dell, 1986; Garrett, 1988; Levelt, 1989; Roelofs, 1996; Dell et al., 1997; Vousden et al., 2000; Pouplier & Hardcastle, 2005; Vousden & Maylor, 2006,). Our results seem to support primarily the activation theory involving the failure of the self-monitoring system (cf. Hartsuiker et al., 2005). This improper activation leads to timing disturbances. In the case of anticipations there is an over-activation of a lexical item, resulting in an earlier pronunciation of the word or of part of it. In the case of perseveration there is an opposite phenomenon. The activated word is not deactivated appropriately after its pronunciation, resulting in a later re-appearance of the word or of some part of it. In the latter case there is a failure of the inhibitory process of activation.

It is likely that anticipations do not disturb the speakers' speech planning processes as much as perseverations do. Producing some part of an upcoming word is an unconsciously accepted error since it signals that the word to be pronounced is ready at hand. Although it is undesirable that an upcoming word is

pronounced earlier, it might help in quick lexical access in the originally intended place in the speech flow. The speakers might not be aware of such errors during speaking spontaneously. Re-appearance of any part of a word that was already produced seems to have a negative effect on the speaker's speech planning process. The speakers unconsciously judge them errors because they may be disturbing both in their covert speech planning and in execution.

CONCLUSIONS

In this paper we studied occurrences and temporal properties of two types of serial errors with opposite directions in spontaneous Hungarian speech. In our corpus, both anticipations and perseverations mostly involved speech sounds. We found a significant interrelation between the anticipatory/perseveratory distances and the lexical complexity of a given linguistic unit: the more complex a unit, the longer the distance it can move in anticipation, or it can re-appear in perseveration. The more speech sounds involved in serial errors, the longer the duration between the two productions. We can conclude that the self-inhibitory turn-off mechanism seems to be slower than the pre-planning mechanism in the case of speech sounds and word fragments. This is supported by the finding that the perseveratory effects were longer than the anticipatory effects. Our present findings provide a better view of the activation characteristics of linguistic units while spontaneously speaking on the one hand, and catch the monitoring characteristics in the act of dealing with serial order errors by means of measured data, on the other hand.

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NEPRAVILNA AKTIVACIJA I NEUSPJEŠNO NADZIRANJE U GOVORNOM PLANIRANJU

SAŽETAK

Govorna se proizvodnja ne nadzire samo tijekom trenutno izgovaranih odsječaka, već se nadziru i prošli i budući odsječci. Pogreške koje nastaju bilo zbog preranog (anticipacije) ili prekasnog (perseveracije) izgovora dokazuju da se tijekom govornog planiranja aktivira sadašnjost, deaktivira prošlost i priprema aktiviranje budućnosti. Cilj je ovog rada istražiti učestalost i fonetske karakteristike anticipacija i perseveracija u mađarskom. Ukupno je analizirano 227 pogrešaka slijeda u spontanom govoru 27 izvornih govornika. Akustička analiza napravljena je u programu Praat. Podaci su pokazali da jedinice višeg reda mogu biti pomaknute od planirane pozicije dalje od jedinica nižeg organizacijskog reda, dok se kod jedinica nižeg reda to događa češće. Samoinhibicijski sustav zaustavljanja čini se sporiji od sustava planiranja u slučaju glasnika i dijelova riječi. Analiza vremenskih parametara potvrdila je da mehanizam govorne proizvodnje uspješnije kontrolira planiranje.

Ključne riječi: *anticipacija, perseveracija, izmjerene udaljenosti, spontani govor*