THE WORD-ONSET EFFECT: SOME CONTRADICTORY FINDINGS

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ABSTRACT

In this paper we describe two experiments exploring possible reasons for earlier conflicting results concerning the so-called word-onset effect in interactional segmental speech errors. Experiment 1 elicits errors in pairs of CVC real words with the SLIP technique. No word-onset effect is found. Experiment 2 is a tongue-twister experiment with lists of four disyllabic words. A significant word-onset effect is found. The conflicting results are not resolved. We also found that intervocalic consonants hardly ever interact with initial and final consonants, and that words sharing a stress pattern are a major factor in generating interactional errors.

1. INTRODUCTION

Recently, in an investigation on interactions speech errors in spontaneous Dutch [1], two things were demonstrated:

(1) Interactional consonant substitutions only rarely cross between initial, medial and final positions in the word (see Fig. 1).

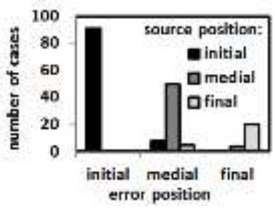

Fig. 1. Error frequencies as a function of source and error position in the word. Data from speech errors in spontaneous speech.

(2) Relative numbers of interactional segmental substitutions may be predicted rather accurately from the relative numbers of opportunities for phonotactically allowed interaction in different positions (see Fig. 2)

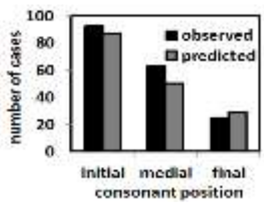

Fig. 2. Numbers. of consonant substitutions. in spontaneous Dutch in three positions. Predictions are made from relative numbers of opportunities for interaction.

Obviously, relatively many interactional consonant errors in spontaneous Dutch are in word-initial position, but this apparent word-onset effect (see Fig. 1) can be explained from the number of phonotactically allowed opportunities for interaction (Fig. 2): There are simply on average more onset consonants than other consonants in the immediate context.

However, tongue-twister experiments reported in the literature have shown a considerable and significant word-onset effect that, at least in the context of those experiments, cannot be explained from the relative numbers of opportunities for interaction for different positions, because those were kept equal. [2] found that in a tongue twister experiment focused on CVC real words no word-onset effect was found in sequences of four words, such as "leap note lap lute" but a considerable word-onset effect was found when such CVC words were embedded in phrases, as in "from the leap of the note to the nap of the lute". This result can perhaps be explained by the fact that in lists of CVC words there are equally many initial as final consonants, but in phrases there are many more initial than final consonants and therefore more opportunities for interaction between initial than between final consonants. But a result reported in [4] cannot be explained from numbers of opportunities. There, in a tongue twister experiment with lists of four CVC words, a considerable and highly significant word-onset effect was found for real words but no effect whatsoever for nonwords. The effect for real words conflicts with both the explanation from numbers of opportunities for interaction proposed in [1] and the data reported in [2]. In [3] some different tongue-twister experiments are described apparently demonstrating a considerable word-onset effect that cannot be easily explained from numbers of opportunities.

To explore possible causes for these contradictory findings, we have conducted two experiments eliciting interactional substitutions of single consonants. The first experiment was set up to elicit interactional substitutions of both the initial and the final consonant in CVC real words. The second experiment was a tongue-twister experiment with disyllabic words.

2. EXPERIMENT 1

In this experiment the classical SLIP technique was used, applying the phonological preparation of substitution errors by precursor word pairs. Targeted errors were either on the initial or on the final consonant. In Table 1 we present examples of how interactional errors on initial and final consonants might be elicited using the SLIP technique.

Table 1. Examples of stimuli eliciting word initial or word final interactions.

	word pair (onset cons.)	word pair (offset cons.)
precursor	kuip gif	giet poes
precursor	kiem goor	feit ros
precursor	kies gut	piet geus
precursor	koos gul	fat bes
precursor	kaai gaar	waad paas
target	gaan kaan	gaas gaat
prompt	?????	?????
response	*kaan gaan*	*gaat gaas*

The precursor word pairs are visually presented to the speaker one by one in the middle of a screen, and have to be read silently. The target word pair is also to be read silently, but is then followed by a series of ?????. This a prompt for the speaker to speak the target word pair aloud. Every now and then in the response the two initial consonants are exchanged. Ninety-four speakers, all students of Utrecht University, participated in the experiment. This method was used to elicit exchanges, anticipations and perseverations of initial and final consonants in CVC real words. Ninety-four speakers, all students of Utrecht University, participated in the experiment. The main results are given in Fig. 3.

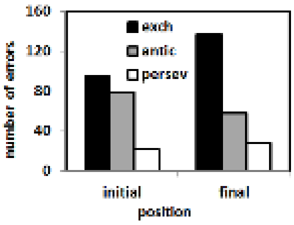

Fig. 3. Main results of Experiment 1. There is no significant difference between the numbers of interactional errors elicited in initial and final position.

The probability of an interactional error was analyzed by means of generalized linear mixed models (GLMM), using Markov Chain Monte Carlo simulations. The dependent variable was the binomial outcome of a response being an interactional substitution error or being a fluent and correct response. Other types of responses were ignored in the present analysis. Fixed effects were the position of the elicited error within the word, the direction of the elicited error, and the interaction of these two fixed effects. Subjects and items were included as random effects. For the current study, the interesting comparison is between the error rates for the initial and final positions. Overall, the error rates do not differ significantly between initial and final positions (*p*=.1854???). For elicited anticipations, there are fewer final errors than initial ones, but the difference is relatively small and not significant (*p*=.1854???). For perseverations, the error rates are approximately the same for initial and final consonants (*p*=.0557???). For elicited exchange errors, however, there are significantly *more* final errors than initial ones, i.e., fewer initial errors than final ones (*p*=.0141). This can perhaps be explained from the fact that final consonants tend to be more confusable than initial consonants [5], although it remains unclear why there are not more final than initial anticipations and perseverations. In any case, these data do not show a clear and significant word-onset effect. They resemble more the results reported by [2] than those reported by [4]. These latter results, showing a considerable and highly significant word onset effect for real words but not for nonwords, in a tongue twister experiment, remain as yet unexplained.

3. EXPERIMENT 2

This experiment was a replication of an experiment reported by [3] but with a twist. Table 2 gives examples of stimuli in [3].

Table 2. Example of stimuli quartets used in [3]. Targeted consonants share word onset and pre-stress position in B, word-onset position in W, pre-stress position in S and neither in N. Numbers of elicited targeted interactional errors are given in the right-most column.

	[3]. (1992)	NE
B	*p*ack *f*ussy *f*ossil *p*ig	**253**
W	*p*ad *f*orsake *f*oresee *p*ot	**132**
S	*p*in su*ff*ice su*ff*use *p*et	**75**
N	*p*od so*f*a su*ff*er *p*eg	**26**

Note that in [3] in conditions S and N interactions are elicited between initial and medial consonants. This probably artificially reduces the numbers of errors (cf. Fig. 1 above). Therefore in our experiment we used two sets of Dutch stimuli, one comparable to the stimuli in Table 2, the other with disyllabic words only, thus avoiding the confound with crossing positions.

Table 3. Examples of stimuli used in the current tongue twister experiment.

	stimuli as in [3]: 1vs2 syllables	stimuli with disyllables only: 2vs2 syllables
B	**w**ok **r**ápper **r**óeper **w**al	*w*áter *r*ápper *r*óeper *w*állen
W	**w**ad **r**appórt **r**apíer **w**ol	*w*óeker *r*appórt *r*apíer *w*íkkel
S	**w**in pa**r**íjs po**r**éus **w**el	be*w*íjs pa*r*íjs po*r*éus ju*w*éel
N	**w**it píe**r**en pá**r**el **w**as	la*w*áai píe*r*en pá*r*el ge*w*ín

As exemplified here, stimulus word pairs of the "2vs2 syllables" type were derived from those of the "1vs2 syllables" type. We have decided that such related quartets should not be presented to the same participant because this might be confusing. Therefore we created two lists of stimuli each with 12 quartets of the "1vs2 syllables" type and 12 quartets of the "2vs2 syllables" type, in such a way that for each quartet of the "1vs2 syllables" type the corresponding quartet of the "2vs2 syllables" type was in the other list and vice versa. Thus each list had 24 quartets and therefore 96 sequences of four words. There were 28 participants, 20 females and 8 males, all students of Utrecht University. Their age ranged from 18 to 26. Data from one participant (female, even-numbered) were lost due to technical malfunction. The analysis reported below is based on the remaining 27 participants.

Each speaker was tested individually in a sound-treated booth. He or she was instructed to repeat each sequence of words that appeared on the screen three times, then to push a button that made the stimulus disappear and to repeat the same sequence of words three more times from memory. The resulting speech from each participant was transcribed and coded separately for "1vs2 syllables" "stimuli and the "2vs2 syllables" stimuli. The source and error position of each interactional error was coded. There was quite some hysteresis in the sense that once a particular error was made, the participant tended to repeat that error during the six response utterances for that stimulus. Because of this we counted only the first of identical errors made to a stimulus. The errors were counted separately for the "visible" and "invisible" phase of the experiment. All interactional substitutions, targeted and not targeted, by exchange, anticipation and perseveration were counted.

Table 4 gives the main results for the targeted interactional substitutions only.

Table 4. Numbers of targeted single consonant substitutions separately for the "1vs2 syllables" and "2vs2 syllables" stimuli, for the visible and invisible part of the experiment, and for the four conditions B, W, S, N.

	1vs2 syllables				2vs2 syllables		
	vis	invis	sum		vis	invis	sum
B	32	85	117		47	80	127
W	18	35	53		19	32	51
S	8	14	22		20	38	58
N	4	4	8		3	12	15
sum	62	138	200		89	162	251

These data were fed into a mixed-effects logistic regression model (GLMM; Quené & Van den Bergh, 2008). Fixed effects were the condition (with N as baseline), 1vs2 syllables (baseline) versus 2vs2 syllables, and visible versus invisible (baseline). Random intercepts were included for participants and for stimulus quartets, and condition was included as a random slope between stimulus quartets (an extended model with random slope of condition between participants did not increase the model's performance). The three-way interaction between the fixed effects was not significant according to a likelihood ratio test (χ^2=6.9, df=3, *p*=.074), and it was therefore dropped from the model. The visibility factor does not interact with the condition factor and does not interact with the "1vs2 syllables" versus the "2vs2 syllables" factor (according to a likelihood ratio test, a simpler model from which these interactions were dropped performs equally well; χ^2=4.2, df=4, *p*=.38).

Two findings are remarkable: (1) There are more targeted interactional substitutions elicited by the "2vs2 syllables" stimuli than by the "1vs2 syllables" stimuli (*p*<.0001), but only in the B and S conditions. Consequently the distributions of interaction errors over conditions are significantly different for the "1vs2 syllables" stimuli and the "2vs2 syllables" stimuli. (2) There are significantly fewer targeted interactional substitutions in the visible phase of the experiment than in the invisible phase (p<.0001). When the participants do not see the four-word sequence on the screen they make more interaction errors. This suggests a memory problem. However, there is no interaction between visibility and condition.

Obviously, the distribution of the numbers over conditions is very different for the two sets of stimuli. This appears to be related to the fact that in the "1vs2 syllables" stimuli in two conditions targeted interactions involved two different positions in the word, whereas in the "2vs2 syllables" stimuli they did not. Therefore we refrain from further analysis of this data set and rather turn to the data set for the "2vs2 syllables" only. This time, however, we choose to include all valid interactional errors and not only the targeted ones.

First we want to see whether in this experiment interactional errors have the same resistance against crossing positions as found for errors in spontaneous speech by [1]. Fig. 4 gives the relevant data.

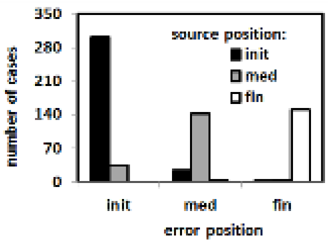

Fig. 4. Error frequencies as a function of the position of both error and source in the word. Data from Experiment 2.

Obviously, as in spontaneous speech, in this experiment also interactional errors have a strong resistance against crossing positions. Only 11 % of errors cross positions. We further analyze only cases for which source and error have the same position in the word.

Table 5 gives the breakdown over positions and conditions of all interactional substitutions for the "2vs2 syllables" stimuli.

Table 5. Numbers of single consonant substitutions for the "2vs2 syllables" stimuli, not crossing positions, for both targeted and not-targeted errors, collapsed over visible and invisible, and separately for the initial, medial and final consonant positions, and for the four conditions B, W, S, N. Positions targeted for interaction are printed in boldface. The highest number of each row is printed in italics.

	initial	medial	final	sum	fluent
B	***126***	55	73	254	456
W	***51***	13	11	75	481
S	*83*	**57**	28	168	462
N	*41*	**16**	38	95	476
sum	301	141	150	592	1875

Two things are immediately conspicuous:

(a) Overall numbers of errors differ considerably between conditions, also for consonants not targeted for interaction.

(b) The highest number of errors in each condition is in word-onset position, whether or not this is the targeted position.

In conditions B and S all 4 words in the tongue twisters share a stress pattern, viz. Sw in B and wS in S. This is not so in conditions W and N. Therefore we suspected that the enormous differences between conditions might have something to do with the sharing of stress patterns. We applied an analysis with a mixed-effects logistic regression model, and three different contrasts for the factor condition:.

(1) initial vs medial position (B & W vs S & N);

(2) sharing vs not sharing a stress pattern (B & S vs W & N);

(3) sharing Sw vs sharing wS (B & N vs W & S). Contrast (1) was insignificant (p = .347), contrast (2) highly significant (p < .0001), contrast (3) significant (p = 0307). Contrast (1) being insignificant suggests that targeting specific pairs of consonants does little to generate interactions between those consonants. This may come as a surprise to those dedicated to doing tongue twister experiments. Contrast (2) being highly significant suggests that activation of all segments of words in each other's immediate context that share a stress pattern is increased, as if by stress-pattern-based priming. Thereby their probability for interactions is increased. The stronger effect of Sw than of wS probably is related to the fact that Sw is by far the most common of the two stress patterns in Dutch.

We found a similar effect of stress pattern in spontaneous speech: In a collection of single segment substitutions there were same and different stress patterns in 151 and 169 cases respectively . Expected values based on stress pattern frequencies were 98 and 222. The distributions are clearly different (Fisher's exact test: p<.0001).

The above analysis could not investigate the effect of position in the word per se, independent of other contrasts, because this was not an experimental variable. However, a post hoc numerical logistic regression analysis with 1000 bootstrap replications over both speakers and matching stimulus sets and position as main variable clearly showed a significant word-onset effect in all 4 conditions (p < .05). This effect cannot be explained from relative numbers of opportunities for.

4. CONCLUSION

We have not succeeded in explaining the absence of a word-onset effect in spontaneous speech, other than caused by number of opportunities for interaction, in [1], and also in lists of real CVC words in [2] and the current experiment 1, as compared to the presence of a clear word-onset effect in CVC words in phrases in [2] and in lists of real CVC words in [4], and also in lists of disyllabic words in the current experiment 2. We stumbled over two major effects that were previously hardly known: (1) Intervocalic consonants do not interact with initial or final consonants. This means that at the level were interactional substitutions arise, there is no resyllabification. (2) There is a major effect, confirmed in spontaneous speech, of words sharing a stress pattern on the frequency of interactions.

5. REFERENCES

[1] Nooteboom, S.G. & Quené, H. 2015. Word onsets and speech errors. Explaining relative frequencies of segmental substitutions. *Journal of Memory and Language* 78, 33-46

[2] Shattuck-Hufnagel, S. 1987. The role of word-onset consonants in speech production planning: New evidence from speech error patterns. In: E. Keller & M. Gopnik (eds.) *Motor and sensory processes of language*. Hillsdale: Lawrence Erlbaum Associates, 17-52.

[3] Shattuck-Hufnagel, S. 1992. The role of word structure in segmental serial ordering. *Cognition, 42,* 213-259.

[4] Wilshire, C.E. 1998. Serial order in phonological encoding: an exploration of the ‘word onset effect’ using laboratory-induced errors. Cognition, 68, 143-166.

[5] Redford, M.A., Diehl, R.L. 1999. The relative perceptual distinctiveness of initial and final consonants in CVC syllables. *Journal of the acoustical Society of America* ***106***, 1555—65.