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The prosodic domain of phonological encoding: Evidence from speech errors

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ABSTRACT

Phonological encoding of segments is thought to occur within a prosodically-defined frame, but it is not clear which of the constituent/s within the prosodic hierarchy (syllables, phonological words, intonational phrases and utterances) serve/s as the domain of phonological encoding. This experiment investigated whether segmental speech errors elicited in tongue-twisters were influenced by position within prosodic constituents above the level of the phonological word. Forty-four participants produced six repetitions each of 40 two-intonational phrase tongue-twisters with error-prone word-initial “target” segments in phrase-initial and phrase-final words. If the domain of phonological encoding is the intonational phrase, we hypothesised that segments within a current intonational phrase would interact in more errors than would segments across intonational phrase boundaries. Participants made more anticipatory than perseveratory errors on target segments in phrase-initial words as predicted. They also made more perseveratory than anticipatory errors on targets in phrase-final words, but only in utterance-final phrases. These results suggest that the intonational phrase is one domain of phonological encoding, and that segments for upcoming phrases are activated while current phrases are being articulated.

1. Introduction

It has long been supposed that phonological encoding of segments takes place within prosodically-defined frames for words or phonological words (Levelt, Roelofs, & Meyer, 1999; Shattuck-Hufnagel, 1992). Models of phonological encoding are, however, underspecified with regard to the integration of phonological encoding and prosodic structure(s) above the level of the phonological word (Keating & Shattuck-Hufnagel, 2002). Current models of prosodic organisation propose a hierarchy of prosodic constituents including syllables dominated by phonological words or phrases, dominated by one or more types of intonational phrase, dominated by utterances (Shattuck-Hufnagel & Turk, 1996), but it is controversial whether constituents above the phonological word are activated prior to phonological encoding.

Levelt et al. (1999) suggested that phonological word structure is generated from phonological segments during phonological encoding, and that phrase-level prosodic encoding is generated subsequently (Levelt, 1981), a *segments-first* account of production. By contrast, Keating and Shattuck-Hufnagel (2002) argued that a default prosodic structure for an entire utterance is computed as soon as the words in the utterance and their surface structure are available, a *prosody-first* account. Segmental speech errors have been taken as evidence for a range of processes during phonological encoding (e.g. Dell, 1986). This

experiment looked for evidence that speech errors elicited in tongue-twisters are influenced by position within the intonational phrase or utterance, which would demonstrate the availability of these prosodic structures at the time of phonological encoding of segments and support a prosody-first account of phonological encoding.

Croot, Au, and Harper (2010, Experiment 2) elicited tongue-twisters in a laboratory study investigating whether prominence and position in the intonational phrase influenced segmental error rates. Error rates were lower on syllables carrying narrow informational focus, consistent with the availability of prosodic prominence at the time of phonological encoding of segments, but results with regard to prosodic constituency were less clear.

Choe and Redford (2012) elicited segmental errors in tongue-twisters of various lengths. They identified the boundaries of larger and smaller intonational units (intonational and intermediate phrases) in each spoken response, the locations of words containing errors within phrases, and whether errors were anticipatory or perseveratory. Error rate increased across phrases within utterances, except in utterance-final phrases, where the error rate was lower in final than in pre-final phrases. Anticipatory and perseveratory error rates on phrase-final words were similar across utterances, except in utterance-final phrases, where there was no upcoming material to anticipate and all errors were perseveratory. Choe and Redford proposed that these intonational units function as the domain of phonological encoding, with each unit

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receiving a jolt of activation that governs selection-by-competition of the elements within the unit via cascading activation through the levels of a spreading activation network. Because the initial jolt of activation decays over time, segments late in a unit are more vulnerable to error. Segments in words in phrase-final position would be particularly error-prone (yielding anticipations as well as perseverations) due to competing activation from segments associated with the upcoming phrase within an utterance. Their experiment did not, however, control for the possibility that participants paused during a tongue-twister once they had made too many errors, yielding intonational units that indexed error mechanisms, rather than errors that indexed the availability of intonational phrases prior to phonological encoding. Further, the probability of anticipatory versus perseveratory errors at boundaries was uncontrolled, because participants determined the boundary locations, thus the source of many errors could not be reliably established.

The present experiment tested the hypothesis that the intonational phrase is the domain of phonological encoding, by eliciting tongue-twisters that manipulated the position of word-initial confusable segments within intonational phrases within utterances, while controlling the probability of anticipatory versus perseveratory errors within and across intonational phrase boundaries. If the intonational phrase is the domain of phonological encoding of segments, there should be more errors with a source within the current intonational phrase than errors with a source in an adjacent (previous or upcoming) phrase, that is, more segment anticipation than perseveration errors on word-initial segments in phrase-initial words, and more segment perseveration errors than anticipation errors on word-initial segments in phrase-final words.

2. Material and methods

2.1. Participants

Forty-five undergraduate psychology students with English as a native language gave informed consent to participate for optional course credit. Data from one participant were excluded due to failure to comply with task requirements throughout the experiment, thus, data from 44 participants (12 male, mean age = 19.9, range 17–45) were analysed.

2.2. Stimuli

Stimuli were 40 tongue-twister items, each containing two 5-word clauses, designed to be elicited with the prosodic structure of two intonational phrases within an utterance, for example, “Deb will back Dave’s bet, Mum won’t burn moist beans”. Items were well-formed and generally meaningful, with some semantic anomalies due to rigorous criteria for selecting and positioning tongue-twister words. The parallel syntax in each half of each item increased the likelihood of the intonational phrase boundary occurring in the intended location, as people tend to divide utterances into prosodic phrases of equal length (Gee & Grosjean, 1983).

Each phrase contained a set of four monosyllabic, singleton onset “tongue-twister words,” and a number or function word, the purpose of which is explained below. Initial segments of the tongue-twister words were a “target segment” (henceforth ‘B’), and two “confusable segments” (‘A’ and ‘C’) that each differed from B on one distinctive feature and that were equally likely to participate in an error with B according to Shattuck-Hufnagel and Klatt’s (1979) segment confusability matrix. Two words beginning with A and two beginning with B were presented in alternating order in one phrase of the utterance, and two words beginning with C and two additional words beginning with B were presented in alternating order in the other phrase. In half the items (items in the phrase-initial word condition) the target segment B occurred at the beginning of the initial word in the phrase. In the other half (the items in the phrase-final word condition), B occurred at the

beginning of the final word in the phrase. Thus the structure of the word-initial-segments in the tongue-twister words in the phrase-initial word condition was $B_1A_1B_2A_2, B_3C_1B_4C_2$, and in the phrase-final word condition it was $A_1B_1A_2B_2, C_1B_3C_2B_4$ (underline shows target segments). Examples are “Guy’s debt guides one deal, Gay’s bag gains one buck,” (phrase-initial word condition) and “Deb will back Dave’s bet, Mum won’t burn moist beans” (phrase-final word condition).

The two conditions were designed to address two complementary questions. The first was whether errors in the production of target segment B in the phrase-initial word condition had their source within the current intonational phrase or the previous phrase. For example, in an item with the structure $B_1A_1B_2A_2, B_3C_1B_4C_2$, a C segment produced when a B was expected at the beginning of the second phrase would indicate an error source within the current phrase. An A segment produced here, by contrast, would indicate a source in the previous phrase. For example, in the erroneous production, “Guy’s debt guides one deal, [beiz] bag gains one buck,” the production of “[b]” instead of “[g]” in “Gay’s” is an anticipation error on the initial segment of a phrase-initial word in the phrase-initial word condition; an error sourced within the current intonational phrase. By contrast, a perseveratory error such as “Guy’s debt guides one deal, [deiz] bag gains one buck,” has a source in the previous intonational phrase.

The second question was whether errors in the production of target segment B in the phrase-final word condition had their source within the same intonational phrase or the upcoming phrase. For example, in an item with the structure $A_1B_1A_2B_2, C_1B_3C_2B_4$, an A segment produced when a B was expected at the end of the first phrase would indicate an error source within the current phrase, whereas as an erroneous C segment would point to a source in the upcoming phrase. For example, the following error “Deb will back Dave’s [dct], Mum won’t burn moist beans” has a source within the current phrase whereas this one, “Deb will back Dave’s [mct], Mum won’t burn moist beans” has a source in the upcoming phrase. In both conditions, a predominance of segment errors with their sources within the current intonational phrase would be evidence for the intonational phrase as the domain of phonological encoding.

Within items, tongue twister words were matched on median frequency and mean neighbourhood density (Balota et al., 2007), factors influencing speech error rates (Vitevitch, 2002), and were selected and positioned to control for lexical bias, whereby errors that result in words are more likely than those resulting in non-words (Baars, Motley, & MacKay, 1975; Dell & Reich, 1981). Tongue-twister words were also positioned to match the number of anticipatory and perseveratory errors resulting in words across phrase and utterance boundaries.

A function word, *will* or *won’t*, or a number, was included in each phrase because Croot et al. (2010) found lower error rates on syllables carrying narrow informational focus in intonational phrases. These words had initial segments selected for low probability of confusion with the A, B or C segments in Shattuck-Hufnagel and Klatt (1979). To prevent the phrase-level prominence confounding error rates associated with the tongue-twister words in prosodic positions of interest, one of the two number/function words in each item was elicited with narrow informational focus. Participants were asked to produce each item aloud in response to a given question, emphasising the number/function word that would answer the question. For example, participants were asked to answer the question, “*Will* Deb back Dave’s bet?” with the tongue twister “Deb will back Dave’s bet, Mum won’t burn moist beans,” emphasising the word “will.” Or to answer the question, “*Will* Mum burn moist beans?” with the response, “Deb will back Dave’s bet, Mum won’t burn moist beans.” Only the errors occurring in the intonational phrase elicited with narrow informational focus (that is, with control for the location of the phrase-level prominence) were analysed for each item; errors on the initial segment of the phrase-initial or phrase-final word in the other intonational phrase were discarded. The number/function words were positioned late in the phrase in the phrase-initial word condition items, and early in the phrase in the

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