

Metrical regularity modulates articulatory rate

Prosodic structure is known to influence utterance production in numerous ways, but the specific influence of repetition of metrical pattern on utterance production has never been investigated. This study compared productions of sequences of four trisyllabic nonwords in two conditions: a metrically regular condition with a repeating strong-weak-weak [sww] pattern, and a metrically irregular condition that lacked a repeating pattern. Speakers produced the utterance more slowly in the irregular condition and made more production errors. These findings are important because they are not readily accommodated by current models of speech production. It is argued that the effects of metrical regularity arise from interference between different prosodic structures, which is due to dynamical constraints on how prosodic structure is represented in the working memory of an utterance plan.

There are many factors that have been shown to influence speech articulation rate, such as position relative to prosodic boundaries, lexical frequency and familiarity, phonological neighborhood density, information status, and sociolinguistic context. This study explores the influence of a previously overlooked factor: metrical pattern regularity, which is the degree of consistency in the alternation of stressed and unstressed syllables in an utterance. For example, the utterance “Sally is hoping to travel to Canada” is more metrically regular than “Sally is avoiding a trip to Canada”. Both utterances contain the same number of stressed and unstressed syllables; however, the former exhibits a repeating trisyllabic pattern of stressed-unstressed-unstressed [sww] feet, while the latter exhibits a less regular pattern consisting of [swww], [sww], [sw], and [sww]. This paper describes two novel approaches to quantifying metrical regularity. One is based upon viewing the pattern of syllables as a Markov process and computing the 2nd-order entropy rate, with the result that regularity is associated with lower entropy, i.e. a greater degree of certainty in the stress of an upcoming syllable. The other approach views the utterance pattern as a collection of syllable oscillators coupled to foot oscillators in $n:1$ harmonic frequency-locking ratios, and derives a regularity metric from the order of n and its running variance.

It was hypothesized that when a sequence of words is planned in parallel, dissimilarity in their metrical structure would effect a form of interference in the preparation and execution of articulatory plans, which would be manifested in a slowing of articulatory rate and higher error rates in sequence production. A prepared speech task (Sternberg et al., 1978, 1988; Wheeldon & Lahiri, 1997, 2002) was used to test this hypothesis. On each trial, speakers were visually presented with a sequence of four nonsense words for 3 seconds, then they subvocally rehearsed those words for another 3 seconds, and when cued with a go-signal, they produced the target sequence as quickly and accurately as possible. The words varied in only two respects: initial consonant, $C\{m, n, p, k, s\}$; and stress pattern, [sww]—/'Citədə/ or [wsw]—/Cə'tidə/. The utterance-initial consonant of the sequence was always /m/ or /n/, while initial consonants of subsequent words were random permutations of /p/, /k/, and /s/. There were two metrical pattern conditions: regular (sww-sww-sww-sww) and irregular (sww-wsw-wsw-sww). 15% of trials were catch trials with no go-signal. 8 subjects participated, each performed approximately 150 trials in both conditions. Dependent variables analyzed were reaction time, utterance duration, word durations, and error/hesitation rates.

Metrically irregular patterns were associated with significantly higher error and hesitation rates than regular patterns, suggesting that metrically irregular sequences are maintained and/or retrieved from working memory with more difficulty. After removal of errorful and hesitatory trials, statistical analyses revealed that utterances were significantly slower in the irregular

condition, which supports the interference hypothesis. These results show that a previously unidentified factor—metrical regularity—influences speech articulation rate. This finding is significant because most current models of speech production predict no such effect. A dynamical model is presented in which interference between metrical patterns in the parallel planning of multisyllabic words effects a slowing of speech rate in execution.

References

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