Metrical Priming in Speech Production

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ABSTRACT

In this paper we report on four experiments in which we attempted to prime the stress position of Dutch bisyllabic target nouns. These nouns, picture names, had stress on either the first or the second syllable. Auditory prime words had either the same stress as the target or a different stress (e.g., *WORtel – MOtor* vs. *koSTUUM – MOtor*; capital letters indicate stressed syllables in prime – target pairs). Furthermore, half of the prime words were semantically related, the other half were unrelated.

In none of the experiments a stress priming effect was found. This could mean that stress is not stored in the lexicon. An additional finding was that targets with initial stress had a faster response than targets with a final stress. We hypothesize that bisyllabic words with final stress take longer to be encoded because this stress pattern is irregular with respect to the lexical distribution of bisyllabic stress patterns, even though it can be regular in terms of the metrical stress rules of Dutch.

1. INTRODUCTION

The stress pattern of a word could be stored in the lexicon or derived by rule. In psycholinguistic and linguistic theories we find different proposals as to which patterns are predictable hence derived, and which patterns are unpredictable hence stored.

Levelt and colleagues present the most prominent theory of phonological encoding to date ([1]; see also [2] and [3]). In this theory the metrical pattern of a word consists at least of the number of syllables and the location of main stress. The metrical pattern of a word is stored in the lexicon only if it deviates from the language-specific default rule for stress assignment, if such a rule exists for that particular language. In Dutch, the default stress pattern for bisyllabic words is initial stress. A lexico-statistical analysis (Schiller, unpublished) of the Dutch lexicon showed that more than 90% of the word tokens in Dutch are stressed on the first syllable in a word that can receive stress (schwa-syllables cannot be stressed in Dutch) ([4]; see also [5], [6]). All words with final stress are considered to be irregular, and have their stress pattern stored in the lexicon. In this account the distributional pattern determines whether a stress pattern is regular and derived or irregular and stored.

In linguistic theory the details of the Dutch stress system are still under debate. In the account of Trommelen and Zonneveld [7] bisyllabic words receive stress on the first syllable, except when the final syllable is a so-called super-heavy syllable, i.e. a syllable with a rhyme of the type VVC or VCC (where V stands for vowel and C stands for consonant). In that case, stress falls on the super-heavy final syllable. According to this theory, then, only words that carry stress on a final syllable that is not super-heavy are exceptional (e.g., *foREL* ‘trout’). These words have their stress pattern stored in the lexicon.

Booij [8] states that the different stress patterns in Dutch can be traced back to the different historical layers in the vocabulary of the language. There is a Germanic pattern, in which stress falls on the initial stressable syllable, a French pattern, with stress on the last syllable with a full vowel, and a Latin pattern, where stress falls on the antepenultimate syllable unless the penultimate syllable is heavy and attracts the stress. According to this account, what is stored in the lexicon is, presumably, whether a word belongs to the Germanic, French, or Latin stratum, but not the stress pattern of a word itself – unless it is exceptional within the stratum.

Departing from the assumption that information that is stored in the lexicon can be primed, the theories mentioned above make different predictions concerning the type of stress pattern that should be sensitive to priming. The general prediction is that there should be a priming effect for targets with exceptional stress, but not for targets with regular stress. In the psycholinguistic model, the stress pattern of all bisyllabic words with final stress is considered to be exceptional. Priming should thus be possible with bisyllabic targets with final stress. From the linguistic theory of Trommelen and Zonneveld [7] it can be deduced that stress priming should be possible with bisyllabic target words with final stress on a syllable that is not super-heavy. Booij’s theory [8] would only predict priming of targets that are exceptional within their stratum.

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Other assumptions about the type of information that is stored can be considered too. First, it could be the case that not only stored information, like exceptional stress, but also a computational rule such as "stress the first syllable of a word with a full vowel" [1] can be primed. This predicts a priming effect for both regular and exceptional stress words in Dutch. However, there might still be a difference in priming effects between stored information and rules. Second, one might assume – contrary to Levelt's model – that all metrical information is stored, whether regular or exceptional. This predicts priming effects of similar magnitude for both types of words. Our research question in the study was whether a) a metrical pattern could be primed and b) whether there was a difference between "stored" and "derived" metrical patterns.

2. THE EXPERIMENTS

We conducted four experiments in which Dutch native speakers named pictures of everyday objects. The experiments only differed in the stimulus onset asynchrony (SOA) between the visual target (picture) and the auditory prime. Thirty-nine black-and-white pictures corresponding to bisyllabic monomorphemic Dutch nouns were selected as targets. Twenty-four had stress on the first syllable, the remaining fifteen on the second. In addition, there were 156 bisyllabic auditory prime words. Half of the prime words had initial stress and the other half had final stress. Crossed with the stress manipulation was semantic relatedness, i.e. half of the primes were semantically related to the targets, half of them were unrelated. Semantic Relatedness was manipulated for control purposes, i.e. to show that prime words were processed by the participants. The prime words in all four conditions had approximately equal frequencies of occurrence, varying on average from 10.4 to 12.6 per one million word forms [9]. The primes were displayed via headphones before, simultaneously with, or after the visual onset of the picture on the screen. Participants were instructed to name the pictures as fast as possible and ignore the auditory prime words. Since similar results were obtained in all four experiments, we will only present the results of Experiment 1 in detail. The results of the other three experiments are presented more concisely, in comparison with the results of Experiment 1 [see also 10].

2.1 EXPERIMENT 1: SOA 0 MS

Nineteen native speakers of Dutch (all undergraduate students at Nijmegen University) took part in this experiment. Results revealed that targets with initial stress (670 ms) were named faster than targets with final stress (739 ms). This 69 ms effect of Target Stress was significant ($F_1(1,36) = 4.64$, $MS_e = 40917.11$, $p < .05$; $F_2(1,37) = 7.19$, $MS_e = 30678.22$, $p < .05$). The main effect of Semantic Relatedness was also significant ($F_1(1,36) = 16.84$, $MS_e = 1153.41$, $p < .01$; $F_2(1,37) = 19.40$, $MS_e = 918.59$, $p < .01$). Semantically related primes yielded longer reaction times (RTs; 704 ms) than semantically unrelated primes (686 ms). Furthermore, Semantic Relatedness interacted with Target Stress ($F_1(1,36) = 8.04$, $MS_e = 1153.41$, $p < .01$; $F_2(1,37) = 7.88$, $MS_e = 918.59$, $p < .01$). For targets with initial stress, the semantic interference effect was smaller (7 ms) than for targets with final stress (28 ms). This was especially due to one data point, i.e. the condition in which targets with initial stress were accompanied by prime words with final stress. In this condition, the semantic effect was 5 ms in the unpredicted direction (i.e. facilitation instead of interference). However, this might be due to the specific items in this condition. In Experiment 3, eleven of the auditory primes in one condition (semantically-related incongruent prime words paired with initial-stress targets) were changed in order to increase the chances of obtaining a semantic interference effect in that condition, and this indeed solved the problem. The factor Congruency describing the interaction between target and prime stress did not yield a significant effect itself (both *F*'s < 1), i.e. stress-congruent trials (692 ms) were on average not produced any faster than stress-incongruent trials (698 ms). However, Congruency interacted with Target Stress ($F_1(1,36) = 16.41$, $MS_e = 896.15$, $p < .01$; $F_2(1,37) = 13.99$, $MS_e = 926.45$, $p < .01$). When targets had initial stress, prime words with initial stress (660 ms) yielded faster RTs than prime words with final stress (689 ms). For targets with final stress, however, the situation was no different: Primes with final stress (748 ms) yielded slower RTs than primes with initial stress (730 ms; see Figure 1). The three-way interaction between Target Stress, Congruency, and Semantic Relatedness was not significant (both *F*'s < 1).

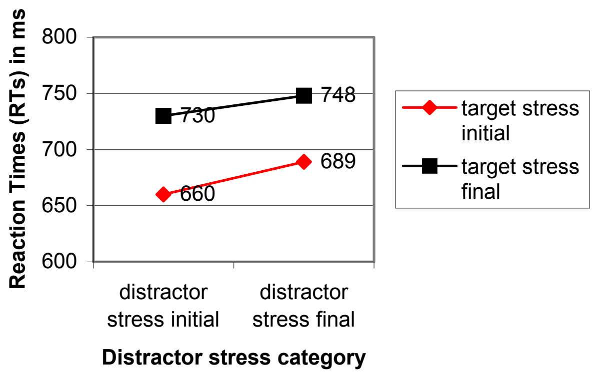

Figure 1. *RTs in Experiment 1.*

The results of Experiment 1 are relatively clear: No stress priming effect was obtained in this experiment. Although targets with initial stress were produced faster when accompanied with prime words of the same stress than when accompanied by primes of different stress, targets with final stress showed the reversed pattern.

2.2 EXPERIMENT 2: SOA –200 MS

In Experiment 2, we presented prime words 200 ms before picture onset. Participants can thus perceive the prime before starting the encoding process for the target word production. In Experiment 1 it might have been the case that when participants perceived the prime words, this was already too late to exert any effect on the naming of the

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targets because the planning of the naming response was already too far ahead. Presenting the prime word earlier might have the effect that the metrical structure gets primed and that the metrical pattern is pre-activated when it is needed for the production of the target. Thirty-four native speakers of Dutch from the same pool as described in Experiment 1 took part in Experiment 2.

The results from the Experiment 2 are very similar to those of Experiment 1. Again, no stress priming effect was obtained. Targets with final stress were produced faster when accompanied by prime words with initial stress than when accompanied by primes with final stress. Contrary to the first experiment, targets with initial stress showed no difference between prime words with initial and final stress in Experiment 2. As in the first experiment, targets with initial stress were named faster than targets with final stress.

2.3 EXPERIMENT 3: SOA +150MS

Prime words were now presented 150 ms after picture onset. According to Indefrey and Levelt [11], phonological encoding of a target picture name takes place between 275 and 400 ms after picture onset – possibly even later for the bisyllabic, low frequency picture names used in the current experiments. If the auditory prime words transfer information about their stress pattern fast and immediately to the phonological output system and if the decay rate of this type of information is also fast, it might be necessary to present the auditory prime after picture onset rather than before. Twenty-seven native speakers of Dutch from the same pool as described in Experiment 1 took part in Experiment 3.

The results of Experiment 3 replicate the results of the first two experiments, i.e. no effect of stress congruency between targets and primes was obtained. Furthermore, Target Stress played a significant role again, i.e. initial stress targets were produced faster than final stress targets. This effect of Target Stress was again in the range of 60-70 ms.

2.4 EXPERIMENT 4: SOA +300 MS

Twenty native speakers of Dutch from the same pool as described in Experiment 1 took part in Experiment 4. As in all previous experiments of this study, there was no stress priming effect. However, the initial vs. final stress advantage for targets remained, demonstrating the stability of the effect of Target Stress. The main effect of Semantic Relatedness was no longer significant (both *F*'s < 1). This was, in fact, expected because according to Levelt's model of speech production, conceptual/semantic encoding precedes all other encoding stages and is supposed to be finished in picture naming after the first few hundred milliseconds ([11, 12]).

3. GENERAL DISCUSSION

All four experiments yielded very similar results: Overall, there was no interaction between Target Stress and Prime Stress, i.e. no stress priming effect. However, strong and reliable semantic interference effects were obtained in three SOAs (–200 ms, 0 ms, and +150 ms), demonstrating that the primes were processed and had an effect on the naming latencies. Another interesting effect obtained in all four experiments is that targets with initial stress were named faster than targets with final stress. This effect of Target Stress was neither due to word frequency nor to a voice-key artifact nor did it have something to do with the recognizability of the pictures in the two stress conditions. However, it might be related to the low frequency of the stress pattern in the language, i.e. the distributionally irregular iambic stress pattern in Dutch. This merits further investigation.

Concerning the predictions made by different theories as to what type of stress pattern might be sensitive to priming, our present negative results have the following interpretation. The fact that we did not find any significant effect of priming could simply mean that stress is not stored in the lexicon, whether it is initial or final. This would undermine psycholinguistic theories in which stress on the final syllable is taken to be irregular, i.e. [1]. In theories based on linguistic accounts of stress assignment, only words ending in a stressed VV (e.g., *buREAU* 'desk') or VC (e.g., *foREL* 'trout') syllable are considered to be irregular. Unfortunately, in our experiments the bisyllabic target words with final stress all had – with one exception – super-heavy final syllables. These words are metrically regular. In further experiments metrically regular targets with final stress will be compared to metrically irregular targets with final stress. For now we propose that the computation of the language's predominant stress pattern is faster than the computation of the less frequent stress pattern, even though the less frequent stress pattern can be metrically regular [10]. This would be in agreement with Miceli and Caramazza's argument that the speech production system has a non-lexical mechanism for stress assignment at its disposal [13]. Until more definite results are obtained, our findings comply best with theories that claim that distributionally exceptional stress patterns are not stored in the lexicon.

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