THE EFFECT OF MISMATCHING SEGMENTAL INFORMATION ON THE MASKED ONSET PRIMING EFFECT (MOPE)

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ABSTRACT

We report two experiments investigating the masked onset priming effect (MOPE) in reading aloud. More specifically, we tried to provide an answer to the question of whether or not mismatching segments in the prime have an inhibitory effect on the MOPE. Dutch native speakers saw four-letter target words preceded by visually masked primes that either consisted of whole words or letters, and either matched or did not match the onset segment of the target. Prime exposure duration was varied between 33 ms and 66 ms to investigate the time course of the obtained effects. Whole-word primes behaved the same as letter primes at the short (33 ms) prime exposure duration, whereas at longer prime exposure (66 ms) effects of mismatching segments present in the whole-word but not in the letter primes led to slower overall naming latencies, suggesting that inhibition from segments beyond the onset needs time to build up.

Keywords: reading aloud, phonological encoding, grapheme-phoneme mapping, masked priming

1. INTRODUCTION

The process of reading aloud – taking a printed letter string as input and producing a fluent speech response – is a complex one, comprising many sub-processes (e.g. [2]). Evidence for the serial left-to-right processing in reading aloud comes from the so-called masked onset priming effect (hereafter MOPE) by Forster and Davis [4]. This effect refers to the finding that a masked prime that overlaps with a target word just in the onset segment (e.g., *save – SINK*) facilitates the naming of the target relative to a prime that has no overlap (e.g., *farm – SINK*). The use of the term "naming" instead of "reading aloud" here is deliberate since the MOPE has also been found when naming picture targets [15] as well as words and nonwords. In addition, the MOPE is found only in tasks that require naming of the target, but not in silent reading tasks like lexical decision [8, 10], and the beneficial effect of overlapping segments is position-dependent: the segments must be at the beginning and not the end of the word [7, 13].

Initially, the serial nature of the MOPE was interpreted by Forster and Davis [4] within a dual-route framework of reading aloud as having a locus in the non-lexical route, which is assumed to map a string of graphemes into a string of phonemes serially, from left-to-right, across the letter string. More recently, however, the MOPE has been taken to have its locus in the preparation of speech output [6], in particular, in the phonological encoding process [7, 8, 13, 14, 15]. There is ample evidence from speech production research that the insertion of phonemic segments into a metrical frame (called the frame-to-segment association process) occurs incrementally during phonological encoding, across the constituents [11]. The serial nature of the MOPE can be explained quite naturally in terms of the segment-to-frame association process.

Recent studies have used a slightly different procedure to measure the MOPE. The procedure used by Forster and Davis [4] in the original report of the MOPE and subsequently used by [7, 10, 12] is to compare whole-word primes that are unrelated to the target, and manipulate the overlap in the onset (e.g., *save – SINK* vs. *farm – SINK*). Alternatively, the MOPE has been studied by comparing a prime consisting of a letter matching the onset of the target followed by percent signs (e.g., *s%%% – SINK*) with a control prime consisting only of percent signs (e.g., *%%%% – SINK*), as was done by Schiller ([13], Experiment 3).

There are a couple of reasons why the effect produced by whole-word primes might differ from that produced by letter primes (compared to percent sign controls). One is that the effect found with a letter prime and percent sign control reflects a facilitative effect of the presence of a matching onset segment, but the effect found with whole word primes reflects a combination of facilitation due to a matching onset segment and interference due to a mismatching onset segment in the control prime. A second possibility is that the mismatching segments beyond the onset in the whole word primes produce additional interference. A third possibility is that the whole word primes carry more information other than segmental information that match (or mismatch) the target, for example, grapho-syllabic structure [1], i.e. the syllabic structure or the structure of syllabic constituents (onset, nucleus and coda).

Support for the third possibility was reported recently by [9]. The present study extends this line of research by investigating the first two possible differences between the two types of primes mentioned above, namely, those that relate to the role of segmental information in the MOPE.

Numerically, whole-word primes seem to produce a MOPE of a larger magnitude than letter primes, for example, the MOPE found with simple-onset targets 5 ms [13], whereas the MOPE found using whole-word primes was 14 ms [7]. However, this is based on comparison between experiments involving different participants and different stimulus materials (including language, Dutch vs. English). Here, we compare the two methods directly, in the same experiment.

2. EXPERIMENT 1A

Experiment 1A tested four types of primes: 1) whole-word primes with matching onset (e.g., *beer – BANK*), 2) whole-word primes with mismatching onset (e.g., *heer – BANK*), 3) a letter prime with matching onset (e.g., *b%%% – BANK*), and 4) a control prime consisting of percent signs (e.g., *%%%% – BANK*). The first two prime conditions were used by [7], and the latter two conditions were used by [13] to investigate the MOPE. If the size of the MOPE differs between the two ways of testing, this could be either because the effect found with whole word primes reflects a combination of facilitation and inhibition due to the match/mismatch of onset segments (rather than a facilitative effect of onset match indexed by the letter prime), or because of the effect of mismatching segments beyond the onset.

Prime duration was also manipulated (66 ms vs. 33 ms) in the present study to track the time course of these sources of difference. Whether or not the primes were truly subliminal has not been tested and is not relevant for the current purposes [3, 5]. An interfering effect of mismatching segments beyond the onset is likely to emerge only with a relatively long prime exposure duration (this is predicted by both a serial *grapheme-to-phoneme conversion* view and a serial phonological encoding view), whereas at shorter prime exposure duration only the initial segment may be able to exert an effect.

2.1. Method

2.1.1. Participants

Thirty-two undergraduate students from the Radboud University in Nijmegen in the Netherlands participated in this experiment in exchange for a small financial reward. All participants were native speakers of Dutch and had normal or corrected-to-normal vision.

2.1.2. Materials

Eighty monosyllabic, four-letter Dutch words were used as targets, which had CVCC or CVVC structure (e.g., *BANK*). There were four types of primes. Two of the prime types were whole words unrelated to the target word, with one type matched in onset (e.g., *beer* ‘bear’), and the other not (e.g., *heer* ‘mister’). The third type of prime consisted of a letter that matched the onset of the target followed by three percent signs (e.g., *b%%%*). The fourth type of prime consisted of four percent signs (e.g., *%%%%*).

2.1.3. Procedure

Participants were tested individually in a dimly lit, soundproof room. They were seated about 60 cm from a computer screen and asked to read aloud the words in capital letters as quickly and as accurately as possible. Target words appeared in white on a black background (Courier New, 24 pts.) on a computer screen and remained in view until a response was given or 1,000 ms had elapsed. Before the presentation of a target, a fixation point appeared for 500 ms in the middle of the screen on which participants were asked to fixate. Then a row of four hash marks (#'s) appeared for 500 ms as a forward mask and replaced the fixation point. Immediately afterwards, a prime was presented in lower case for 66 ms, followed by a backward mask for 17 ms, which was identical to the forward mask. The target word immediately replaced the backward mask. All stimuli were centered on the screen.

Participants were instructed to read the target words aloud as fast as possible while avoiding errors. Naming latencies (reaction times; RTs hereafter) were measured with a voice key from target onset. When a response was given, the next trial started after 1,000 ms. Trial sequencing was controlled by NESU (Nijmegen Experimental Set-Up). The presence of a prime was not mentioned to the participants.

2.1.4. Design

Each participant saw the four priming conditions equally often but a particular target word only once, i.e. each participant received eighty items, twenty target words per priming condition. The 32 participants were divided in four groups, each group receiving the same set of prime-target pairs randomized individually for each participant with the constraint that a particular priming condition could not appear more than twice in a row.

2.2. Results

The mean RTs and error rates are summarized in Table 1. RTs faster than 200 ms or slower than 1,000 ms (i.e. 0.2% of the data) were removed and counted as outliers. An ANOVA was run with Type of Prime (words vs. characters) and Presence of Matching Onset Segment (match vs. no match) as independent variables. Separate analyses were carried out with participants (F_1) and items (F_2) as random variables.

Naming latencies. Planned contrasts showed that the onset-matching whole-word condition (e.g., *beer – BANK*; 507 ms) was faster than the onset-mismatching whole-word condition (e.g., *heer – BANK*; 520 ms). This 13 ms difference was significant ($t_1(31) = 2.51$, $SD = 29.05$, $p < .05$; $t_2(79) = 3.32$, $SD = 39.68$, $p < .01$), indicating that a MOPE was observed with the whole word primes. Also, the 10 ms difference between the onset-matching letter prime (e.g., *b%%% – BANK*; 494 ms) and the percent control prime (e.g., *%%%% – BANK*; 504 ms) was significant ($t_1(31) = 3.28$, $SD = 17.07$, $p < .01$; $t_2(79) = 3.04$, $SD = 30.39$, $p < .01$), indicating that a MOPE was found using Schiller's [13] procedure. The interaction contrast (Presence of Matching Onset Segment x Type of Prime) was not significant ($F_1(1,31) < 1$; $F_2(1,79) = 1.01$, $MS_e = 377.89$, n.s.), indicating that there was no difference in the size of the MOPE tested using the two procedures. Finally, the 13 ms difference between the onset-matching letter prime (e.g., *b%%% – BANK*; 494 ms) and the onset-matching whole-word prime was significant ($t_1(31) = 3.30$, $SD = 22.36$, $p < .01$; $t_2(79) = 3.02$, $SD = 37.04$, $p < .01$). This indicated that the mismatching segments beyond the onset interfered with the naming of the target.

Table 1: Mean Naming Latencies (in Milliseconds) and Percentage Errors (in Parentheses) as a Function of Experimental Conditions for Experiments 1A and 1B

Experiment	Condition	Mean RT (and % errors)
1A (66 ms)		
	(beer – BANK)	507 (3.8)
	(heer – BANK)	520 (3.8)
	(b%%% – BANK)	494 (3.1)
	(%%%% – BANK)	504 (4.2)
1B (33 ms)		
	(beer – BANK)	478 (5.2)
	(heer – BANK)	494 (4.8)
	(b%%% – BANK)	483 (5.2)
	(%%%% – BANK)	489 (5.0)

Error rates. Participants made few errors in Experiment 1A. The overall error rate was 3.7% and the errors were distributed equally across conditions (see Table 1). Therefore, no formal analysis of the error rates was conducted.

3. EXPERIMENT 1B

3.1. Method

3.1.1. Participants

Another 32 participants from the same population as used in Experiment 1A took part in Experiment 1B for a small financial reward.

3.1.2. Materials, Procedure, and *Design*

Materials, Procedure, and Design were identical to Experiment 1A except for the prime exposure duration which was set to 33 ms in Experiment 1B.

3.2. Results

The mean RTs and error rates are summarized in Table 1. RTs faster than 200 ms or slower than 1,000 ms (i.e. 0.3% of the data) were removed and counted as outliers. The same analyses as in Experiment 1A were performed on the data.

Naming latencies. Planned contrasts showed that the onset-matching whole-word condition (e.g., *beer – BANK*; 478 ms) was faster than the onset-mismatching whole-word condition (e.g., *heer – BANK*; 494 ms). This 16 ms difference was significant ($t_1(31) = 4.54$, $SD = 19.80$, $p < .001$; $t_2(79) = 3.87$, $SD = 39.12$, $p < .001$), again reflecting a MOPE. The 6 ms difference between the onset-matching letter-prime (e.g., *b%%% – BANK*; 483 ms) and the percent-sign control prime (e.g., *%%%% – BANK*; 489 ms) was only significant by participants ($t_1(31) = 2.43$, $SD = 15.64$, $p < .05$; $t_2(79) = 1.39$, $SD = 35.47$, n.s.). The interaction contrast between Type of Prime and Presence of Matching Onset Segment was marginally significant ($F_1(1,31) = 4.38$, $MS_e = 153.99$, $p < .05$; $F_2(1,79) = 3.57$, $MS_e = 731.42$, $p = .06$). Unlike in Experiment 1A, the 5 ms difference between the onset-matching letter prime (e.g., *b%%% – BANK*) and the onset-matching whole-word prime (e.g., *beer – BANK*) was non-significant ($t_1(31) = 1.49$, $SD = 17.70$, n.s.; $t_2(79) = 1.38$, $SD = 38.19$, n.s.), indicating that the mismatching segments beyond the onset did not interfere with the naming of the target at 33 ms prime exposure duration.

Error rates. No formal analysis of the error rates (5.0 %) was conducted because the errors were distributed equally (see Table 1).

4. DISCUSSION

The results of Experiment 1A showed that at the 66 ms prime exposure duration, a MOPE was found with both whole word primes (e.g., *beer – BANK* vs. *heer – BANK*) and letter primes tested against percent-sign controls (e.g., *b%%% – BANK* vs. *%%%% – BANK*). The size of the MOPE did not differ between the two procedures, but the whole-word primes with matching onset were slower than the letter primes, indicating that the mismatching segments beyond the matching onset interfered with the naming of the target.

At the 33 ms prime exposure duration, a MOPE was present with whole-word primes although marginal for the letter primes tested against the percent-sign control primes. This is presumably due to the fact that the percent-sign control primes do not carry any information about the onset structure as well as the onset segment. An important difference between the two prime exposure durations was that whereas the whole-word and letter primes with matching onset segments (e.g., *beer – BANK* vs. *b%%% – BANK*) did not differ at the 33 ms, whole-word primes were slower than letter primes at the 66 ms prime exposure duration, suggesting that interfering effects of mismatching segments beyond the onset emerge only at longer prime exposure duration.

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