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Brief article

The masked onset priming effect in picture naming

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Abstract

Reading aloud is faster when targets (e.g., *PAIR*) are preceded by visually masked primes sharing just the onset (e.g., *pole*) compared to all different primes (e.g., *take*). This effect is known as the *masked onset priming effect* (MOPE). One crucial feature of this effect is its presumed non-lexical basis. This aspect of the MOPE is tested in the current study. Dutch participants named pictures having bisyllabic names, which were preceded by visually masked primes. Picture naming was facilitated by first-segment but not last-segment primes, and by first-syllable as well as last-syllable primes. Whole-word primes with first or last segment overlap slowed down picture naming latencies significantly. The first-segment priming effect (i.e., MOPE) cannot be accounted for by non-lexical response competition since pictures cannot be named via the non-lexical route. Instead, the effects obtained in this study can be accommodated by a *speech-planning account* of the MOPE.

Keywords: Masked onset priming effect; Phonological encoding; Speech planning; Language production; Picture naming

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1. Inroduction

One important question in reading aloud is: How are visually presented letter strings phonologically encoded for naming? Some computational models of visual word recognition assume that the phonology of words is computed in parallel from its orthography (e.g., Plaut, McClelland, Seidenberg, & Patterson, 1996; Zorzi, Houghton, & Butterworth, 1998), whereas others make the assumption of a serial component involved in translating a string of letters into a sound form (e.g., Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001).

One source of support for the seriality assumption of grapheme-to-phoneme conversion comes from the *masked onset priming effect* (MOPE). Using the masked priming paradigm, Forster and Davis (1991) found that one determinant of (word) naming latencies appears to be a shared initial segment. For instance, the prime-target pair *pole* – *PAIR* yielded shorter naming latencies than *take* – *PAIR*. This MOPE has been replicated several times in different laboratories and across a variety of languages (e.g., Grainger & Ferrand, 1996; Kinoshita, 2000; Kinoshita & Woollams, 2002; Schiller, 2004).

Forster and Davis (1991) accounted for the MOPE in terms of a *response competition hypothesis* within a dual route framework. Participants may begin to assemble at least the pronunciation of the initial segment upon presentation of the masked prime resulting in a competing tendency to pronounce the prime as well as the target. When prime and target have the same onset, the first segment of the target is already activated and can be named faster. In contrast, when they have different onsets, there is Stroop-like response competition between the prime's and the target's initial segments, leading to slower naming responses than in the onset-matching case. Forster and Davis observed this interference effect, however, only for stimuli whose pronunciation is strongly influenced by the non-lexical grapheme-to-phoneme conversion route, such as non-words and low-frequency words. Words whose pronunciation is lexically controlled, such as high-frequency and irregular words, did not show a MOPE (see Kinoshita, 2003 for a review). In Forster and Davis' dual-route account, the MOPE has its locus in the sequential computation of the target word phonology from its orthography. That is, it arises during grapheme-to-phoneme conversion and could be classified as an early phonological effect.

Kinoshita (2000) offered a different account for the MOPE, which has been referred to as the *speech-planning account* (see also Malouf & Kinoshita, in press). Kinoshita proposed that the locus of the MOPE is later than orthography-to-phonology conversion, i.e., at the level of phonological encoding of the speech response (see Levelt, Roelofs, & Meyer, 1999 for an overview). Phonological encoding is a serial left-to-right component of speech planning that comprises the processes from the retrieval of a lexical item to constructing its phonetic-articulatory form, including the selection of segments (phonemes), the retrieval or computation of metrical frames with lexical stress, and the construction of – possibly syllabic – output units. When prime and target share their onset, phonological encoding of the target is facilitated due to pre-activation of the initial segment compared to when prime and target have mismatching onsets (see also Schiller, 2004, in press). A similar account has been put forward by Grainger and Ferrand (1996) drawing a parallel between onset effects in reading aloud and the *initialness effect* reported for speech errors (i.e., the predominance of speech errors that involve word onsets; see Dell, Juliano, & Govindjee, 1993; Shattuck-Hufnagel, 1987). Grainger and Ferrand suggested that these two effects may have a common origin, i.e., articulatory output units.

To account for the absence of the MOPE for irregular words, and in a lexically contingent (go/nogo) reading-aloud task, in terms of the speech-planning account, Kinoshita and Woollams (2002) suggested that the effect may be eliminated whenever the initiation of articulation is delayed: for irregular words, it may be delayed because lexical and non-lexical routes arrive at conflicting pronunciations of the target, and in a lexically contingent reading-aloud task participants have to decide whether or not the target is a word before responding. That is, the absence of the MOPE under these circumstances can be accounted for by the speech-planning account. More recently, Malouf and Kinoshita (in press) obtained a MOPE for both low- and high-frequency words, failing to replicate Forster and Davis' (1991) finding of a frequency-dependent MOPE. This result supports the speech-planning account of the effect according to which target frequency should not play a role because the locus of the MOPE is presumably too late to be affected by lexical variables such as word frequency.

In the current study, I will test the presumed non-lexical basis of the MOPE (Forster & Davis, 1991) by introducing a new approach using targets that cannot be named via the non-lexical route, namely pictures. Picture naming is a complex cognitive process that entails at least the following steps: visual object recognition, conceptualization, lexical name retrieval, morpho-phonological encoding of the picture name, phonetic encoding, and articulation (for reviews see Glaser, 1992; Levelt et al., 1999). The predictions are straightforward: if the dual-route account (i.e., the response competition hypothesis) is correct, no MOPE should occur in picture naming because pictures can only be named via the lexical route. If, however, picture naming is facilitated by onset-related primes, this may be taken as further support for the speech-planning account of the MOPE.

2. Experiments: Picture naming with begin- and end-related masked primes

In order to name a picture, participants have to recognize and conceptualize the target picture. Then they have to retrieve the appropriate lexical entry, i.e., the picture name, from their mental lexicon. Since an articulatory response is required, participants must encode the picture name phonologically and phonetically. Thus, they must activate phonological representations, but they have no reason to activate orthographic representations. Therefore, picture naming cannot be influenced by the non-lexical route.

In addition to an onset-related and a control condition, a syllable and a whole-word condition as well as end-related conditions were included in the experiments to be able to demonstrate that a potential MOPE is different from other form-related priming effects.

2.1. Method

2.1.1. Participants

Two groups of 20 undergraduates from the Radboud University in Nijmegen took part in the experiments in exchange for a financial reward. All participants were native speakers of Dutch and had normal or corrected-to-normal vision.

2.1.2. Procedure

The procedure was similar to the one reported in Schiller (1998, 2004). Participants were seated about 60 cm from a computer screen in a dimly lit, soundproof room. Target pictures appeared as black-on-white line drawings and remained in view until a response was given or after 1000 ms had elapsed. Before the presentation of a target, a fixation point appeared for 500 ms centered on the screen. Then a forward mask (i.e., a row of eight hash marks, #) appeared for 500 ms and replaced the fixation point. Afterwards the prime was presented in lower case for 50 ms, followed by a backward mask for 17 ms, which was identical to the forward mask. The target immediately replaced the backward mask. The presence of a prime was not mentioned to the participants.

In earlier studies, prime visibility was formally assessed, and it was found that even in a picture naming experiment participants performed basically at chance level when trying to recognize the primes (see prime visibility tests reported in Schiller, 1998, p. 489). The current experiments were run in the same laboratory using the same equipment and prime exposure duration as the experiments reported in the Schiller (1998) study. Informal interviewing of the participants at the end of the present experiments revealed that some participants noticed some sort of flickering before the target picture appeared on the screen. However, nobody was able to identify the primes. Before and after the prime, percent signs ("%") were added until the prime matched the length of the masks (see examples below). This procedure was used to avoid additional flickering on the screen due to presentation of primes differing in length.

The experiments started with a picture presentation block: all pictures in the experiments were presented once with their corresponding names printed underneath. Then participants practiced naming the objects with their corresponding names in a practice block in which each picture was presented once in random order without any prime. After they finished the practice block, the experiment proper started. Participants were instructed to name the target pictures 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 1000 ms. Trial sequencing was controlled by NESU (Nijmegen Experimental Set-Up).

2.1.3. Design

There were two separate experiments, one to test begin-related primes and one to test end-related primes. Across the begin-related experiment, each target picture (e.g., BANAAN) was preceded by four primes: a first-segment (e.g.,

%b%%%%% – BANAAN), a first-syllable (e.g., %ba%%%% – BANAAN), a begin-related whole-word (e.g., %beroep% – BANAAN), and a control prime (e.g., %%%%%%% – BANAAN). The same targets (e.g., BANAAN) were employed in the end-related experiment, again preceded by four primes: a last-segment (e.g., %%%%%n% – BANAAN), a last-syllable (e.g., %%%naan% – BANAAN), an end-related whole-word (e.g., %robijn% – BANAAN), and a control prime (e.g., %%%%%%% – BANAAN). The total of 180 trials (45 words $\times$ 4 priming conditions) per experiment was divided into 4 blocks of 45 trials. In each block, each target appeared once and there was an approximately equal number of priming conditions. Order of blocks was varied across participants and blocks were randomized individually for each participant.

2.1.4. Materials

Forty-five black-on-white line drawings (taken from the Max Planck Institute's picture database) having monomorphemic, bisyllabic Dutch words denoting the corresponding objects were chosen as targets. The targets were pictures of the words used in Schiller (2004, Experiment 1). All targets referred to concrete nouns and were of low to moderate frequency (16.9 per one million word forms according to CELEX; Baayen, Piepenbrock, & Gulikers, 1995). First- and last-segment primes consisted of exactly the first and last segment of the picture name, respectively. Begin- and end-related whole-word primes were semantically unrelated to the targets and overlapped with them in the first or last segment, respectively, avoiding other segmental overlap. As first- and last-syllable primes, the first and second syllables of the target pictures' name were taken, respectively. Prime-target overlap in the first- and last-syllable priming condition was on average 43% and 51%, respectively. The complete list of targets and whole-word primes used in this experiment can be found in the Appendix.

2.2. Results

The mean naming latencies and error rates are summarized in Table 1. RTs faster than 200 ms or slower than 900 ms, i.e., 4.8% and 5.2% of the data in the begin- and end-related experiments, respectively, were removed and counted as outliers. An ANOVA was run with Type of Prime (segment, syllable, whole word, or control) as independent variable. Separate analyses were carried out with participants (F_1) and items (F_2) as random variables.

2.2.1. Naming latencies

In the begin-related experiment, the main effect of Type of Prime was significant ($F_1(3,57) = 84.32$, $MS_e = 276.73$, $p < .01$; $F_2(3,132) = 122.01$, $MS_e = 452.27$, $p < .01$). Compared to the control primes (639 ms), first-syllable primes (616 ms) yielded 23 ms faster RTs ($t_1(19) = 5.01$, $SD = 20.40$, $p < .01$; $t_2(44) = 5.12$, $SD = 30.27$, $p < .01$), and first-segment primes (632 ms) yielded 7 ms faster RTs ($t_1(19) = 2.41$, $SD = 13.32$, $p < .05$; $t_2(44) = 2.07$, $SD = 24.23$, $p < .05$). Whole-word primes (694 ms) were significantly slower than control primes (55 ms; $t_1(19) = 8.71$,

Table 1
Mean naming latencies (in milliseconds) and percentage errors (in parentheses) as a function of experimental conditions for both experiments

Experiment	Condition	Example	Mean RT (and % errors)	Mean priming effect (Control – Condition)
Begin-related				
	First-segment	(%b%%%%% – BANAAN)	632 (3.3)	7 (2.4)
	First-syllable	(%ba%%%% – BANAAN)	616 (3.3)	23 (2.4)
	Whole-word	(%beroep% – BANAAN)	694 (4.3)	−55 (1.4)
	Control	(%%%%%%% – BANAAN)	639 (5.7)	
End-related				
	Last-segment	(%%%%%n% – BANAAN)	634 (4.3)	−10 (0.6)
	Last-syllable	(%%%naan% – BANAAN)	607 (3.1)	17 (1.8)
	Whole-word	(%robijn% – BANAAN)	691 (4.4)	−67 (0.5)
	Control	(%%%%%%% – BANAAN)	624 (4.9)	

$SD = 28.53$, $p < .01$; $t_2(44) = 14.58$, $SD = 26.30$, $p < .01$). First-syllable primes yielded significantly faster RTs than first-segment primes (16 ms; $t_1(19) = 4.24$, $SD = 16.53$, $p < .01$; $t_2(44) = 3.54$, $SD = 29.63$, $p < .01$).

In the end-related experiment, the main effect of Type of Prime was also significant ($F_1(3,57) = 72.09$, $MS_e = 367.63$, $p < .01$; $F_2(3,132) = 118.58$, $MS_e = 515.17$, $p < .01$). Compared to the control primes (624 ms), last-syllable primes (607 ms) yielded 17 ms faster RTs ($t_1(19) = 3.46$, $SD = 22.76$, $p < .01$; $t_2(44) = 3.35$, $SD = 31.99$, $p < .01$). Last-segment primes (634 ms), however, were 10 ms slower than control primes ($t_1(19) = 3.33$, $SD = 12.79$, $p < .01$; $t_2(44) = 3.19$, $SD = 21.86$, $p < .01$). Whole-word primes (691 ms) were again significantly slower than control primes (67 ms; $t_1(19) = 9.95$, $SD = 29.91$, $p < .01$; $t_2(44) = 14.94$, $SD = 30.79$, $p < .01$).

2.2.2. Error rates

The overall error rate was 4.2% both in the begin- and end-related experiment. In the begin-related experiment, the main effect of Type of Prime was significant ($F_1(3,57) = 3.13$, $MS_e = 1.58$, $p < .05$; $F_2(3,132) = 3.70$, $MS_e = 0.59$, $p < .05$). The differences between the whole-word primes and both the control ($t_1(19) = 2.50$, $SD = 1.88$, $p < .05$; $t_2(44) = 2.61$, $SD = 1.20$, $p < .05$) and the first-segment primes ($t_1(19) = 2.06$, $SD = 2.28$, $p = .05$; $t_2(44) = 2.46$, $SD = 1.27$, $p < .05$) were – marginally – significant due to more errors in the former than in the latter condition.

In the end-related experiment, the main effect of Type of Prime was not significant ($F_1(3,57) < 1$; $F_2(3,132) = 1.32$, $MS_e = 0.79$, n.s.). None of the differences between the individual conditions was significant (all ts < 1.6) except for the difference between whole-word and last-segment primes, which approached significance ($t_1(19) = 1.75$, $SD = 2.04$, $p = .10$; $t_2(44) = 1.94$, $SD = 1.23$, $p = .06$) reflecting more errors in the former than in the latter condition.

3. Discussion

Form-priming effects in picture naming were investigated. The experiment tested the effects of visually masked primes overlapping in the initial or final part with the target in a picture-naming task. In some sense, the current study can be seen as a response to Grainger and Ferrand's (1996) suggestion that: "One fruitful area for further research involves comparing naming performance in the standard word naming task with performance in production tasks such as picture naming" (pp. 642–643).

While the first-segment prime (e.g., *%b%%%%%* – *BANAAN*) significantly facilitated the naming of the target picture, the last-segment prime (e.g., *%n%%%%%* – *BANAAN*) had the opposite effect. Thus, in the begin-related condition, a MOPE was obtained. However, the dual-route account cannot accommodate this effect since picture naming does not engage the non-lexical route. In contrast, the speech-planning account can explain the present MOPE. Why the last-segment condition yielded slower RTs than the control condition is not completely clear. One potential explanation is that the preceding and trailing percent signs did not cue the position of the segment in the to-be-named target, possibly leading to response competition due to the activation of a non-target onset segment.

Moreover, syllabic primes were more effective than segmental primes both begin- and end-related. This finding supports and extends earlier results by Schiller (2004, Experiment 1) from reading aloud. While the first-syllable priming effect might be due to a phonological priming effect and/or a MOPE, although it yielded significantly more priming than the first-segment condition, the last-syllable priming effect cannot be due to a MOPE, but must be due to a genuine phonological priming effect.

The experiments also showed that whole-word primes that overlapped either in the onset or offset with the to-be-named target slowed down naming latencies of those targets significantly. This may be due to at least one of the following two reasons: first, mismatching segments (in bold print, e.g., ***beroep*** – ***BANAAN*** or ***robijn*** – ***BANAAN***) from the whole-word primes presumably inhibit the naming process due to the activation of non-target segments in the phonological output lexicon. These non-target segments might compete with the target segments for selection. Alternatively, non-target segments may activate non-target syllables when the target syllables are selected from a mental syllabary (Cholin, Levelt, & Schiller, 2006; Levelt & Wheeldon, 1994; Levelt et al., 1999). In the WEAVER model, syllable selection is contingent on the Luce ratio: the more non-target syllables are activated, the lower the Luce ratio and the longer the selection times (Roelofs, 1997).

Second, whole-word primes presumably activate their corresponding words in the lexicon leading to a situation resembling the picture-word interference paradigm: the interfering stimulus in the present study, i.e., the word, was presented as a visually masked stimulus and at a slightly negative SOA (i.e., –67 ms). Picture-word interference is known to lead to slower RTs compared to control conditions. For instance, Lupker (1982, Experiment 1) reported that both *BOOT* (698 ms) and *BAR* (754 ms) yielded significantly slower naming latencies for the target picture *foot* than their corresponding control conditions, i.e., *XXXT* (665 ms) and *XXR* (690 ms), respectively. Presumably, whole-word primes in the present experiments activate their corresponding entries in the mental lexicon, and the competition between target and non-target words creates a well-investigated response conflict (see Levelt et al., 1999 for an overview) which needs to be resolved by the speaker and slows down naming latencies. For instance, upon perceiving the to-be-named picture of a *banana*, speakers activate the corresponding concept and lexical entry. However, semantically unrelated distractor words such as *beroep* ('profession') or *robijn* ('ruby') activate other lexical entries relatively strongly. These lexical entries enter into a competition with the target lexical entry (i.e., *banaan*) making the selection of the target more difficult than in the control condition and therefore leading to longer RTs.

In conclusion, the MOPE due to the first-segment primes obtained here cannot be accounted for by the dual-route account proposed by Forster and Davis (1991) because pictures have to be named via the lexical route (see also Kinoshita, 2003, p. 229). In contrast, the present results are predicted and can readily be accommodated by the speech-planning account (Grainger & Ferrand, 1996; Kinoshita, 2000; Malouf & Kinoshita, in press; Schiller, 2004, in press). The first-segment primes overlapped with the target names and pre-activated segments, i.e., articulatory output units, which were needed to name the picture, hence facilitating picture naming. Since phonological encoding for speech production is proceeding from beginning to end of words, the effect of first-segment primes – in contrast to last-segment primes – can be measured by a voice-key and is reflected in the RTs. The whole-word primes, however, did not yield facilitation, presumably because non-target segments in the prime activated non-target segments/syllables in the production process, which decreased/canceled out the facilitation from the overlapping segments in the prime (in addition to lexical competition).

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Appendix A

Stimulus materials

Targets	Whole-word primes	
	Begin-related	End-related
anker ('anchor')	aarde ('earth')	humor ('humour')
auto ('car')	ader ('blood vessel')	polo ('polo')
banaan ('banana')	beroep ('profession')	robijn ('ruby')
beha ('bra')	baron ('baron')	hoera ('hurrah')
beitel ('chisel')	bakker ('baker')	middel ('means')
beker ('cup')	bande ('bend')	donor ('donor')
bezem ('broom')	balie ('counter')	visum ('visa')
borstel ('brush')	berging ('storage room')	vleugel ('wing')
cactus ('cactus')	condor ('condor')	vonnis ('verdict')
cirkel ('circle')	censor ('censor')	rommel ('junk')
citroen ('lemon')	cement ('concrete')	termijn ('date')
dolfijn ('dolphin')	dictaat ('dictation')	patroon ('pattern')
fabriek ('factory')	fortuin ('fortune')	banket ('banquet')
foto ('photograph')	file ('queue')	giro ('giro')
geweer ('rifle')	gigant ('giant')	natuur ('nature')
gitaar ('guitar')	gebied ('territory')	majoor ('major')
halter ('weights')	hengel ('fishing rod')	fosfor ('phosphor')
hamer ('hammer')	heide ('heath')	kefir ('kefir')
kameel ('camel')	komiek ('comedy')	moraal ('moral')
kanon ('cannon')	kuras ('cuirass')	decaan ('dean')
ketel ('kettle')	koren ('grain')	wafel ('waffle')
konijn ('rabbit')	kajuit ('cabin')	pension ('guest house')
kubus ('cube')	kamer ('room')	polis ('policy')
magneet ('magnet')	massief ('solid')	produkt ('product')
masker ('mask')	middag ('mid day')	dollar ('dollar')
mijter ('mitre')	mening ('opinion')	sector ('sector')
molen ('wind mill')	marge ('margin')	satan ('satan')
motor ('motor bike')	magma ('magma')	boter ('butter')
penseel ('brush')	pastoor ('priest')	moeraal ('moray')
pinguin ('penguin')	pantser ('armour')	bekken ('pelvis')
pleister ('plaster')	prikkel ('tingling')	winnaar ('winner')
raket ('rocket')	rebel ('rebel')	marot ('bauble')
ratel ('rattle')	regen ('rain')	gevel ('outer wall')
robot ('robot')	rebus ('rebus')	ambacht ('trade')
sigaar ('cigar')	succes ('success')	manier ('manner')
sleutel ('key')	sieraard ('jewelery')	gordel ('belt')
spijker ('nail')	storing ('disturbance')	dienaar ('servant')
stempel ('stamp')	slijter ('wine dealer')	trommel ('drum')

Appendix A (*continued*)

Targets	Whole-word primes	
	Begin-related	End-related
tafel ('desk')	teken ('sign')	zegel ('stamp')
tijger ('tiger')	tennis ('tennis')	nectar ('nectar')
tractor ('tractor')	toendra ('tundra')	meester ('master')
trompet ('trumpet')	textiel ('textile')	conflict ('conflict')
varken ('pig')	vinger ('finger')	divan ('divan')
vlinder ('butterfly')	voering ('lining')	minnaar ('lover')
wortel ('carrot')	warmte ('heat')	kachel ('oven')

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