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BRIEF REPORT

Semantic interference from distractor pictures in single-picture naming: evidence for competitive lexical selection

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Abstract Picture-naming studies have demonstrated interference from semantic-categorically related distractor words, but not from corresponding distractor pictures, and the lack of generality of the interference effect has been argued to challenge theories viewing lexical selection in speech production as a competitive process. Here, we demonstrate that semantic interference from context pictures does become visible, if sufficient attention is allocated to them. We combined picture naming with a spatial-cuing procedure. When participants' attention was shifted to the distractor, semantically related distractor pictures interfered with the response, as compared with unrelated distractor pictures. This finding supports models conceiving lexical retrieval as competitive (Levelt, Roelofs, & Meyer, 1999) but is difficult to reconcile with the response exclusion hypothesis (Finkbeiner & Caramazza, 2006b) proposed as an alternative.

Keywords Speech production · Semantic context effects · Lexical access · Lexical competition · Response exclusion

Lexical access—that is, the activation and selection of words appropriate for conveying part of a speaker's communicative intention—is a core process in speech production. Lately, a vivid debate has emerged on whether it is a competitive or a noncompetitive process. Our study addressed this issue. Specifically, we looked at semantic context effects from distractor pictures during picture naming, because the lack of semantic interference in this situation observed in earlier studies has been one key argument for claiming that lexical access is noncompetitive (Finkbeiner & Caramazza, 2006a; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007).

Two paradigms have been used extensively to explore the lexical access process: the picture–word interference task (PWI; e.g., Schriefers, Meyer, & Levelt, 1990) and the picture–picture interference task (PPI; e.g., Morsella & Miozzo, 2002). In the PWI task, participants name a target picture while ignoring a distractor word. Key findings are interference from semantic-categorically related distractor words (*monkey*; picture: pig) and facilitation from phonologically related distractor words (*pin*; e.g., Damian & Martin, 1999; Jescheniak, Schriefers, & Hantsch, 2001; Schriefers et al., 1990). These two effects are assumed to reflect the processing of abstract lexical and phonological codes, respectively. Moreover, the finding of semantic interference (as opposed to facilitation) has been a major motivation for postulating that lexical access involves competition (Levelt, 1999; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992; Starreveld & La Heij, 1995). The effect is explained as follows. When preparing an utterance (*pig*), lexical representations of semantically related concepts (*cow, monkey,* etc.) also become activated due to connections within the conceptual network. Consequently, the target must be selected from these activated candidates. Semantic interference arises because a related distractor (*monkey*) further increases the activation of a competitor activated by the target picture, while an unrelated distractor (*table*) activates an inactive representation. Thus, a related distractor reduces the difference in activation between target and competitor, rendering target selection more difficult.

In the PPI task, participants name a target picture while ignoring a distractor picture. Several studies have demonstrated facilitation from phonologically related distractor pictures (e.g., Meyer & Damian, 2007; Morsella & Miozzo, 2002; Navarrete & Costa, 2005; Roelofs, 2008b; for qualifications, see Jescheniak et al., 2009; Kuipers & La Heij, 2009; Mädebach, Jescheniak, Oppermann, & Schriefers, 2011),

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resembling the effect in the PWI task. However, semantically related distractor pictures did not yield a clear pattern. Studies most comparable to those showing phonological effects (i.e., picture naming with a perceptual stimulus feature such as color or size identifying the target) did not find a semantic effect (Damian & Bowers, 2003; Humphreys, Lloyd-Jones, & Fias, 1995; Navarrete & Costa, 2005; see also Meyer & Damian, 2007; Roelofs, 2008b). Glaser and Glaser (1989) did find semantic interference in a sequential discrimination task, when participants named the first or second of two pictures presented in close temporal proximity. This effect, however, could result from difficulties in target identification and the use of very few items (La Heij, Heikkop, Akerboom, & Bloem, 2003). Humphreys et al. observed semantic interference with a postcuing procedure only—that is, when the target could only be identified after the pictures' onset, but not with a predefined task cue. When naming is replaced with categorization or word translation, semantic facilitation is observed (Bloem & La Heij, 2003; Glaser & Düngelhoff, 1984).

This situation raises the question why in picture naming—under comparable conditions—distractor pictures induce phonological facilitation but not semantic interference, whereas distractor words yield both effects. If semantic interference were restricted to a particular task (PWI) and would not generalize to a seemingly similar task (PPI), the theoretical inferences that could sensibly be drawn from the effect would be severely limited.

There are different possibilities why no clear semantic interference effect from distractor pictures in picture naming has been observed. On one account, distractors need to exceed a competition threshold to induce interference (La Heij, Boelens, & Kuipers, 2010; Piai, Roelofs, & Schriefers, 2012). Possibly, picture distractors do not exceed this threshold as consistently as word distractors do.[1] On a second account, semantic interference at the lexical level might have been masked by semantic facilitation (larger for pictures than for words) at the conceptual level (Abdel Rahman & Melinger, 2009; Hantsch, Jescheniak, & Schriefers, 2009; Kuipers, La Heij, & Costa, 2006; Navarrete & Costa, 2005). On a third account, no such effect has been found because the semantic interference effect obtained in the PWI task is confined to this particular task (Finkbeiner & Caramazza, 2006a; Mahon et al., 2007) and, thus, does not inform us about the nature of lexical access. The assumption is that lexical selection is noncompetitive and that the semantic interference effect in the PWI task arises postlexically, in an articulatory output buffer. According to this *response exclusion hypothesis*, words (other than picture names) have privileged access to the buffer, which holds only one production-ready utterance at a time. When a picture and a word are presented simultaneously (in PWI experiments), the word fills the buffer and needs to be excluded before the picture name can enter it. Critically, the decision process responsible for purging the buffer is assumed to have semantically interpreted information available, such that semantically related words are excluded more slowly than unrelated words, yielding interference. Since the PPI task does not involve words that could block the buffer, no semantic interference should result, in line with the extant data.

Critically, the first two accounts, which view lexical selection as competitive, predict that semantic interference from distractor pictures should be observed under suitable conditions. By contrast, the latter, response exclusion hypothesis predicts that such an effect should generally not be obtained. The aim of the present study was thus to reexplore semantic effects from distractor pictures under conditions in which an effect is likely to become visible, if existing. It builds on evidence that selective attention plays a pivotal role in tasks in which a target picture is named in the context of a distractor stimulus (Mädebach et al., 2011; Oppermann, Jescheniak, & Schriefers, 2008; Roelofs, 2003). We manipulated the allocation of attention by combining the PPI task with a version of the spatial attention cuing paradigm (Posner, 1978, 1980; Posner, Snyder, & Davidson, 1980). In the original cuing paradigm, participants respond as quickly as possible to the onset of a visual stimulus. Briefly before the onset of a single stimulus, a central arrow appears pointing to the left or the right, indicating that the stimulus will appear in the respective location. In a control condition, an arrow pointing to the left and right provides no spatial information. With a sufficiently high proportion of valid cues, responses are fastest with valid cues (cue correctly indicates the target location) and slowest with invalid cues (cue indicates nontarget location), with the neutral cue condition being positioned in between. This pattern suggests that participants use the cue to orient their attention to the cued location, which subsequently facilitates target processing at that location. These studies led to the attentional spotlight model, which postulates that stimuli falling into the spotlight are processed preferentially.

In our version of the cuing task, there were two stimuli, one to the left and one to the right of the cue. The target was identified by its color. Valid cues pointed toward the upcoming target, and invalid cues toward the upcoming distractor. Neutral cues provided no spatial information. Critical was the invalid cue condition, because the shift of attention should lead to preferential processing of the upcoming distractor stimulus. If previous studies failed to demonstrate semantic interference from distractor pictures because these pictures were not sufficiently processed to exceed a critical competition threshold, the effect should now become visible. By contrast, if previous studies failed to demonstrate the effect because it is specific to the PWI task and does not generalize

[1] Phonological facilitation (due to activation added to the target's phonological segments) may not be contingent on such a threshold and, thus, might be observable under conditions under which semantic interference effects are not (La Heij et al., 2010).

to other tasks, there should be no interference effect; possibly, one might expect semantic facilitation due to enhanced conceptual priming (cf. Mahon et al., 2007). For the neutral cue condition, no distractor effect was expected, replicating earlier findings. The same was true for the valid cue condition.

Method

Participants

Twenty-four students from the University of Leipzig, all native speakers of German with normal or corrected-to-normal vision and normal color vision, participated.

Materials

Experimental items were 40 line drawings, combined into 20 semantic-categorically related pairs and 20 unrelated pairs (see the Appendix). The semantic manipulation was validated in a rating ($N = 19$; 5-point scale: 1 = *little*, 5 = *strong semantic similarity*). Related pairs were judged more similar (related, $M = 4.28$, $SD = 0.32$, range = 3.63–4.84; unrelated, $M = 1.38$, $SD = 0.36$, range = 1.00–2.47; *p*s < .001). Possible differences in visual similarity were assessed in another rating ($N = 12$; 5-point scale: 1 = *little*, 5 = *strong visual similarity*). There was no difference (related, $M = 1.99$, $SD = 0.57$, range = 1.08–2.92; unrelated, $M = 1.98$, $SD = 0.71$, range = 1.08–3.33; *p*s > .90).

The cue was a central fixation cross flanked by arrowheads pointing to the left and to the right, in which either one arrowhead (pointing to the target's location on valid trials and pointing to the distractor's location on invalid trials) or both arrowheads (on neutral trials) briefly changed color (Andersen, Fuchs, & Müller, 2011).

Pictures were sized to 6 × 6 cm (visual angle of ca. 5.6° at 60-cm viewing distance), and the cue to 2 × 3 cm (ca. 1.9° × 2.8°). Practice and warm-up trials were created with an additional 12 pictures.

Design

The repeated measure design included the variables semantic relatedness (related, unrelated) and cue type (valid, neutral, invalid). Each picture appeared once as target and once as distractor in each combination of the two variables, yielding 240 experimental trials. To increase cue validity, we added 240 valid-cue filler trials; to create them, experimental pictures were recombined into 20 new unrelated pairs. This resulted in 66.7 % valid, 16.7 % neutral, and 16.7 % invalid trials.

There were two experimental blocks. In the first, half of the pictures were targets and half distractors. In the second, this assignment was reversed. The blocks were counterbalanced. Within each block, the sequence of the experimental conditions was sequentially balanced.

Apparatus

Stimuli were presented on a TFT monitor. The experiment was controlled by NESU (MPI for Psycholinguistics). Responses were registered with a microphone and digitally recorded. Speech-onset latencies were rechecked off-line.

Procedure

Viewing distance was about 60 cm. Participants were familiarized with the pictures and names and were instructed to name the pictures as quickly and accurately as possible. Then they named all the pictures once. Nonexpected responses were corrected. Next, participants were told that there would be two pictures and were asked to name the blue one. They were also informed that a cue, pointing to either one or both sides, would precede the pictures and, in most cases, would correctly indicate the target's position. Participants were encouraged to use this information to respond quickly. A practice block (12 trials) preceded the two experimental blocks, each containing 120 experimental, 120 filler, and 12 warm-up trials.

Trials were structured as follows. At central position, the cue (fixation cross and arrowheads) appeared in gray (RGB 170 170 170) on a light gray background (RGB 220 220 220). At some point, either one (valid and invalid cues) or both (neutral cues) arrowheads turned black. After a random 400- to 600-ms interval (minimizing temporal expectation effects), target and distractor appeared to the left and the right of the cue (8.5 cm [ca. 8.1°] distance between the pictures' midpoints). Targets appeared in blue (RGB 0 0 128), and distractors in black. After 300 ms, the pictures disappeared, and the arrowhead(s) returned to gray. The next picture was cued 3,500 ms after picture onset (Fig. 1).

Results

Observations were coded as erroneous whenever no response, a nonexpected response, or a disfluency was registered (2.5 % of the data). Observations deviating from a participant's and an item's mean by more than 2 *SD*s were considered outliers and also discarded (1.8 %). Averaged RTs and error rates were submitted to ANOVAs involving the variables cue type, relatedness, and block. Greenhouse–Geisser corrected values are reported, if the sphericity assumption was violated (Mauchly test $p < .05$). Table 1 shows the results.

In the RT analysis, cue type was significant, $F_1(1.15, 26.42) = 83.89$, $p < .001$, $\eta_p^2 = .79$; $F_2(1.65, 64.32) = 292.83$, $p < .001$, $\eta_p^2 = .88$. As compared with neutral cues, valid cues accelerated responses, $F_1(1, 23) = 69.28$, $p < .001$, $\eta_p^2 = .75$; $F_2(1, 39) = 103.03$, $p < .001$, $\eta_p^2 = .73$, and invalid

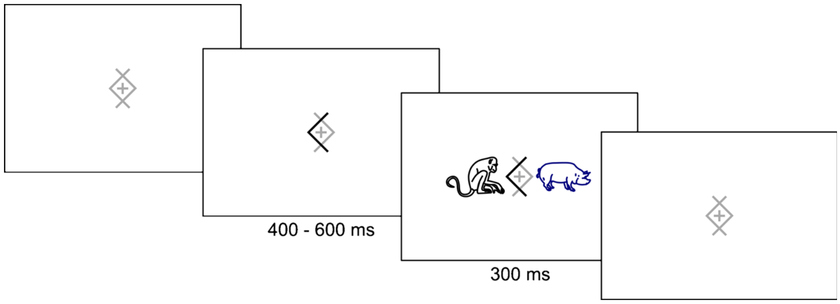

Fig. 1 Illustration of an experimental trial. The cue is invalid and the distractor picture (in black) is semantically related to the target picture (in blue; print version: dark gray). Total trial length varied between 3,900 and 4,100 ms, depending on the duration of the cue

cues decelerated responses, $F_1(1, 23) = 74.85$, $p < .001$, $\eta_p^2 = .77$; $F_2(1, 39) = 307.99$, $p < .001$, $\eta_p^2 = .89$. Responses were slower with related than with unrelated distractors, $F_1(1, 23) = 7.98$, $p < .01$, $\eta_p^2 = .26$; $F_2(1, 39) = 3.64$, $p = .06$, η_p^2- = .09. The two variables interacted, $F_1(2, 46) = 7.47$, $p < .01$, $\eta_p^2 = .25$; $F_2(2, 78) = 5.11$, $p < .01$, $\eta_p^2 = .12$. There was significant interference with invalid cues, $F_1(1, 23) = 15.91$, $p < .001$, $\eta_p^2 = .41$; $F_2(1, 39) = 7.69$, $p < .01$, $\eta_p^2 = .17$, but no effect with neutral or valid cues, Fs < 1. Responses were slower in the second block, $F_1(1, 23) = 17.92$, $p < .001$, $\eta_p^2 = .44$; $F_2(1, 39) = 29.42$, $p < .001$, $\eta_p^2 = .43$, possibly reflecting negative priming, because now participants responded to previously ignored distractors (Grison, Tipper, & Hewitt, 2005).

In the error analysis, cue type was significant, $F_1(1.58, 36.23) = 3.95$, $p < .05$, $\eta_p^2 = .15$; $F_2(2, 78) = 8.96$, $p < .001$, $\eta_p^2 = .19$. As compared with neutral cues, valid cues did not differ, ps > .14, and invalid cues slightly increased errors, $F_1(1, 23) = 2.89$, $p = .10$, $\eta_p^2 = .11$; $F_2(1, 39) = 6.97$, $p < .05$, $\eta_p^2 = .15$. More errors were observed with related than with unrelated distractors, $F_1(1, 23) = 6.20$, $p < .05$, $\eta_p^2 = .21$; $F_2(1, 39) = 10.64$, $p < .01$, $\eta_p^2 = .21$.

RT distributions were also analyzed. We computed vincentized distributions (cf. Ratcliff, 1979; Roelofs, 2008a) by splitting the rank ordered latencies (per participant/item) into deciles (separated by cue type and relatedness) before averaging across these deciles means (see Fig. 2). For invalid cues, semantic interference was present throughout the whole distribution, as indexed by the absence of a relatedness by decile interaction, $F_1(2.43, 55.96) = 1.14$, $p = .33$, $\eta_p^2 = .05$; $F_2(2.10, 81.74) = 2.45$, $p = .09$, $\eta_p^2 = .06$; in the participant analysis, the semantic effect was significant in deciles 2–10, ps < .05, in the item analysis in deciles 4–9, ps < .05. This pattern excludes the possibility that the interference effect resulted from slow responses only.

Discussion

Recently, the response exclusion hypothesis has been proposed as an alternative to models assuming lexical access to be competitive. It attributes the semantic interference effect

Table 1 Naming latencies (in milliseconds) and error rates (%) broken down by experimental block, type of cue, and semantic relatedness (with standard errors in parentheses)

	Block 1		Block 2		Overall	
	M	%	M	%	M	%
Valid cue						
Related	572 (11)	1.7 (0.5)	581 (13)	2.1 (0.7)	576 (12)	1.9 (0.5)
Unrelated	567 (11)	1.7 (0.7)	582 (13)	1.3 (0.5)	575 (12)	1.5 (0.6)
Difference	5 (4)	0 (0.7)	-1 (6)	0.8 (0.6)	1 (3)	0.4 (0.4)
Neutral cue						
Related	610 (9)	2.5 (1.2)	626 (11)	3.3 (0.9)	618 (9)	2.9 (0.9)
Unrelated	610 (10)	1.0 (0.6)	619 (12)	2.3 (0.9)	614 (11)	1.7 (0.7)
Difference	0 (6)	1.5 (1.1)	7 (4)	1.0 (0.7)	4 (4)	1.2 (0.7)
Invalid cue						
Related	677 (13)	3.3 (0.8)	706 (11)	5.0 (2.0)	691 (11)	4.2 (1.2)
Unrelated	664 (12)	3.5 (1.4)	681 (13)	2.5 (0.9)	672 (12)	3.0 (0.9)
Difference	13 (7)	-0.2 (1.3)	25 (6)	2.5 (1.6)	19 (5)	1.2 (0.8)

Note. Difference = related − unrelated.

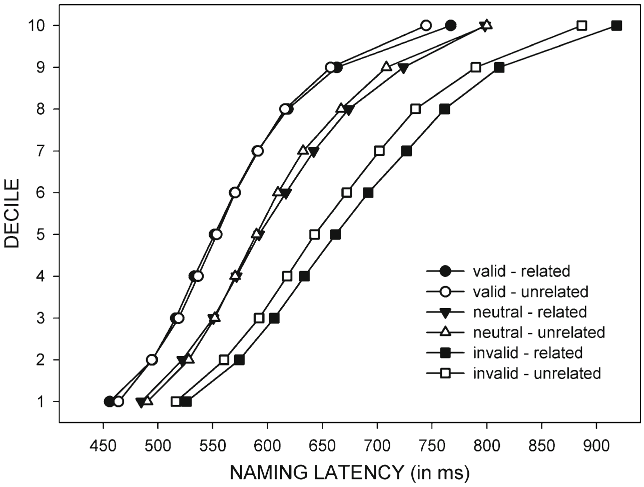

Fig. 2 Vincentized cumulative distribution curves for naming latencies broken down by cue type and semantic relatedness. Distribution curves are based on participants

from distractor words in the PWI task to processes operating at a postlexical articulatory output buffer to which words (as opposed to pictures) have privileged access. Because the PPI task does not involve words that could block the buffer, no semantic interference should be obtained in this task. In contrast to this prediction, we observed semantic interference, when attention was directed to the distractor pictures.

To possibly reconcile our result with the response exclusion hypothesis, one might argue that the covert correction of misselections, initiated after a cued distractor has been selected and its name consequently blocked the buffer, drives the interference effect. Because such a correction process takes time, the semantic effect should be confined to slow responses or at least be larger for slower than for faster responses (De Jong, Berendsen, & Cools, 1999; Roelofs, 2008a). The latency distribution analyses, however, clearly show that this was not the case.

One might wonder whether the semantic interference effect arises during conceptual rather than lexical processing, possibly because the extra attention given to the distractor picture makes conceptualization of the related target picture harder. However, the current theoretical debate focuses on the question of whether semantic interference arises at a lexical level (as argued by proponents of the selection-by-competition view; cf. Levelt et al., 1999) or at a postlexical level (as argued by proponents of the response exclusion hypothesis; cf. Finkbeiner & Caramazza, 2006b). With respect to the conceptual level, there is a large consensus among researchers—regardless of whether they adhere to the selection-by-competition view or to the response exclusion view—that this processing level is the source of semantic priming (yielding facilitation effects), following the idea advanced by early work on semantic network models (Collins & Loftus, 1975; cf. Abdel Rahman & Melinger, 2009; Bloem & La Hei, 2003; Finkbeiner & Caramazza, 2006b; Hantsch et al., 2009; Levelt et al., 1999; Mahon et al., 2007; Navarrete & Costa, 2005; Roelofs, 1992). Thus, in the framework of current theorizing about lexical access, it seems most parsimonious to assume a lexical locus of the semantic interference effect we observed, albeit our data do not allow one to rule out some conceptual contribution to the effect.

One might also speculate whether the polarity of the semantic effect is due to the cuing procedure. We replicated our experiment with phonologically (un)related distractor pictures, which had yielded facilitation in previous studies, and also observed facilitation (7 ms), $F_1(1, 23) = 8.96, p < .01, \eta_p^2 = .28$; $F_2(1, 39) = 4.02, p < .06, \eta_p^2 = .09$. This demonstrates that our procedure does not induce interference and that, thus, the polarity of the observed semantic interference effect is indeed informative with respect to the issue of—lexical—competition.

Our observation that attention is crucial for semantic context effects converges with findings by Aristei, Zwitserlood, and Rahman (2012). Their participants saw two pictures and produced novel German noun–noun compounds (*Fuchs* [fox]–*Löwe* [lion] to be named as *Fuchslöwe* [fox–lion]). Responses were slower with semantically related pictures—that is, interference emerged—when both pictures were attentively processed (in order to name them). However, this study differs from all other PWI and PPI studies discussed earlier in one important aspect—namely, that the second stimulus was named rather than ignored, introducing additional processes. Here, we demonstrate that interference from semantically related (context) pictures is also obtained in the standard task configuration—that is, if they are not named.

In summary, semantically related distractor pictures yield interference during picture naming, when sufficient attention is devoted to them. This observation strongly supports models conceiving lexical access as competitive (Levelt et al., 1999; Starreveld & La Heij, 1995) and challenges the response exclusion hypothesis (Finkbeiner & Caramazza, 2006b) proposed as an alternative.

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Appendix List of the picture pairs used (with English translations given in brackets)

Semantically related pairs

Affe [monkey] – Schwein [pig]; Arm [arm] – Kopf [head]; Auge [eye] – Ohr [ear]; Auto [car] – Flugzeug [airplane]; Bett [bed] – Sessel [couch]; Blume [flower] – Kaktus [cactus];

Bogen [bow] – Kanone [gun]; Burg [castle] – Haus [house]; Flöte [flute] – Harfe [harp]; Gurke [cucumber] – Tomate [tomato]; Kirsche [cherry] – Banane [banana]; Lampe [lamp] – Kerze [candle]; Mantel [coat] – Hose [trousers]; Mütze [cap] – Socke [sock]; Raupe [caterpillar] – Spinne [spider]; Schere [scissors] – Säge [saw]; Schiff [ship] – Zug [train]; Schlitten [sled] – Roller [scooter]; Schwert [sword] – Pistole [pistol]; Trommel [drum] – Gitarre [guitar].

Unrelated pairs

Affe [monkey] – Flugzeug [airplane]; Arm [arm] – Tomate [tomato]; Auge [eye] – Sessel [couch]; Auto [car] – Kopf [head]; Bett [bed] – Zug [train]; Blume [flower] – Harfe [harp]; Bogen [bow] – Spinne [spider]; Burg [castle] – Schwein [pig]; Flöte [flute] – Roller [scooter]; Gurke [cucumber] – Säge [saw]; Kirsche [cherry] – Pistole [pistol]; Lampe [lamp] – Socke [sock]; Mantel [coat] – Kerze [candle]; Mütze [cap] – Haus [house]; Raupe [caterpillar] – Gitarre [guitar]; Schere [scissors] – Banane [banana]; Schiff [ship] – Ohr [ear]; Schlitten [sled] – Kaktus [cactus]; Schwert [sword] – Hose [trousers]; Trommel [drum] – Kanone [gun].

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