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Set size and repetition in the picture–word interference paradigm: implications for models of naming

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Abstract

Caramazza and Costa (*Cognition* 75 (2000) B51) reported results which demonstrate that a semantically related word distractor interferes in picture naming even when it is not in the response set and there is no possibility for mediated interference. They interpreted the results to be problematic for the model of lexical access proposed by Levelt, Roelofs, and Meyer (*Behavioral and Brain Sciences* 22 (1999) 1). Roelofs (this issue) argues that those results are not inconsistent with Levelt et al.'s model when certain new assumptions about the mechanism of lexical selection are considered. Here we show that even with these assumptions the model still makes the wrong predictions. We report new results which demonstrate that the semantic interference and facilitation effects that are obtained respectively in the basic-level and category-level naming variants of the picture–word interference paradigm are not the result of response set size and response repetitions.

Keywords: Speech production; Lexical access; Picture–word interference

1. Introduction

There are a number of contending proposals about the mechanisms of lexical access in language production. To help choose among them, researchers have

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considered various types of data. The three major types are the patterns of spontaneously and experimentally induced speech errors, the patterns of language production deficits in aphasia, and the patterns of response latencies in picture naming tasks. One theory in particular has relied heavily on reaction time (RT) data in support of its central claims (Levelt, 2000). This theory has been implemented in the computer model WEAVER++ (e.g. Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992). The model has been credited with considerable success in simulating the patterns of RT data in the picture–word interference paradigm. However, Caramazza and Costa (2000) produced evidence that undermines a crucial assumption needed to simulate the RT data obtained with this task, thereby undermining a major part of the empirical basis used to support the theory. Roelofs (this issue) has challenged the conclusions reached in Caramazza and Costa (2000). Here we respond to Roelofs' criticisms by providing further arguments and empirical evidence which show that the selection mechanism in WEAVER++ is indeed inadequate to account for the patterns of semantic effects in the picture–word interference paradigm.

2. The issue: the mechanisms of semantic effects in the picture–word interference paradigm

There are two well-established semantic effects in the picture–word interference paradigm. In this paradigm, subjects are asked to name a picture while ignoring a superimposed distractor word. It has been reliably found that when the distractor (e.g. *cat*) is a semantic co-ordinate of the picture's name (e.g. *dog*) naming latencies are *slower* relative to an unrelated control distractor (e.g. *mat*) (e.g. Glaser & Glaser, 1989; Lupker, 1979). However, when the task involves the production of the category name of the picture, for example *animal* in response to a picture of a *dog*, response latencies are *faster* when the distractor is a semantic co-ordinate (e.g. *cat*), relative to an unrelated distractor (e.g. *mat*) (e.g. Glaser & Glaser, 1989). In other words, co-ordinate word distractors produce contrasting effects in the picture–word naming task: *interference* when the response is a basic-level name, and *facilitation* when the response is a category-level name.

Roelofs (1992) (see also Levelt et al., 1999) proposed an explanation of the two effects in terms of selection competition at the same stage of lexical processing. There are two crucial assumptions in this account. One assumption is that when target and distractor are semantically related they activate each other, resulting in higher activation levels for both (but a little more for the distractor than the target), relative to the condition where target and distractor are unrelated. This assumption leads to the prediction that semantically related distractors should produce interference in naming because they are stronger competitors for selection than unrelated distractors. However, given only this assumption we would expect to observe semantic interference both in the case of basic-level and category-level naming, contrary to the established pattern of results (e.g. Glaser & Glaser, 1989). The other crucial assumption is that selection competition is restricted to items that

are 'flagged' as part of the response set. In the category-level naming condition, the semantically related distractors (basic-level terms, e.g. *cat*) are assumed not to compete for selection because they are not in the response set (only category-level terms are used, e.g. *animal*), and therefore cannot produce interference (and may even produce facilitation).

Many studies have shown, however, that semantic interference is found even when the distractors are not part of the response set (e.g. La Heij, 1988; Lupker, 1979; Meyer, 1996; Starreveld & La Heij, 1995). Roelofs argued that the interference effects that were found in those studies reflect a kind of 'mediated interference', which results from having more than one category member in the response set. To illustrate, suppose that subjects are shown the picture–distractor pair *dog–cat* and that *cat* is never used as a response (i.e. it is never presented as a picture). Because *cat* is not in the response set its lexical node will not compete for selection with the lexical node of the target response *dog*. However, if the experiment also contained the picture *fox*, then the distractor *cat* would interfere indirectly with the selection of the lexical node of *dog* through the activation of the lexical node of *fox*, which, because it is part of the response set, would compete for selection with the lexical node *dog*.

Roelofs (1992) noted that previous studies in which distractors were not part of the response set were not careful to prevent the possibility of this type of mediated interference. However, in three experiments in which only one picture–word pair was presented for any given semantic category, and therefore there was no possibility for mediated interference, Caramazza and Costa (2000) found strong and reliable semantic interference effects. These results demonstrate that the interference effect of semantic distractors does not depend on their membership in the response set. This conclusion undermines the claim by Roelofs (1992) (see also Levelt et al., 1999) that the contrast between semantic interference and facilitation obtained respectively in basic-level and category-level naming conditions is due to response set differences in the two tasks.

Roelofs (this issue) argues that the results obtained by Caramazza and Costa (2000) are consistent with his model if we assume that the response set can only be marked in memory (flagged) when the number of responses is small (say up to eight to ten items). If, however, the number of responses is 'a dozen or more' (as in Caramazza and Costa's experiments) they cannot be kept in short-term memory (STM)[1] and therefore all words are considered as potential responses, leading to interference even when only one category member is used for each semantic category. Roelofs further argues that if the responses are repeated many times, a response set can be established if the set is not too large. In support of this contention, Roelofs reviews the results of an experiment by La Heij and van den Hof

[1] It is unclear how 'short-term memory' interacts with the lexical access system proposed by Levelt et al. (1999). Presumably any flagging would have to be done in the lexical system and not in a 'general-purpose' memory system. The authors do not elaborate this crucial aspect of their claim, which, rather than being motivated by theory-internal considerations, was introduced in response to criticisms concerning the validity of the response set assumption (Starreveld & La Heij, 1999).

(1995) in which the response set and repetitions were systematically investigated and it was found that both factors determine the size of interference. But all of this is really beside the point. We do not dispute that the response set size and repetitions *can* affect the magnitude of interference in the picture–word interference paradigm. The results of La Heij and van den Hof (1995) are clear in this regard.[2] What is at issue is something else: (1) whether only distractors that are part of the response set produce interference in the picture–word naming paradigm and, more importantly, (2) whether the interference and facilitation effects that are respectively obtained in the basic-level and category-level naming conditions are reducible to response set effects. These are relatively simple empirical matters that can be resolved by carrying out the right experiments. So rather than continuing with a fruitless debate on whether a particular response set size is or is not too large to keep in STM (since this parameter has never been formally defined in the Levelt et al. (1999) model), we turn to a direct experimental test of the issues under contention.

3. A simple but compelling test of the response set assumption

To resolve the issue of whether the interference and facilitation effects that are respectively observed in the basic-level and category-level naming tasks merely reflect effects of the response set size we can consider data obtained in experiments that used *the same response set sizes* in the two tasks. In this way, any difference between the two tasks cannot be attributed to set size effects. Similarly, to test whether the interference produced by semantically related distractor words that are not in the response set is due to mediated interference or to the impossibility of establishing a response set, we can compare same-size response sets that differ only in terms of whether or not the response set is 'well-established', while keeping only one element per semantic category in the response set. We have carried out these experiments and the results are unambiguous.

Fig. 1 displays the results of three tasks/conditions in experiments using the picture–word interference paradigm. The graph shows the difference in naming latencies between semantically related and unrelated conditions. Positive and negative values respectively indicate interference and facilitation, relative to relevant unrelated control conditions. Across tasks, the response set size was constant (11 category- or basic-level names were used in each condition) and none of the distractors were part of the response set. In the experimental phase, each picture was named six times, twice each with semantically related and unrelated basic-level words and a

[2] Roelofs' conclusion that the effects reported by La Heij and van den Hof (1995) demonstrate that response set membership is necessary for semantic interference is based on an oversimplification of the factors that are involved in determining response latencies in the picture–word interference paradigm. *Massive* repetition (as in the experiments of La Heij & van den Hof, 1995) probably does affect the response set but it can also affect response strategies, response learning, the ability to 'ignore' distractors for a given picture, and so on. It is important, therefore, to distinguish between factors that determine the response set and other effects of repetition in the picture–word interference paradigm. Further research is needed to clarify which parameters affect the amount of interference created by a distractor word (see La Heij, 1988).

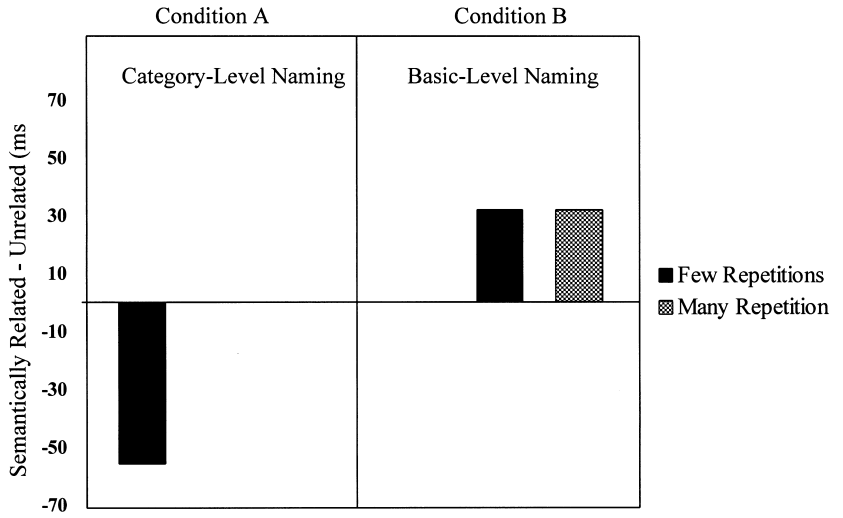

Fig. 1. Differential effects of semantically related distractors in category-level and basic-level naming considering the number of repetitions of the responses included in the experiment.

string of XXXs. Only one item per semantic category was in the response set in each of the three conditions. On the left panel of Fig. 1 is shown performance in the category-level naming task – Condition A (e.g. producing *animal* in response to the picture *dog*; for details see Costa, Savova, & Caramazza, 2001). On the right panel is shown performance in the basic-level naming task – Condition B (e.g. *dog* in response to the picture *dog*), where two conditions were tested: Few-Repetitions (B-Few) versus Many-Repetitions (B-Many) Conditions. The only difference between the latter two conditions is in the number of times participants were asked to name the pictures without distractors in the pre-experimental phase: twice in the B-Few condition (as was the case in the category-level naming task) and ten times in the B-Many condition (see Appendix A).

Comparison of performance across the three conditions allows a direct test of the issues under contention. According to Roelofs, since the response set size is the same across all three conditions, it is the number of repetitions and not the task type that is the critical variable in determining whether distractors will lead to interference or facilitation. This predicts that the category-level and the basic-level naming conditions should produce comparable levels of interference or facilitation when the number of repetitions is the same in the two conditions (Conditions A and B-Few). Furthermore, the two basic-level naming conditions should vary in the magnitude of interference produced by semantic distractors as a function of the number of naming repetitions: there should be more interference in the Few- than the Many-Repetition condition. The results reported in Fig. 1 are clearly at variance with these expectations. Contrary to predictions derived from Roelofs (this issue) and Levelt et al. (1999), we find that for same-size response sets semantic distractors produce facilitation in category-level naming (Condition A) and interference in basic-level

naming (Condition B). Furthermore, the results obtained in Conditions B-Few and B-Many replicate and extend those reported in Caramazza and Costa (2000) and demonstrate that simply having many repetitions to establish a response set, without confounding effects due to massive exposure to picture–word pairs, does not affect the direction or the magnitude of effects of semantic distractors. In other words, in basic-level naming semantic distractors interfere whether or not they are part of the response set, and in category-level naming semantic distractors facilitate naming.

4. Conclusion

The results we have reviewed establish two clear facts. First, the contrast between semantic interference and facilitation that is respectively obtained in basic-level and category-level naming with the picture–word interference paradigm is not reducible to a difference in the response set between tasks (comparison of Conditions A versus B). Second, simply establishing a response set (if that is what happens with repetition of the response) does not change the direction of the effects of semantic distractors in basic-level naming in the picture–word interference paradigm (Condition B-Few versus B-Many). These facts are inconsistent with predictions derived from the WEAVER++ model of naming, which is the core component of the lexical access theory proposed by Levelt et al. (1999). Since the bulk of the empirical evidence cited in support of the theory consists of the ability of WEAVER++ to simulate RT data in naming experiments and since our results disconfirm a crucial assumption of the model, the theory as a whole is provisionally undermined, especially when considered in the context of other results that are problematic for this theory (e.g. Caramazza & Miozzo, 1997; Costa, Caramazza, & Sebastián-Gallés, 2000; Jescheniak & Schriefers, 1998; Peterson & Savoy, 1998; Starreveld & La Heij, 1995).

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Appendix A. Method used in the experiment on basic-level naming (Condition B)

Forty native English speakers were asked to name 11 pictures belonging to different semantic categories. Pictures were paired with three different distractors: a semantically related word, an unrelated distractor, and a string of XXXs (see Caramazza & Costa, 2000, for the criteria followed in selecting the stimuli). Participants were assigned to two groups. The difference between groups concerned how many times participants were asked to name the pictures (two versus ten) during a

familiarization phase of the experiment. In this phase of the experiment, participants were asked to name the pictures with the word they usually use and they were told that the pictures were the ones that would appear in the experiment proper. The main goal of this phase was to allow participants to 'flag' the lexical nodes included in the response set. Presumably, for a set size of 11 participants can fix the response set only when many repetitions of the word responses are produced (Roelofs, this issue) before the experiment proper. During the experimental phase, stimuli were presented in three different blocks of 11 pictures each. Each picture appeared once per block. In each block, stimuli of the three conditions appeared an equal number of times. Block trials were randomized with the restriction that distractors of the same condition appeared in no more than two consecutive trials. The order of block presentation was varied across participants. The 33 different picture–distractor pairs were presented twice. The other details of the design and procedure are similar to those presented in Caramazza and Costa (2000).

A.1. Results

Following the same criteria as in Caramazza and Costa (2000), 2.4% of the responses were excluded from the analyses. Two independent variables were analyzed by means of two ANOVAs (by subjects and by items): a within-subjects variable (type of distractor: semantically related and unrelated), and a between-subjects variable (group of participants: Group 1 (few repetitions) and Group 2 (many repetitions)).

Slower naming latencies were observed with semantically related than with unrelated distractors ($F1(1, 38) = 17.2$, MSE $= 1160.4$, $P < 0.001$; $F2(1, 10) = 10.4$, MSE $= 1043.9$, $P < 0.009$). Participants' responses were similar in the two groups ($F1 < 1$; $F2(1, 10) = 24.5$, MSE $= 584.1$, $P < 0.01$). More importantly, the interaction between the two variables was not significant (both $F < 1$), indicating that the magnitude of the semantic interference effect was statistically identical in the two groups of subjects (31 ms for both groups). Post-hoc analyses revealed that the semantic interference effect was significant for both groups of subjects (all $P < 0.03$). The differences between the two experimental conditions and the XXX condition were also significant (all $P < 0.001$). No differences were observed in the error analyses.

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