



## Brief article

# The semantic interference effect in the picture-word interference paradigm: does the response set matter?

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Received 5 October 1999; received in revised form 12 November 1999; accepted 9 December 1999

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**Abstract**

In three picture-word interference experiments we explore some properties of the semantic interference (SI) effect in the picture-word interference paradigm. In Experiments 1 and 2, we test whether SI may be obtained when the distractor words are *not* part of the response set and when only one picture per semantic category is included in the experiment. In Experiment 3, we explore if the magnitude of the SI effect depends on whether or not the distractor words are part of the response set. Reliable SI effects were obtained in all three experiments and the magnitude of the effect did not vary as a function of whether or not distractor words are part of the response set. These results are problematic for the selection mechanism in the WEAVER++ lexical access model (Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*. 22, 1–75; Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, 42, 107–142). © 2000 Elsevier Science B.V. All rights reserved.

*Keywords:* Speech production; Lexical access; Picture-word interference; WEAVER++

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**1. Introduction**

Levelt, Roelofs and Meyer (1999) have proposed one of the more influential theories of speech production. The success of the theory is based on two very appealing properties. First, the theory has an impressively broad scope. It covers

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many of the processes and stages involved in language production, ranging from the selection of lexical items and their grammatical properties, to word-form encoding and the retrieval of the word's phonetic composition. Second, since the theory has been implemented as a computer model, WEAVER++, it is exquisitely explicit both in terms of its assumptions about representation types and processes. Much of the credit that WEAVER++ has received comes from its success in simulating the effects observed with the picture-word interference paradigm and especially the results produced by semantically related distractors in picture naming and in picture categorization. In this paradigm, participants are required to name a picture while ignoring the presentation of a distractor word (see MacLeod, 1991; for a review). One of the basic findings obtained with this paradigm is the semantic interference (SI) effect. This effect stands for the slower naming latencies observed when the distractor word and the picture belong to the same semantic category (picture: 'cat', distractor word: 'dog'; e.g. Glaser & Dünghoff, 1984; Glaser & Glaser, 1989; Lupker, 1979; Lupker & Katz, 1981).

In WEAVER++, the SI effect is assumed to reflect differences in the time it takes to select the lemma node of the target response. The selection mechanism makes the following assumptions. First, the lexical nodes corresponding to the pictures' names used in the experiment are *flagged* to indicate that they belong to the response set<sup>1</sup>. Second, the activation coming from the picture or the word is *source-tagged*. Lexical selection is determined by the intersection between a flagged lexical node (always corresponding to a picture's name) and the activation coming from the picture (activation that is tagged). That is, the lexical node that is selected corresponds to the first flagged lexical node that receives activation from the picture source. Third, the previous intersection is not sufficient for triggering a response, but two other criteria must be met: a) the activation of the 'selected' lexical node has to surpass the activation of the other flagged lexical nodes by a critical amount, and b) once this criterion has been met the selection is a random event that depends on the general activation of all the items included in the experiment (the so-called Luce ratio<sup>2</sup>).

In this framework, the SI effect is explained in terms of the time it takes to reach the postulated critical difference between the target and other flagged nodes (criterion *a*). This difference is reached later in the case of semantically related than semantically unrelated distractors. This is because the activation levels of the target and semantically related distractor nodes are more similar than the activation levels of the target and semantically unrelated distractor nodes. This difference comes about because the related but not the unrelated distractors receive some activation

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<sup>1</sup> In the picture-word interference experiments, the experimental pictures are usually presented in advance to the participants in order to familiarize them with the experimental materials. According to Roelofs (1992), flagging of possible responses takes place during this training phase.

<sup>2</sup> This index is computed by dividing the activation of the target lexical node at a particular moment in time by the sum of the activation of all the lexical nodes involved in the experiment (distractors and targets). At a particular moment in time, the probability of selecting the target lexical node depends on the result of this ratio: the greater the product of this ratio, the higher the probability of selecting the target lexical node.

from the target conceptual node. Thus, for example, when the picture of a “cat” is presented with the distractor “dog”, the picture activates the concept *CAT(X)* which spreads activation to the concept *DOG(X)* which, in turn, activates the lexical node *dog*<sup>3</sup>. However, if the distractor word were “pot,” it would not receive activation from *CAT(X)* and thus its lexical node *pot* would have a lower level of activation than *dog*. Thus, everything else being equal, the level of activation of *dog* is higher than that of *pot*.

Note, however, that what is important in *WEAVER++* is not the absolute levels of activation of distractor nodes but their activation levels relative to that of the target lexical node. And since activation flows not only from the target stimulus to the distractor lexical node but also from the distractor word to the target lexical node, we must assume that the amounts of activation that reaches the two lexical nodes are not the same. This assumption of asymmetric activation of target and distractor lexical nodes is necessary for otherwise the simple addition of equal amounts of activation to the two nodes would leave unchanged their relative activation levels and therefore would not provide the basis for greater interference for related than unrelated distractors. In *WEAVER++* asymmetric activation of target and distractor lexical nodes is achieved by **stipulating** that a larger number of nodes must be traversed for activation to reach the target lexical node from the distractor word than for activation to reach the distractor lexical node from the picture. And, on the assumption that longer pathways result in smaller activation the expectation is that the distractor lexical node will receive relatively more activation than the target lexical node. Thus, for example, when the picture of a “cat” is presented with the distractor “dog”, the lexical node *dog* sends activation to the concept *DOG(X)*, which in turn sends activation to the concept *CAT(X)*, which finally activates the target lexical node *cat*. This involves traversing three nodes: *dog* → *DOG(X)* → *CAT(X)* → *cat*. By contrast, only two nodes must be traversed in the lexical system for activation to reach the target lexical node: *CAT(X)* → *DOG(X)* → *dog*. Therefore, the distractor lexical node *dog* will benefit more than the target lexical node *cat*.

Of particular importance here is the model’s assumption that the critical activation difference needed to trigger the response depends on the activation of the target lexical node in comparison to the activation of **only** the previously flagged lexical nodes. Given this assumption, lexical competition (and SI) can only be obtained with distractors that are also flagged (i.e. they are part of the response set). This is because the critical activation difference is computed by considering only the activation of **possible** responses in the experiment (the previously flagged lexical nodes). We will call this assumption the “restricted set assumption” (RSA).

The assumption that only distractors that are part of the response set can induce interference seems to fly in the face of the well established fact that SI is obtained for distractor words that are not pictures in the experiment, and therefore are not part of

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<sup>3</sup> Following the notation used by Roelofs (1992), words in capital letters denote conceptual representations, WORDS IN ITALIC AND IN LOWERCASE represent lexical nodes, and words in quotations represent either the pictures or the distractor words.

the response set (e.g. Costa, Miozzo & Caramazza, 1999; La Heij, 1988; Lupker, 1979; Meyer, 1996; Miozzo & Caramazza, 1999; Schriefers, Meyer & Levelt, 1990; Starreveld & La Heij, 1995, 1996). Nonetheless, Roelofs (1992) has provided a possible explanation of the SI effect with non-response-set distractors that is compatible with the seemingly paradoxical RSA. The claim is that the SI effects that are observed in those studies are the result of **mediated** rather than direct interference from distractor lexical nodes. In the studies cited above there were at least two pictures from the same semantic category (e.g. “cat” and “dog”) in the response set. In this situation, it could be that the interference created by a distractor word (e.g. “fox”) that is not in the response set is due to the fact that the distractor word (“fox”) activates the lexical node of a semantically related word that is in the response set (e.g. *dog*). In the example considered here, since “dog” is a possible response in the experiment, it can act as a competitor in trying to select *cat* ( $fox \rightarrow FOX(X) \rightarrow DOG(X) \rightarrow dog$ ). It follows from this argument that the interference created by the distractor word “fox” would disappear if “dog” were not in the response set.

Roelofs (1992) tested this prediction in an experiment in which only one picture per semantic category was included. The results of this experiment showed: a) no SI when the distractor word and the picture were presented simultaneously (SOA 0); and b) semantic facilitation when the word was presented 100 ms. before the picture (SOA -100). These results are consistent with quantitative predictions from WEAVER++.

Here we report a series of experiments designed to test the selection mechanisms in WEAVER++. We have two objectives. First, we examine whether SI may be obtained when the distractor words are not part of the response set and when there is only one picture per semantic category. This is an important issue since the RSA has only been tested directly in one experiment. In that experiment, Roelofs (1992) used only a very small number of target pictures, which were repeated many times. However, it has been shown that the number of target items and the number of times they are presented affect the magnitude of SI (La Heij & van den Hof, 1995) - the smaller the target set and the larger the number of repetitions the smaller the SI effect. Thus, it is important to assess the RSA with a more powerful experimental design. This issue is investigated in Experiments 1 and 2. Second, in Experiment 3 we attempt to establish whether the magnitude of the SI effect depends on the response set status of the distractors.

## 2. Experiment 1: One picture per semantic category

### 2.1. Method

Thirty-six native English speakers were asked to name 21 pictures belonging to different semantic categories (see appendix A). Pictures were paired with 3 different distractors: a semantically related word, an unrelated distractor, and a string of XXXs (see appendix A for the criteria used in the selection and pairing of the

distractors). The size of the pictures was approximately  $10 \times 10$  cm and the distractors were presented in upper-case Geneva 20 points bold. The picture outlines and the words were presented in black on a white background. The stimuli were presented in the center of the screen. To prevent participants from anticipating a distractor's position, word position varied randomly in the region around fixation. For a given picture, however, the distractors always appeared in the same location.

Participants were assigned to two groups corresponding to two SOAs (SOA  $-100$ , and SOA  $0$ ). Stimuli were presented in 3 different blocks of 21 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. Participants were tested individually and were instructed to name the pictures as fast and as accurately as possible while ignoring the printed words. Before the experiment proper, two training blocks containing all the pictures were administered. Participants were asked to name these pictures with the word they usually use and they were told that those pictures were the ones appearing in the experiment. These two blocks should allow participants to "flag" the lexical nodes included in the response set if such a mechanism exists. Each experimental trial had the following structure. First, a fixation point (a cross) was shown in the center of the screen for 700 ms, and was then replaced by the stimulus. In the negative SOA group, the word was presented 100 ms before the picture and the two stimuli remained on the screen for 600 ms. In the other SOA group, the picture and the word were presented simultaneously and they remained on the screen for 600 ms. Participants initiated the next trial by pressing the space bar.

## 2.2. Results and discussion

The following types of responses were scored as errors and were excluded from the analyses (2% of the responses): (a) production of names that differed from those designated by the experimenter; (b) verbal disfluencies (stuttering, utterance repairs); c) recording failures. 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 (type of SOA:  $-100$  and  $0$ ). The results of the error analyses are reported only if significant (see Table 1).

Slower naming latencies were observed with semantically related than with unrelated distractors ( $F(1, 34) = 23.9$ ,  $MSE = 605.5$ ,  $P < 0.001$ ;  $F(1, 20) = 6.8$ ,  $MSE = 2115.4$ ,  $P < 0.017$ ). Participants responses were also slower for the SOA  $0$  than for the SOA  $-100$  although the difference only reached significant levels in the analyses by items ( $F(1, 34) = 2.4$ ,  $MSE = 13209.5$ ,  $P < 0.12$ ;  $F(1, 20) = 73.7$ ,  $MSE = 503.1$ ,  $P < 0.001$ ). The interaction between the two variables was not significant (both  $F_s < 1$ ), indicating that the magnitude of the SI effect was statistically identical in the two SOAs. Post-hoc analyses revealed that the SI effect was significant for the two SOA's (all  $P_s < 0.05$ ). The differences between the two

Table 1

Mean reaction time (RT), standard deviation (SD) and Error% - Experiment 1

Distractor type	SOA					
	SOA -100			SOA 0		
	SD	Error%	RT's	SD	Error%	RT's
Semantically related	723	81	3.3	766	102	3.1
Semantically unrelated	695	63	3.1	737	80	2.1
XXXXX	669	60	1.2	680	67	0.7
Semantic interference (Related-unrelated)	27			29		

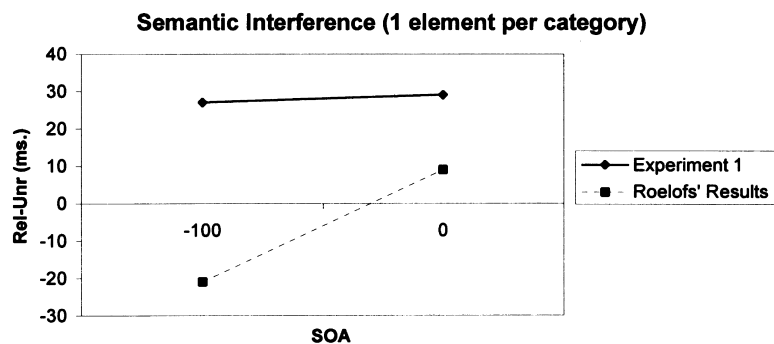


Fig. 1. The difference in RT between related and unrelated distractors in Experiment 1 and in Roelofs' experiment (Roelofs, 1992).

experimental conditions and the XXX condition were also significant (all  $P$ s < 0.001). The only significant difference observed in the error analyses was between the semantically related and the XXX conditions (both  $P$ s < 0.001).

The results of this experiment show that SI may be obtained at negative and zero SOAs both when the distractor words are not part of the response set (e.g. they are not pictures in the experiment) and when only one picture per semantic category is included in the experiment. These results contrast with the results reported by Roelofs (1992), where no SI was obtained at SOA 0, and semantic facilitation was obtained at negative SOAs (see Fig. 1).

### 3. Experiment 2: Replication and extension of Experiment 1

The goal of this experiment is to replicate the SI effect obtained in the previous experiment with two different sets of distractors in order to assess the reliability of the effect.

### 3.1. Method

#### 3.1.1. Material

We selected 20 pictures belonging to 20 of the 21 categories used in Experiment 1 (see Appendix B). Two sets of semantically related and unrelated distractors were selected following the same criteria as in Experiment 1. None of the distractors was in the response set of the experiment. Each picture was presented five times, twice with a semantically related, twice with an unrelated distractor, and once with a string of XXXs. Each word distractor was paired once with a semantically related picture and once with a semantically unrelated picture. For example, the distractor “chair” appeared once with the picture of a “bed” (semantically related condition) and once with the picture of a “bow” (semantically unrelated condition); and the word “gun” appeared once with the picture of a “bed” (semantically unrelated condition) and once with the picture of a “bow” (semantically related condition). Only one SOA was tested in this experiment (SOA 0). Stimuli were presented in 5 different blocks of 20 pictures each. Each picture appeared once per block. In each block, stimuli of the various conditions appeared an equal number of times. Block trials were randomized with the restriction that distractors of the same experimental condition appeared in no more than two consecutive trials. Care was taken not to include the same distractor words in the same block. We also made sure that the distractor word preceding a given picture was not from the same semantic category as the picture. The order of block presentation varied across participants. The procedure was identical to the one in Experiment 1. Twenty five participants took part in Experiment 2.

### 3.2. Results and discussion

Following the same criteria as in Experiment 1, 2.4% of the data points were excluded from the analyses. Two variables were examined: Type of Distractor (semantically related vs. unrelated) and Set of Distractors (SET 1 vs. SET 2) (see Table 2).

Naming latencies were significantly slower with semantically related distractors than with unrelated distractors ( $F(1, 24) = 15.3$ ,  $MSE = 604.2$ ,  $P < 0.001$ ;  $F(1, 19) = 7.8$ ,  $MSE = 900.7$ ,  $P < 0.01$ ). The main effect of Set of Distractor was only significant in the analysis by subjects ( $F(1, 24) = 4.3$ ,  $MSE = 275.2$ ,  $P < 0.03$ ;  $F(1, 19) = 1.9$ ,  $MSE = 842.2$ ,  $P < 0.17$ ). As indicated by the lack of interaction between these two variables (both  $F$ s  $< 1$ ), the magnitude of the SI effect was similar for the two sets of distractors. The differences between each of the experimental conditions and the XXX condition were also significant (all  $P$ s  $< 0.001$ ). No differences were observed in the error analyses. The results of this experiment fully replicate the results obtained in Experiment 1. We have observed a reliable SI effect when the distractors are not part of the response set and when only one picture per semantic category is included in the experiment.

Table 2

Mean reaction time (RT), standard deviation (SD) and Error% - Experiment 2

Distractor type	Set of distractors					
	SET 1			SET 2		
	RT	SD	%Error	RT	SD	%Error
Semantically related	756	86	2.6	764	90	2.6
Unrelated	737	70	2.6	745	78	2.2
XXXXX <sup>a</sup>	676	47	2.2			
Semantic interference (Related-unrelated)	19			19		

<sup>a</sup> Notice that the XXXX condition was part neither of set one nor of set two, it was an independent condition.

#### 4. Experiment 3. Semantic interference and response set

Roelofs (1992) has argued that distractor words that are not part of the response set (e.g. “dog”) may nonetheless produce mediated SI (e.g. through “fox,” say). However, the magnitude of the effect is not expected to be the same in direct and mediated SI. According to WEAVER++, the level of activation spread through the network diminishes with the number of links that are traversed. Thus, for example, the activation received by the non-target lexical node *dog* through the presentation of the distractor word “fox” should be smaller than the activation received by that lexical node when the word “dog” is presented. This is because when the lexical node *dog* is activated through the distractor word “fox” it involves three links ( $fox \rightarrow FOX(X) \rightarrow DOG(X) \rightarrow dog$ ), whereas when the node *dog* is activated by the word “dog” it is direct. As a consequence, one should expect that distractors that are part of the response set (e.g. “dog”) should interfere more than those that are not (e.g. “fish”)<sup>4</sup>.

In this experiment the 20 distractor words included in SET 1 of Experiment 2 appeared both as distractors **and** as pictures (response set distractors). In contrast, the distractors in SET 2 of Experiment 2 were presented only as distractors (non-response set distractors). If the SI created by a given distractor is modulated by its presence in the response set, we should expect a larger SI effect for the words included in SET 1 (response set distractors) than for the words included in SET 2 (non-response set distractors).

##### 4.1. Method

###### 4.1.1. Material

The same pictures as in Experiment 2 were used here. These pictures were

<sup>4</sup> Starreveld and La Heij (1996; 1999) have argued that the parameter values that have been used with WEAVER++ to fit RT data should produce negligible mediated SI. Certainly, mediated SI should be smaller than direct SI.

considered the experimental pictures. In addition, we included 20 new filler pictures corresponding to the 20 distractor words present in SET 1 of Experiment 2. By including these pictures, the words of SET 1 become distractors that are part of the response set. The 20 filler pictures were also paired with two sets of distractors. The first set of distractors corresponds to the names of the 20 experimental pictures. The distractors in the second set were new words. The distractor-picture pairing for the 20 filler pictures followed the same criteria as for the 20 experimental pictures. Stimuli were presented in five different blocks of 40 pictures each. Each picture appeared once per block. In each block, stimuli of the various conditions appeared an equal number of times. Block trials were randomized with the restriction that distractors of the same experimental condition appeared in no more than two consecutive trials. Pictures of the same semantic category were separated at least by 5 different pictures. The procedures, statistical analyses, and precautions taken in ordering stimuli were the same as those used in Experiment 2. Twenty-five participants took part in the experiment.

#### 4.2. Results and discussion

Table 3 shows the mean response latencies and error rates (2.2% of the data) for the experimental conditions as a function of Set of Distractors for the 20 experimental pictures.

As in Experiments 1 and 2, the main effect of Type of Distractor was significant ( $F(1, 24) = 12.5$ ,  $MSE = 1110.3$ ,  $P < 0.002$ ;  $F(1, 19) = 7.7$ ,  $MSE = 1415.0$ ,  $P < 0.01$ ), indicating that naming latencies were significantly slower for semantically related than for unrelated distractors. The main effect of Set of Distractors was not significant (both  $F$ s  $< 1$ ). Of crucial interest here is the interaction between Type of Distractor (Semantically related vs. Unrelated) and Set of Distractors (Set 1 vs. Set 2). This interaction was not significant (both  $F$ s  $< 1$ ), indicating that the magnitude of the SI effect was similar for the two sets of distractors (SET 1 and SET 2). The differences between the two experimental conditions and the XXX condition

Table 3  
Mean reaction time (RT), standard deviation (SD) and Error% - Experiment 3

Distractor type	Set of distractors					
	SET 1 (response set)			SET 2 (non-response set)		
	RT	SD	Error	RT	SD	Error
Semantically related	828	107	3.2	827	111	2.6
Unrelated	805	109	1.4	803	111	1.4
XXXXX <sup>a</sup>	741	99	2.2			
Semantic interference (Related-unrelated)	23	24				

<sup>a</sup> Note that the XXXX condition was part neither of set one nor set two, but it was an independent condition.

were significant (all  $P$ s < 0.01). There were no differences in the error analyses. Thus, the results of this experiment do not support the argument that the SI effect observed with non-response set distractors is mediated through response set distractors (see also La Heij, 1988).

Post-hoc analyses were carried out to compare the results of Experiment 2 and 3. As noted in the Introduction, WEAVER++ predicts that the distractors in Experiment 3 should produce larger SI than distractors in Experiment 2. This is because, in Experiment 3 the distractors were either part of the response set (SET 1), or they would produce interference through the mediation of SET 1 words (SET 2). In this analysis, Experiments (2 vs. 3) were treated as a between-subjects variable and Type of Distractor (semantically related vs. unrelated) and Set of Distractors (Set 1 and Set 2) were treated as within-subjects variables. The results are clear: the interaction between Type of Distractor and the Experiment factors was not significant (both  $F$ s < 1), revealing that the magnitude of the SI effect was similar in the two experiments. Therefore, our results replicate those reported by La Heij (1988) and they suggest that the magnitude of the SI effect does not depend on whether the distractors are part of the response set.

## 5. General discussion

The experiments reported here were designed to test a crucial assumption of Levelt, Roelofs and Meyer (1999) model of lexical access. In WEAVER++ competition for selection among lexical nodes is restricted to those that are possible responses in the experiment, and therefore SI effects should only be found when the experiment contains distractors that are part of the response set. Our experiments found no support for this assumption. We obtained a reliable SI effect even when distractor words are not part of the response set and when only one picture per semantic category is included in the response set.

The results of the present study contrast with the results obtained by Roelofs (1992) who found a non-significant semantic interference trend (9 ms.) in his experiment. A possible explanation for this discrepancy is suggested by the results of a study by La Heij and van den Hof (1995). They found that the magnitude of the semantic interference effect decreases when: (a) small numbers of pictures are used in the experiment; and (b) when the targets are presented repeatedly. In our experiments, we used a reasonably large number of pictures (20 and 21) that were presented only three times in Experiment 1 and five times in Experiments 2 and 3. In contrast, Roelofs only used 9 pictures and they were presented 21 times each in the course of his experiment. As pointed out by La Heij and van den Hof (1995), the combined effects of a very small number of pictures presented very many times may explain why Roelofs did not obtain a SI effect in his experiment.

The other important result in our experiments is the fact that the magnitude of the SI effect does not depend on whether or not the distractor words are part of the response set. This result and the fact that SI is obtained even when only one target name per category is used have two important implications.

First, the results undermine the assumption that the only lexical nodes that are considered for selection in lexical access are those that are included in the response set. In WEAVERTT the target lexical node is selected when its activation surpasses by a critical amount the activation of other lexical nodes that are possible responses in the experiment (the so-called flagged lexical nodes). In such a model, the activation of non-response lexical nodes cannot create interference. However, as our results show, this is not the case – distractors that are not part of the response set also produce SI. This means that the lexical selection mechanism considers for selection all lexical nodes regardless of their status in the experiment.

Second, the results also question the idea that distractor words that are not part of the response set interfere through the activation of a word that is in the response set. As argued above, if this were the case, one should expect larger SI effects from distractors that are in the response set than from distractors that are not. Our results clearly contradict this prediction.

The results of the three experiments reported here undermine the assumptions that define the processing structure of the selection mechanism of the WEAVERTT model of lexical access. Does this mean that we must reject the WEAVERTT model as a whole? Such a move could be premature. Clearly, not all the assumptions in a model are equally important. And it could be argued that the assumptions we have tested are not among the more important ones of the model. Certainly they are not as important as some of its structural properties, such as, for example, the lemma/lexeme distinction (but see Caramazza, 1997). And recently Levelt et al. (1999) suggested that the response set principle implemented in WEAVERTT may be too narrow and not completely accurate. However, it is not obvious what would be the consequences of changing the structure of the selection mechanism of WEAVERTT for its ability to account for other experimental evidence that has been used to support the model. This is because much of the evidence cited in favor of WEAVERTT is based on simulations that include the restricted set assumption. And if we were to reject the latter assumption we would have to re-evaluate the model's ability to account for those other results.

To conclude, if one were willing to drop the response set principle used in WEAVERTT, the *new* model would have to be able to account for the data reported here and the various other data that were previously used to support the old WEAVERTT model. And, of course, it is not obvious that minor changes to the model - that is, changes that do not alter the fundamental architecture of the model - would be successful in this regard. Thus, even though the selection mechanism assumptions we have tested here may not be among the more important assumptions of the model they have played a crucial role in fitting RT data to the model and thus rejection of these assumptions provisionally undermines the model as a whole.

### **Acknowledgements**

The work reported here was supported in part by NIH grant NS22201. Albert Costa was supported by a Fulbright Fellowship from the Spanish government. We

thank Virginia Savova for her help in testing subjects and her comments on various aspects of the research. Correspondence about this article may be addressed to either author at Cognitive Neuropsychology Laboratory, Department of Psychology, William James Hall, Harvard University, 33 Kirkland St., Cambridge, MA 02138, USA.

## Appendix A

### Material employed in Experiment 1<sup>a,b</sup>

Category	Picture	Semantic related	Unrelated
Weapons	Bow	Gun	Cell
Food	Bread	Sausage	Luggage
Vehicle	Car	Bus	Disk
Furniture	Chair	Bed	Farm
Geometry	Circle	Square	Shoulder
Clothes	Coat	Skirt	Nest
Accessories	Comb	Brush	Link
Professions	Doctor	Teacher	Machine
Animals	Dog	Mouse	Bishop
Music	Drum	Violin	Globe
Plants	Flower	Tree	Hair
Tools	Hammer	Wrench	Scallop
Body parts	Hand	Foot	Room
Buildings	Castle	Temple	Stomach
Landscape	Mountain	Island	Paper
Utensils	Plate	Cup	Star
Measures	Ruler	Scales	Mulch
Imagery	Sculpture	Mask	Veil
Cutlery	Spoon	Fork	Dot
Astronomy	Sun	Comet	Clam
Colors	Black	Yellow	Minor

<sup>a</sup>In an informal pretest we asked ten native English speakers whether the 21 pictures and their corresponding semantically related words belonged to the same semantic category. The picture-word pairs included in the experiment were considered to be from the same semantic category by at least the 80% of the participants.

<sup>b</sup>Mean number of letters: semantically **related** = **4.9**, **unrelated** = **5.1**;  $F < 1$ , **range** = **3–8**; mean frequency, semantically **related** = **78**, **unrelated** = **81**;  $F < 1$ .

**Appendix B**Material employed in Experiments 2 and 3<sup>a,b</sup>

Category	Picture	Semantic related Set 1	Unrelated Set 1	Semantic related Set 2	Unrelated Set 2
Furniture	Bed	Chair	Gun	Desk	Star
Weapon	Bow	Gun	Chair	Tank	Piano
Food	Bread	Sausage	Violin	Cheese	Cartoon
Vehicle	Car	Bus	Temple	Truck	Knife
Building	Castle	Temple	Bus	Palace	Fish
Profession	Chef	Teacher	Hair	Waiter	Bush
Accessories	Comb	Brush	Skirt	Barrette	Shovel
Animal	Dog	Mouse	Scales	Fish	Palace
Clothes	Dress	Skirt	Brush	Shirt	Sphere
Music	Drum	Violin	Sausage	Piano	Tank
body parts	Foot	Hair	Teacher	Wrist	Compass
Tools	Hammer	Wrench	Comet	Shovel	Barrette
Landscape	Island	Mountain	Circle	Ocean	Bowl
Astronomy	Moon	Comet	Wrench	Star	Desk
Utensils	Plate	Cup	Flower	Bowl	Ocean
Measurements	Ruler	Scales	Mouse	Compass	Wrist
Cutlery	Spoon	Fork	Mask	Knife	Truck
Imagery	Statue	Mask	Fork	Cartoon	Cheese
Plants	Tree	Flower	Cup	Bush	Waiter
Geometry	Triangle	Circle	Mountain	Sphere	Shirt

<sup>a</sup>Mean number of letters, SET 1: 5.2, SET 2: 5.2;  $F < 1$ , range = 3–8.<sup>b</sup>Mean frequency, SET 1: 54, SET 2: 32;  $F(1, 38) = 2.9$ ,  $P < 0.01$ .**References**

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