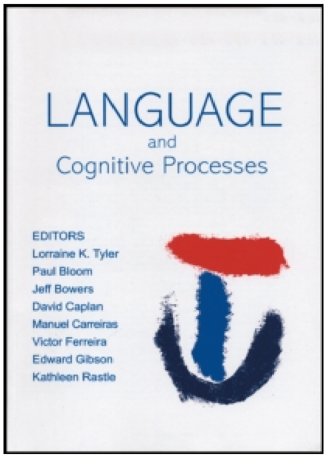

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A critique of simple name-retrieval models of spoken word planning

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A critique of simple name-retrieval models of spoken word planning

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Simple name-retrieval models of spoken word planning (Bloem & La Heij, 2003; Starreveld & La Heij, 1996) maintain (1) that there are two levels in word planning, a conceptual and a lexical phonological level, and (2) that planning a word in both object naming and oral reading involves the selection of a lexical phonological representation. Here, the name retrieval models are compared to more complex models with respect to their ability to account for relevant data. It appears that the name retrieval models cannot easily account for several relevant findings, including some speech error biases, types of morpheme errors, and context effects on the latencies of responding to pictures and words. New analyses of the latency distributions in previous studies also pose a challenge. More complex models account for all these findings. It is concluded that the name retrieval models are too simple and that the greater complexity of the other models is warranted.

INTRODUCTION

In studying spoken word planning, the picture-naming task and Stroop-like paradigms such as picture-word interference have become increasingly important since the early 1990s (e.g., Damian & Martin, 1999; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Levelt, Roelofs, & Meyer, 1999; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991; Roelofs, 1992, 2003; Schriefers, Meyer, & Levelt, 1990; Starreveld & La Heij, 1996). In performing the picture-word interference task, speakers have to

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name pictured objects while simultaneously trying to ignore spoken words that are presented over headphones or written words that are superimposed onto the pictures (e.g., Damian & Martin, 1999; Glaser & Düngelhoff, 1984; Schriefers et al., 1990). Alternatively, speakers respond to the words while ignoring the pictures (e.g., Glaser & Düngelhoff, 1984). Usually, the measurements of interest are the naming latencies and errors. The naming latency refers to the time elapsing between the onset of a stimulus and the onset of the articulation of the word response to that stimulus. Picture naming and picture-word interference experiments have tested a wide range of predictions of models of spoken word planning, both with normal and aphasic speakers (e.g., Dell et al., 1997; Levelt et al., 1999; Rapp & Goldrick, 2000; Ruml, Caramazza, Shelton, & Chialant, 2000).

One of the simplest explanations of spoken word planning and associated context effects is given by 'name retrieval' models. Early, verbally specified versions of such models were proposed by Glaser and Glaser (1989) and La Heij (1988) within a long tradition of research on picture-word processing originating in the 1970s (e.g., Collins & Loftus, 1975). Name retrieval models have more recently been further specified and computationally implemented by La Heij and colleagues (Bloem & La Heij, 2003; Bloem, Van den Bogaard, & La Heij, 2004; Jonkersz, 2004; Starreveld, 1997; Starreveld & La Heij, 1996). For a related implemented model, I refer to Humphreys, Lamote, and Lloyd-Jones (1995). The name retrieval models proposed by La Heij and colleagues maintain: (1) that there are two levels in word planning, a conceptual and a lexical phonological level, whereby lexical concept representations are directly linked to lexical phonological representations; and (2) that planning a word in both object naming and oral reading involves the selection of a lexical phonological representation. The model proposed by Starreveld and La Heij (1996) assumes that activation cascades from the conceptual to the phonological level, whereas the model proposed by Bloem and La Heij (2003) assumes that only selected concepts activate their phonological forms. These models are important, because if they were valid, other models of spoken word planning (i.e., Dell, 1986; Dell et al., 1997; Foygel & Dell, 2000; Levelt et al., 1999; Rapp & Goldrick, 2000; Roelofs, 1992, 1997, 2003) developed within a psycholinguistic line of research would be needlessly complex. Although the name retrieval models are much simpler than these psycholinguistic models, La Heij and colleagues (e.g., Bloem & La Heij, 2003; Jonkersz, 2004; Starreveld, 1997; Starreveld & La Heij, 1996) nevertheless claim that the simple models do a better job in accounting for several facts about word planning than do the more complex models.

In this article, I present an evaluation of the theoretical and empirical adequacy of the name retrieval models proposed by La Heij and colleagues. I start by briefly describing the cascade model proposed by Starreveld and La Heij (1996; Starreveld, 1997), which assumes that concepts automatically activate their phonological forms. Next, I consider how this model accounts for classic findings on errors in spoken word production and for context effects in Stroop-like experiments. Table 1 lists 10 basic findings on spoken word production that are used in evaluating the name retrieval models. The first three findings concern properties of speech errors, and the remainder of the findings concern properties of context effects of picture and word distractors on the latencies of responding to pictures and words. Finding numbers in the text refer to the finding numbers in Table 1. It appears that the model fails to account for the speech error findings and does not account well for the findings on context effects, as I show by two different sets of computer simulations. Modifications that save the model appear to make it equivalent in relevant respects to the more complex models that it challenges, such as the model of Dell and colleagues (Dell, 1986; Dell et al., 1997) and the WEAVER++ model (Levelt et al., 1999; Roelofs, 1992, 1993, 1997, 2003, 2004a, 2004b, 2006a). Next, I evaluate the discrete name-retrieval model presented by Bloem and La Heij (2003; Jonkersz, 2004), which assumes that only selected concepts activate their phonological forms. The discrete model appears to be challenged by existing data and new analyses of the latency distributions of responding in previous studies (i.e., Roelofs, 2006b). Based on these theoretical, computational, and empirical

TABLE 1

Ten findings on spoken word production that are used in evaluating the simple name-retrieval models in the current article

No.	*Finding*
Speech Errors	
1	Mixed semantic-phonological errors are statistically overrepresented.
2	Phonological errors that create words are statistically overrepresented.
3	The distributional properties of some morphemic errors correspond to those of word errors, whereas the distributional properties of other morphemic errors correspond to those of phoneme errors.
Latencies of Responding to Pictures	
4	Distractor words yield semantic interference and phonological facilitation in picture naming.
5	Semantic and phonological effects of distractor words in picture naming interact.
6	The interaction between semantic and phonological effects of distractor words in picture naming may occur before the onset of pure phonological effects.
Latencies of Responding to Words	
7	Distractor pictures yield no Stroop-like and no semantic effects in word reading.
8	Distractor words yield Stroop-like effects but no semantic effects in word reading.
9	Distractor pictures yield semantic facilitation in conceptually driven responding to words.
10	Distractor pictures yield semantic facilitation and gender congruency effects in generating gender-marked noun phrases in response to words.

evaluations, it is concluded that the view on word planning embodied by the name retrieval models is too simple. The greater complexity of the other models is justified, because the latter models provide a better account of the empirical findings than do the name retrieval models.

THE CASCADE NAME-RETRIEVAL MODEL

According to the name retrieval model of word planning proposed by Starreveld and La Heij (1996; Starreveld, 1997), the mental lexicon is a network of nodes and links, which is illustrated in Figure 1. There are two layers of nodes. One layer contains lexical concept nodes like CAT(X) and the other layer contains lexical phonological nodes like *cat*. The two layers are bidirectionally connected. Furthermore, picture input nodes are unidirectionally connected to the corresponding lexical concept nodes (e.g., CAT(X)), and orthographic input nodes (e.g., CAT) are unidirectionally connected to the

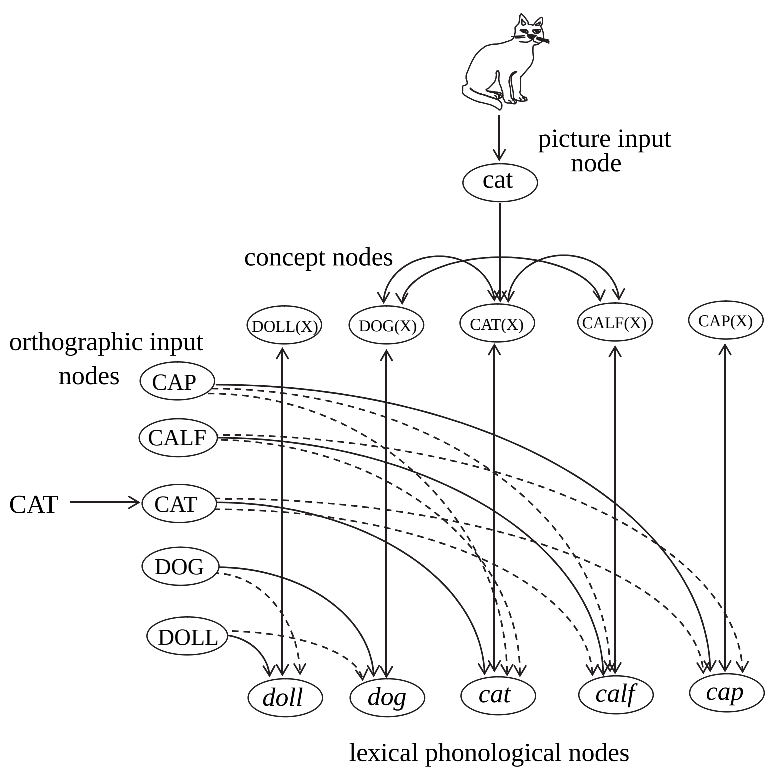

Figure 1. Illustration of the network of the simple name-retrieval model of spoken word planning proposed by Starreveld and La Heij (1996).

corresponding lexical phonological nodes (*cat*). In addition, each orthographic node is weakly connected to the lexical phonological nodes of form-related words. For example, CAT is weakly connected to *calf* and *cap*, which is indicated by the dashed lines in Figure 1. The lexical phonological nodes of such form-related items are not connected, however, presumably because this creates a host of difficult issues concerning the criteria for connecting nodes in the model. For example, should end-related items such as *cat* and *pat* be connected? The nodes of related concepts are connected, however.

In the model, words are retrieved by spreading activation. On a picture-word interference trial, a concept node is activated by the picture and activation cascades through the network. In perceiving a written distractor word, the corresponding orthographic input node is activated. The activated input node sends activation to the corresponding lexical phonological node and to those of phonologically related words. A naming trial ends when a lexical phonological node is selected, which happens when one of the nodes exceeds a critical difference in activation relative to the other lexical phonological nodes. Selection of the lexical phonological node is followed by "the processing of the phonological code through the articulatory system into a vocal response" (Starreveld & La Heij, 1996, p. 904).

FINDINGS 1–3 ON SPEECH ERRORS

Findings on speech errors have motivated assumptions made by more complex models in the literature (Dell, 1986; Foygel & Dell, 2000; Levelt et al., 1999; Rapp & Goldrick, 2000), but the error findings have played no role in developing the name retrieval models. However, models of word planning should be able to account for all findings, of all kinds. The error findings concern mixed error bias (Finding 1 in Table 1), lexical bias (Finding 2), and two types of morpheme errors (Finding 3).

Finding 1. Semantic errors preserve phonological characteristics of the target word at rates greater than would be expected by chance, called 'mixed error bias' (e.g., Dell et al., 1997). For example, when *cat* is intended, the substitution *calf* for *cat* is more likely than *dog* for *cat* if error opportunities are taken into account. Mixed error bias has been observed in corpora of naturally occurring speech errors and also in picture naming experiments, both with aphasic and non-aphasic speakers (e.g., Dell et al., 1997; Rapp & Goldrick, 2000).

The standard interactive account of the mixed error bias (e.g., Dell, 1986; Foygel & Dell, 2000; Rapp & Goldrick, 2000) assumes at least *three* levels of planning. These levels include concept nodes, word nodes (e.g., nodes for *cat*, *dog*, and *calf*), and phoneme nodes (e.g., nodes for /k/, /æ/, /t/, and /f/), which are bidirectionally connected. Semantic substitution errors are taken to involve failures in word node selection. The word *calf* shares phonemes with the target *cat*. Consequently, the word node of *calf* receives feedback from these shared phonemes (e.g., /k/), whereas the word node of *dog* does not. Therefore, the word node of *calf* has a higher level of activation than the word node of *dog* (assuming that calves and dogs are equally cat-like conceptually), and *calf* is more likely than *dog* to be erroneously selected. This may explain the mixed error bias. In addition, it has been argued that in some cases, mixed errors arise at the phoneme level, as a result of cascading of activation from word to phoneme nodes (Rapp & Goldrick, 2000).

Another account for the mixed error bias is in terms of self-monitoring (e.g., Levelt et al., 1999; Roelofs, 2004a). This account holds that, before articulation, a planned word is internally perceived via the speech comprehension system and monitored by a speaker. In planning to say 'cat', the target word *cat* is in the speech comprehension 'cohort' of the error *calf*, but *cat* is not in the comprehension cohort of the error *dog*. Therefore, the error *dog* has a higher chance of being detected than the error *calf* (Roelofs, 2004a). This would also explain the mixed error bias.

The name retrieval model, however, fails to account for the mixed error bias. As Figure 1 shows, in planning to say 'cat', the lexical phonological nodes of *calf* and *dog* also become active. However, *calf* attains the same level of activation as *dog*. This is because there are no phoneme nodes that are shared between *cat* and *calf*. Consequently, there is no preference of selecting *calf* over *dog*. Thus, there is no phonological facilitation of semantic substitution errors. A self-monitoring account is also not possible. According to the designers of the name retrieval model, "the same representations can be used for the production and the comprehension of words" (Starreveld & La Heij, 1996, p. 912). Comprehension is based on spreading of activation from *calf* and *dog* to the corresponding concepts nodes. But the amount of activation that spreads back from *calf* and *dog* is the same, thus the likelihood of error detection should not differ. Hence, a monitoring explanation along the lines of Roelofs (2004a) cannot be given by the name-retrieval model.

Perhaps the failure of the name retrieval model to account for the statistical overrepresentation of mixed errors can be remedied by directly connecting the lexical phonological nodes of form-related words. For example, the nodes *cat*, *calf*, and *cap* may be connected to each other. However, this raises the issue of what the criteria are for connecting nodes. Moreover, connecting phonological nodes leaves other error findings unexplained.

Finding 2. Phonological errors may create nonwords or words. Word outcomes occur at rates greater than would be expected by chance, called 'lexical bias' (e.g., Dell, 1986). For example, in planning to say 'cat', the error 'hat' is more likely than the error 'jat' if error opportunities are taken into account. Lexical bias has been observed in natural speech error collections and also in picture-naming experiments, again both with aphasic and non-aphasic speakers (e.g., Dell, 1986; Rapp & Goldrick, 2000).

According to the standard interactive account of lexical bias (e.g., Dell, 1986; Foygel & Dell, 2000; Rapp & Goldrick, 2000), the effect is due to activation feedback, now from shared phoneme nodes to word nodes (e.g., from /æ/ and /t/ to *cat* and *hat*) and from these word nodes to other phoneme nodes (i.e., from *cat* to /k/ and from *hat* to /h/). Such feedback is not present for nonwords, because there are no word nodes for nonwords in the network (i.e., there is no node *jat* to activate /j/). Consequently, it is more likely that /h/ is selected (yielding 'hat') than that /j/ is selected (yielding 'jat'). This explains the lexical error bias. Alternatively, lexical bias may be explained in terms of self-monitoring of speech planning (e.g., Roelofs, 2004a).

In the name retrieval model, only lexical phonological nodes are selected. Hence, *all* errors will necessarily be word errors. Therefore, the model fails to account for the fact that phonological planning failures typically result in nonword outcomes.

Finding 3. Analyses of corpora of naturally occurring speech errors (e.g., Garrett, 1975, 1980, 1988) have revealed that the distributional properties of some morphemic speech errors correspond to those of word errors, whereas the distributional properties of other morphemic errors correspond to those of phoneme errors. The two types of morpheme errors have been taken as evidence that morphemic information plays a role at two levels of speech planning.

The distributional properties of a first type of morpheme errors correspond to those of word errors. For example, in 'how many pies does it take to make an apple?' (from Garrett, 1988), the interacting stems belong to the same syntactic category (i.e., noun) and come from distinct phrases. This is also characteristic of word exchanges (e.g., as in 'we completely forgot to add the list to the roof', from Garrett, 1980), which virtually always involve items of the same syntactic category and typically ignore phrase boundaries (Garrett, 1975). Morpheme errors such as 'that I'd hear one if I knew it' for 'that I'd know one if I heard it' (from Garrett, 1980) suggest that words at an abstract morpho-syntactic level of planning (*hear*, *know*) may trade places while stranding their morpho-syntactic specification (first person + singular + present tense; first person + singular + past tense). The similarity in distributional properties between these morpheme exchanges and word exchanges suggests that these morpheme errors and word errors occur at the same level of planning. The errors occur when morpho-syntactically specified word representations in a developing syntactic structure trade places.

The distributional properties of a second type of morpheme errors correspond to those of phoneme errors. For example, the exchanging morphemes in an error such as 'slicely thinned' (from Stemberger, 1985) belong to different syntactic categories (adjective and verb) and come from the same phrase. This is also characteristic of phoneme exchanges (e.g., as in 'rack pat' for 'pack rat', from Garrett, 1988), which are typically not affected by syntactic class and which concern words within a single phrase. The second type of morpheme error is constrained by morphological class. Stems exchange with stems and affixes exchange with affixes, but stems do not exchange with affixes. The similarity in distributional properties between these morpheme exchanges and phoneme exchanges suggests that the second type of morpheme errors and phoneme errors occur at the same level of processing, namely the level at which word form components are retrieved and the morpho-phonological form of the utterance is constructed. The exchange errors occur when morphemes or phonemes in a developing morpho-phonological structure trade places.

The name retrieval model has only one lexical level, namely a level of lexical phonological nodes, and therefore it cannot easily account for the two types of morpheme errors. Because lexical phonological nodes are selected, only whole-word errors should occur. In contrast, the two types of morpheme errors are readily explained by models that draw a distinction between a level of abstract morpho-syntactic 'lemma' representations of words and a morpho-phonological level that includes morphemic forms (e.g., Dell, 1986; Levelt et al., 1999; Roelofs, Meyer, & Levelt, 1998).

It is unclear whether Starreveld and La Heij (1996) argue against a lemma level in word planning per se or whether they maintain that a lemma level plays no role in naming isolated objects. At first sight, the latter position would make sense, because the role of lemmas would seem to lie primarily in sentence production. However, this is not the case. Even in picture naming, the functionality provided by lemmas is used. Lemmas allow for the specification of abstract morpho-syntactic parameters. Such parameters need to be specified if speakers have to produce, for example, singular 'cat' rather than plural 'cats' in referring to a pictured cat. Similarly, in naming pictured actions by using verbs (e.g., Roelofs, 1993), morpho-syntactic parameters have to be set. Otherwise, there is no way for the speech production system to know whether, for example, the form *drink*, *drank*, or *drinks* needs to be produced in referring to a drinking person. By having no lemma level, the name retrieval model leaves open how the appropriate form of a word is generated, even in picture naming.

In summary, the name retrieval model of Starreveld and La Heij (1996) does not do a good job in accounting for facts about speech errors, such as mixed error bias (Finding 1), lexical bias (Finding 2), and the two types of morpheme errors (Finding 3). To account for the error findings, the model may drop the assumption that only two levels are involved in planning words. The model may be modified by including a level of phoneme nodes attached to the lexical phonological nodes. Furthermore, the model may include a lemma level intermediate between concepts and phonological word forms to account for the two types of morpheme exchanges and for the generation of the appropriately inflected word form in picture naming. But by changing the name retrieval model in these ways, it becomes equivalent in relevant respects to the more complex models that it challenges (e.g., Dell, 1986; Dell et al., 1997; Foygel & Dell, 2000; Levelt et al., 1999; Rapp & Goldrick, 2000; Roelofs, 1992, 1997).

FINDINGS 4–8 ON RESPONSE LATENCIES

Starreveld and La Heij (1996) and Starreveld (1997, 2000) differentiated phonemic and lexical phonological explanations of phonological effects of distractors in picture naming.[1] They argued for a lexical phonological account, as implemented in the name retrieval model. Next, I evaluate the name retrieval model of Starreveld and La Heij (1996) with respect to its ability to account for findings on context effects in picture naming and word reading.

Context effects in picture naming

Findings 4 and 5. Picture naming is slowed by semantically related distractor words and speeded up by phonologically related words compared with unrelated ones (e.g., Schriefers et al., 1990). For example, the naming of a picture of a cat is typically interfered with by the semantically related distractor DOG compared with a semantically unrelated distractor, and the naming is facilitated by the phonologically related distractor CAP relative to a phonologically unrelated distractor. Semantic and phonological effects interact, which has been taken as critical support for the name retrieval model by Starreveld and La Heij (1996).

In a picture-word interference experiment with written distractor words conducted by Starreveld and La Heij (1996), semantically related, phonologically related, mixed semantic-phonological, and unrelated distractors were presented at stimulus onset asynchronies (SOAs) of -200, -100, 0,

[1] Starreveld (2000) seems to suggest that phonemes may play a role in word planning (p. 515), but that they do not contribute to the phonological effect of distractors (p. 517). The simple name-retrieval model contains no phoneme nodes and it implements the view that phonological effects arise at the lexical phonological level (Starreveld, 2000, p. 517).

100, and 200 ms (a pre-exposure of the distractor is indicated by a minus sign). Production onset latency was the dependent variable of interest. The distractors yielded main semantic and phonological effects, and together the effects interacted at the SOAs of −100 and 0 ms. For example, the semantic interference effect was smaller when target and distractor were phonologically related (CALF versus CAP) than when they were unrelated in form (DOG versus DOLL). Damian and Martin (1999) replicated the interaction with spoken distractor words.

According to the name retrieval model, the orthographic input node CAP not only activates the lexical phonological node of *cap* but also (to a lesser extent) the lexical phonological nodes of phonologically related words such as *calf* and *cat*. Therefore, distractor CAP speeds up the planning of the target *cat* compared to the phonological unrelated distractor DOLL, causing the phonological facilitation effect. The lexical phonological node of distractor DOG (but not that of DOLL) is activated by a pictured cat due to the connection between the concept nodes CAT(X) and DOG(X). Consequently, distractor DOG is a stronger competitor than the semantically unrelated distractor word DOLL, causing the semantic interference effect. When the mixed distractor CALF is presented, the orthographic input node CALF activates the lexical phonological node of the target *cat*, and therefore the impact of the semantic relationship between target and distractor (*cat* and *calf*) is less. This explains the interaction between phonological and semantic relatedness. Starreveld and La Heij (1996) showed by means of computer simulations that the name retrieval model could capture the phonological facilitation effect, the semantic interference effect, and the interaction.

However, if phoneme and lemma nodes are adopted to account for the findings on speech errors (Findings 1–3), these simulation results no longer support the name retrieval model. It then needs to be shown that the *modified* model with phoneme and lemma selection is still able to account for the semantic effect, the phonological effect, and their interaction. In spite of their presence, phonemes and lemmas should play no role in picture-word interference experiments. If they play a role, the model needs to address issues such as how much of the phonological facilitation effect arises at the levels of lexical phonological nodes, phonemes, and lemmas (e.g., Roelofs et al., 1996; Roelofs, 2004a). If phoneme or lemma activation contributes to the phonological facilitation in the model, this would be a change of theory, because currently the name retrieval model implements the claim that phonological facilitation is fully due to the speeding up of the selection of lexical phonological representations (Starreveld, 1997, 2000; Starreveld & La Heij, 1996).

Moreover, there exists an empirical challenge (Roelofs, 2004a). According to the name retrieval model, the interaction effect and the pure phonological effect go together. Because semantic and phonological relatedness affect the same level in the model, a reduction of semantic interference for mixed distractors (e.g., CALF) should not be observed *before* the onset of the pure phonological facilitation from distractors (e.g., CAP). However, this prediction is not supported empirically, as I discuss next.

Finding 6. Damian and Martin (1999) presented spoken distractor words at three SOAs during picture naming. The onset of the spoken distractor was 150 ms before picture onset, simultaneously with, or 150 ms after picture onset. They observed semantic interference at the SOAs of −150 and 0 ms, and phonological facilitation at 0 and 150 ms. The mixed distractors yielded no effect at SOA = −150 ms and facilitation at the later SOAs. Thus, the reduction of semantic interference for mixed distractors was observed at an SOA (i.e., at SOA = −150 ms) at which there was *no* pure phonological facilitation. This is displayed by the left-most panel of Figure 2.

To assess how well the name retrieval model accounts for the data of Damian and Martin (1999), I implemented the model following the specifications in Starreveld and La Heij (1996) and replicated the simulation results reported in their article. Next, I examined the relationship in the model between the reduction of the semantic effect for mixed distractors and the pure phonological effect. The phonological effect was manipulated in the simulations by varying parameter w_{io} of the model, which is the proportion of the activation of the distractor input that is sent to the lexical nodes of phonologically related words. The percentages shown in Figure 2 indicate percentages of parameter w_{io}. Figure 2 shows the effect of manipulating this parameter on the mixed and pure phonological effects in the simulations.

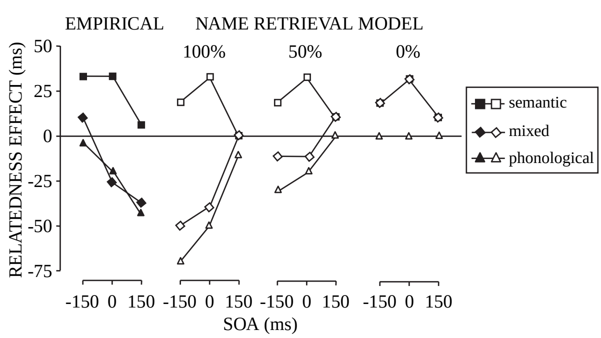

Figure 2. Effects of semantic, phonological, and mixed spoken-word distractors relative to unrelated distractors per stimulus onset asynchrony (SOA) in picture naming. The far left panel shows the real data (Finding 6) of Damian and Martin (1999), and the other panels show the results of computer simulations with the name retrieval model of Starreveld and La Heij (1996). The percentages indicate the proportion of w_{io} of activation given to form-related neighbours of the distractors in the simulations.

Starreveld and La Heij (1996) used SOAs of −200, −100, 0, 100, and 200 ms, whereas I ran the simulations using SOAs of −150, 0, and 150 ms, which were the SOAs of Damian and Martin (1999).

When the proportion of shared input was 100% w_{io}, the model produced pure phonological effects and an interaction between semantic and phonological effects at SOA = 0 and 150 ms. When phonologically related neighbours received 50% less activation (50% w_{io}), the size of both the phonological effects and the mixed effects was reduced. Reducing the shared input further (not shown in Figure 2) also decreased the phonological and mixed effects, whereby the effects disappeared earlier at SOA = 0 ms than at SOA = −150 ms. The interaction effect did not precede the phonological form effect. Finally, when phonologically related neighbours were no longer co-activated (0% w_{io}), there was no pure phonological effect and the mixed distractors behave exactly like the semantic distractors. To conclude, in the name retrieval model, the interaction and the phonological form effect go together. The interaction is not observed before the onset of a pure phonological effect, in disagreement with the empirical observations of Damian and Martin (1999).

An important difference between the experiments of Starreveld and La Heij (1996) and Damian and Martin (1999) is the distractor modality. Whereas Starreveld and La Heij (1996) used written distractor words, Damian and Martin (1999) used spoken words. Perhaps the name retrieval model has trouble explaining the findings of Damian and Martin (1999) because it was developed for written distractors. However, Starreveld (2000) proposed to "adopt the same account of phonological effects obtained with auditory distractors as the one that is used for phonological effects obtained with visual distractors" (p. 517) with one additional assumption. With auditory distractors "the word-form representation of the target (the picture's name) is first activated, as long as it matches the input signal and then, as soon as the input signal starts to mismatch the target's representation, is quickly deactivated" (p. 518). This explains why the onset of semantic effects may precede those of phonological effects when the distractors are presented in the auditory modality (e.g., Schriefers et al., 1990), whereas the effects overlap in the visual modality (e.g., Starreveld & La Heij, 1996).

However, if phonological mismatch reduces the facilitation of spoken distractors at SOA = −150 ms, it should also reduce the effect for the mixed distractors, as the manipulations of parameter w_{io} showed (see Figure 2). If no pure phonological effect is present at SOA = −150 ms because of the mismatch, an interaction effect for the mixed distractors should be absent. However, the data of Damian and Martin (1999) showed that the interaction effect was present at SOA = −150 ms despite the absence of a pure phonological effect at this SOA. Thus, it is unlikely that the name retrieval model fails to explain the findings of Damian and Martin (1999) because it was originally developed for written distractors. Instead, the failure stems from the type of connection between semantic and phonological effects in the model.

Elsewhere (Roelofs et al., 1996; Roelofs, 2004a), I demonstrated the utility of an account according to which the interaction effect and the pure phonological effect happen at different planning levels, namely the lemma and the word-form level, respectively. Such an account explains why the interaction and the pure phonological effect do not necessarily go hand in hand, as demonstrated by WEAVER++ simulations (Roelofs, 2004a). According to this view, the mixed distractor CALF yields less interference than DOG, because the lemma of the target CAT is primed as a comprehension cohort member of the distractor CALF but not of the distractor DOG, yielding an interaction between semantic and phonological relatedness. The phonological effect itself is due to the priming of the subsequent processes of word-form encoding for production, including phoneme retrieval.[2]

Context effects in reading aloud

Finding 7. Whereas distractor words yield Stroop-like and semantic effects in picture naming, distractor pictures yield no effect at all in oral reading (e.g., Glaser & Düngelhoff, 1984; Roelofs, 2003, 2006a, 2006b). Starreveld and La Heij (1996) showed that the name retrieval model was able to simulate the absence of an effect of picture distractors on word reading. Because the selection of lexical phonological nodes in reading happens very quickly in the model, there is little room for influences of distractor pictures. This explains the absence of effects of distractor pictures on word reading.

Finding 8. Starreveld and La Heij (1996) claim that the name retrieval model is also able to simulate the context effects obtained in the word-word variant of the Stroop task. When word-word stimuli are used and one of the words has to be read aloud, Stroop-like interference of more than 100 ms is obtained, but no semantic effect (e.g., Glaser & Glaser, 1989; Roelofs,

[2] According to an anonymous reviewer, the cascade account of Vigliocco and Hartsuiker (2002, p. 453) is able to account for the mixed effect in the absence of a phonological effect. Their proposal holds that the semantic effect occurs at the lemma level and the mixed effect at the phonological level. At the early SOA, phonological priming would be present and cause the mixed effect, but the pure phonological effect itself would be too weak to be observable. According to the reviewer "This proposal does not claim the effects are absent – just that they are not visible. Of course, such a proposal relies on a number of interacting assumptions that would have to be more explicitly modelled". Different from Starreveld and La Heij (1996), this account assumes levels of lemmas and phonemes, like the two-level account proposed by Roelofs (2004a).

2006b). For example, relative to a control condition with a series of Xs, the congruent distractor word CAT facilitates reading CAT, and the incongruent words DOG and TREE yield interference (see left-hand panel of Figure 3). However, there is no difference in effect between DOG and TREE (i.e., the semantic effect is absent). Stroop-like effects are also obtained from spoken distractor words in word reading (Roelofs, 2005a). Simulations by Starreveld and La Heij (1996, p. 906) showed that the name retrieval model captures the absence of a semantic effect in reading aloud. However, new simulations that I conducted revealed that the model yields almost no Stroop-like conflict, contrary to the empirical data.

The right-hand panel of Figure 3 shows the simulation results by the lines labelled '100%', indicating that the activation input A_{in} to the target and distractor nodes was set to the parameter value used by Starreveld and La Heij (1996). In the model, incongruent distractor words (e.g., distractor word DOG in reading aloud the word CAT) yielded a very small interference effect at the longest pre-exposure SOA only. Congruent distractors (the word CAT in reading aloud CAT) yielded no effect at all. The simulation results clearly disagree with the empirical data (Roelofs, 2006b; see also Glaser & Glaser, 1982; Glaser & Glaser, 1989).

The simulations also revealed that by increasing the amount of activation input A_{in} to the distractor word relative to the target from 100% to 400%, as indicated by the percentages in Figure 3, the impact of distractors increased.

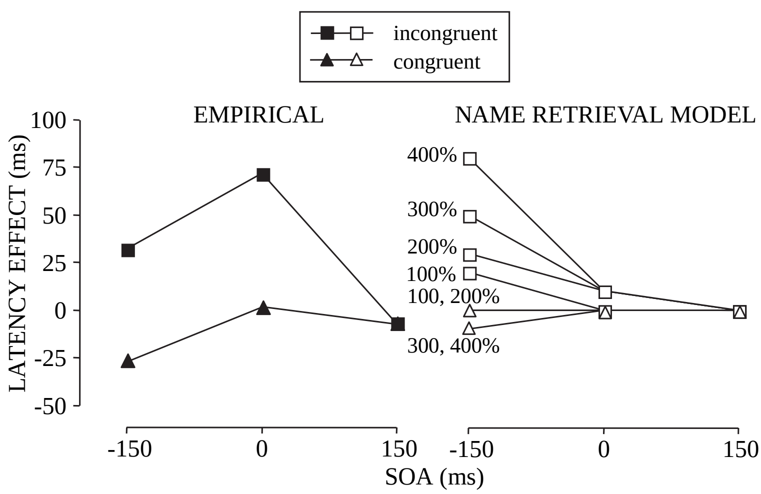

Figure 3. Effects of incongruent and congruent written-word distractors relative to a control condition per stimulus onset asynchrony (SOA) in word reading. The left-hand panel shows the real data (Finding 8) of Roelofs (2006b) and the right-hand panel shows the results of computer simulations with the name retrieval model of Starreveld and La Heij (1996). The percentages indicate the amount of activation A_{in} given to the distractor word.

This manipulation implies that distractors provide more activation to the network than targets, which is odd. However, the input manipulation reveals the fundamental shape of the SOA curves. Increasing the selection threshold had a similar impact. The effects peaked with distractor pre-exposure, in contrast to the real data (Roelofs, 2006b; see also Glaser & Glaser, 1982; Glaser & Glaser, 1989).

To summarise, the name retrieval model correctly yields no semantic effect in the word-word variant of the Stroop task. However, the model yields almost no Stroop-like effect in this task, contrary to the empirical data. Moreover, when the distractor input is much increased relative to the target input, interference is obtained, but with the wrong time course.

The reason why Starreveld and La Heij (1996) believe that the name retrieval model was able to simulate the word-word findings was that they choose to simulate Glaser and Glaser's (1982) Experiment 4. However, this experiment is atypical in that it specifically tested for an effect of spatial certainty of the target and distractor word on the Stroop phenomenon. Indeed, the normal Stroop conflict around SOA = 0 ms was absent in the real data, but this is an unusual finding. With spatial uncertainty (e.g., Glaser & Glaser, 1982, Experiment 3), which is the standard situation, a Stroop conflict around SOA = 0 ms is present.

Elsewhere (Roelofs, 2003, 2006b), I have shown that Findings 7 and 8 on word reading are readily explained by a model like WEAVER++. This model postulates a level of representation intermediate between concepts and phonological word forms, namely the lemma level. Picture naming necessarily involves both lemma selection and word-form encoding, but oral reading can be accomplished by word-form encoding only. In reading aloud, alternative word forms compete for selection during the encoding of the target word form. However, because no lemmas are selected, a semantic effect is absent (see Roelofs, 2003, 2006b, for details).

To conclude, the name retrieval model does not account well for classic context effects in word reading. The model explains why distractor pictures have no effect on word reading (Finding 7), but it fails to explain why distractor words *do* have an impact on reading (Finding 8). To account for the Stroop-like findings, the name retrieval model may drop the assumption that only two levels are involved in planning words. The model may include a level of representation intermediate between concepts and lexical phonological forms, and assume that this intermediate level is critically involved in picture naming but not in word reading. Moreover, a level of phonemes may be included in the model. The levels of lexical phonological nodes and phoneme nodes may give rise to form effects in simulations of the word-word task. But by adding these planning levels, the name retrieval model becomes equivalent in relevant respects to models that it challenges, like WEAVER++ (Levelt et al., 1999; Roelofs, 1992, 1997, 2003).

THE DISCRETE NAME-RETRIEVAL MODEL

The cascade name-retrieval model proposed by Starreveld and La Heij (1996; Starreveld, 1997) has been modified by Bloem and La Heij (2003). In particular, Bloem and La Heij (2003; Jonkersz, 2004) assume that only selected concepts activate their lexical phonological representations. The modification intended to account for certain new empirical findings from a word translation task, namely a 'semantic relatedness paradox'.

Below, I first discuss the finding that motivated the discreteness assumption (i.e., Finding 9). Next, I evaluate the discrete model on the basis of other findings. The findings concern existing data and new distributional analyses of previous studies (i.e., Roelofs, 2006b).

FINDINGS 9 AND 10 ON RESPONSE LATENCIES

Finding 9. Bloem and La Heij (2003) observed that a written English word is translated faster into Dutch (e.g., saying Dutch 'hond' in response to English DOG) by Dutch-English bilingual speakers when the English word is superimposed onto a pictured cat (semantically related) compared with a pictured tree (semantically unrelated). In contrast, translating the word DOG is slower when the Dutch distractor word KAT (CAT, semantically related) is presented compared with the Dutch word BOOM (TREE, semantically unrelated). Thus, the direction of the semantic effect differs between distractor pictures and words: a semantic relatedness paradox (Bloem & La Heij, 2003). A similar difference in the direction of semantic effects has been obtained with picture naming and word categorising. In naming pictured objects, semantic interference is obtained from word distractors (e.g., Glaser & Düngelhoff, 1984). For example, naming a pictured dog is slowed down by the distractor word CAT (semantically related) compared with the word TREE (semantically unrelated). However, picture distractors yield semantic facilitation in word categorising. For example, producing the hyperonym 'animal' in response to the word DOG is faster when the word is superimposed onto a pictured cat compared with a pictured tree.

According to Bloem and La Heij (2003), the difference in direction of the semantic effects suggests that "context pictures activate their conceptual representations, but do not automatically activate their names" (p. 476). Consequently, distractor pictures help concept selection in a translation task but they do not lead to competition in selecting the target word, yielding semantic facilitation. In contrast, because distractor words automatically activate the corresponding names, they compete in naming pictures and translating words, yielding semantic interference.

However, the discreteness assumption of Bloem and La Heij (2003) is not necessary, because models without this assumption can also account for the semantic relatedness paradox. For example, WEAVER++ has simulated both the semantic interference from distractor words in picture naming and the semantic facilitation from distractor pictures in conceptually driven responding to words (e.g., Roelofs, 1992, 2003, 2006b; Levelt et al., 1999). More importantly, the discreteness assumption is challenged by empirical findings.

Finding 10. If perceived objects activate their names only if a speaker wants to name the objects, the concept selection in word categorising and translating is critical for obtaining the semantic facilitation effect from pictures. The effect should not be obtained when only lemma level information, such as a word's grammatical gender, needs to be selected. I have tested this prediction in experiments that exploited the linguistic fact that nouns take gender-marked articles in Dutch definite noun phrases, namely 'het' with neuter gender and 'de' with non-neuter gender (Roelofs, 2003, 2006b). When a noun is presented and participants have to read aloud the noun while preceding the noun by its gender-marked article (not visually presented), the grammatical gender of the noun needs to be retrieved to determine the right article, 'de' or 'het'. For example, if participants have to respond to the word HOND (dog) by saying 'de hond', the gender of the noun *hond* needs to be accessed to determine the correct determiner, 'de'. If distractor pictures do not activate the lemmas of their names, as the discrete name-retrieval model holds, semantic facilitation should not be obtained.

However, contrary to this prediction by the discrete model (Bloem & La Heij, 2003; Jonkersz, 2004), semantic facilitation was obtained in the experiments (Roelofs, 2003, 2006b). This finding suggests that activation cascades from concepts to lemmas, as assumed by WEAVER++. Moreover, in other experiments, distractor pictures yielded a gender congruency effect. Saying 'de hond' to the word HOND went faster when a semantically unrelated picture had a name with the same gender as the word than when the gender of picture and word differed (Roelofs, 2006b). The pictures had no effect at all when the words were simply read aloud without article. These findings challenge the discrete name-retrieval model.

Moreover, the discrete model is challenged by findings of Morsella and Miozzo (2002) and Navarette and Costa (2005). Participants were given pictures in green superimposed onto pictures in red. The task was to name the pictures in green while ignoring the pictures in red. The picture names were phonologically related or unrelated. Morsella and Miozzo (2002) and Navarette and Costa (2005) observed that target pictures were named faster when the distractor picture was phonologically related than when it was unrelated. This suggests that activation spreads continuously from the distractor picture to the phonological form of its name, unlike what the discrete name retrieval model assumes. Roelofs (2007) presented a weakly cascading version of WEAVER++ to accommodate this finding (cf. Roelofs, 2003; Roelofs & Verhoef, 2006).

In response to the empirical challenges, Bloem et al. (2004; Jonkersz, 2004) suggested that lapses of attention, leading to an erroneous selection of the distractor picture concept and activation of its name on some of the trials, explain the context effects of pictures. I performed a new test of this account by examining the latency distributions of the responses in my previous studies. If the semantic and gender congruency effects of context pictures on producing gender-marked noun phrases are due to an inadvertent activation of the context picture name on some of the trials, followed by a covert repair, the effects should be present for only a part of the latency distribution, namely for the slow responses only (cf. De Jong, Berendsen, & Cools, 1999). Instead, if the context effects are due to cascading of activation from concepts to lemmas, the effects are expected to be present across the whole latency distributions.

To obtain the latency distributions for the relevant experiments of Roelofs (2006b), I divided the rank-ordered response latencies for each participant into deciles (10% bins) and computed mean latencies for each bin, separately for the semantically related and unrelated conditions (Experiment 1A, SOA = 0 ms) and the gender congruent and incongruent conditions (Experiment 3B). By averaging these bin means across participants, so-called Vincentised cumulative distribution functions are obtained (Ratcliff, 1979). Vincentising the latency data across individual participants provides a way of averaging data while preserving the shapes of the individual distributions. Figure 4 shows the distributional plots for the semantic and gender conditions.

The left-hand panel of Figure 4 shows the latency distributions for the semantically related and unrelated conditions. The figure shows that the size of the semantic effect increased with latency, but importantly, the effect was present throughout the entire latency range. Statistical analysis revealed that there were effects of semantic relatedness, $F(1, 11) = 20.61$, $p = .001$, and decile, $F(9, 99) = 126.87$, $p = .001$. Relatedness and decile interacted, $F(9, 99) = 2.63$, $p = .009$, confirming that the magnitude of the semantic facilitation increased with latency. However, the semantic effect was already present for the first decile, $F(1, 11) = 6.55$, $p = .027$. The presence of the semantic effect across the whole latency distribution challenges the suggestion by Bloem et al. (2004) that the effect is due to occasional lapses of attention. If this were the case, the effect should have been present for the slowest responses only.

The right-hand panel of Figure 4 shows the latency distributions for the gender congruent and incongruent conditions. The gender congruency effect was small (i.e., only 9 ms, on average), but the effect was present throughout

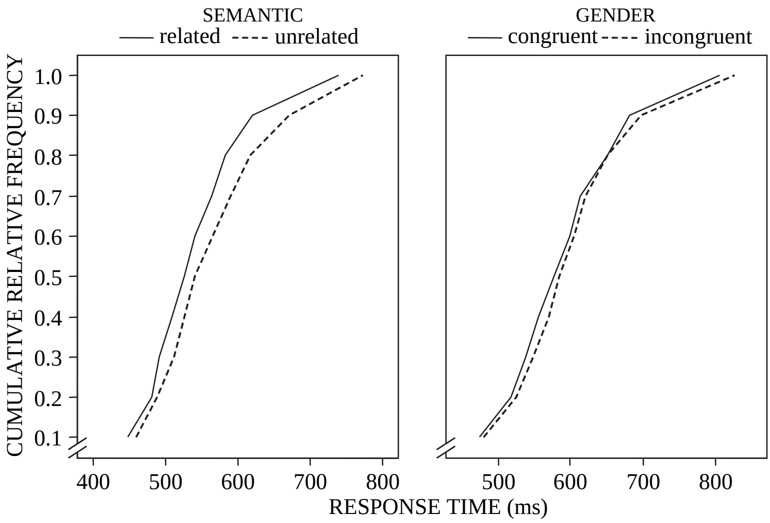

Figure 4. Vincentised cumulative distribution curves for the latencies of producing gender-marked noun phrases in response to written nouns with semantically related and unrelated distractor pictures (left-hand panel) and gender congruent and incongruent distractor pictures (right-hand panel). The data are from Roelofs (2006b).

the entire latency range, except for the eighth decile. Statistical analysis revealed that there were effects of gender congruency, $F(1, 11) = 4.90$, $p = .046$, and decile, $F(9, 99) = 150.27$, $p = .001$. Congruency and decile did not interact, $F(9, 99) = 0.33$, $p = .96$, confirming that the magnitude of the gender effect was constant across the latency range. The presence of the gender congruency effect of picture distractors across the whole latency distribution challenges the suggestion by Bloem et al. (2004) that the effect is due to the occasional odd trial.

To conclude, analyses of the latency distributions reveal that the semantic and gender effects of context pictures are present across the whole latency distribution rather than being restricted to part of it. This excludes an interpretation of the context effects of the pictures in terms of lapses of attention on some of the trials, as suggested by Bloem et al. (2004).

A final problem with the discrete model needs to be discussed. If only selected concepts activate their lexical phonological representations, the account of semantic interference effects provided by Starreveld and La Heij (1996) no longer holds, as Bloem and La Heij (2003, p. 478) noted. In the cascade model, semantic interference occurs because a pictured cat activates, via the concepts CAT(X) and DOG(X), the lexical phonological node of *dog* (semantically related) but not of *tree* (unrelated). Consequently, *dog* will be more highly activated than *tree*. Therefore, *dog* will be a stronger competitor than *tree* in selecting the target *cat*. This explains the semantic interference (cf. Roelofs, 1992). However, if CAT(X) only activates its lexical phonological node *cat*, then the nodes *dog* and *tree* will have the same level of activation, and the semantic interference effect is no longer explained. To remedy this problem, Bloem and La Heij (2003) propose that concepts nodes are not only connected to their own lexical phonological node, but also to those of semantic competitors. For example, the concept CAT(X) is also weakly linked to the lexical phonological node of *dog*.

A problem with the proposal of connections between concepts nodes and the lexical phonological nodes of semantic competitors is that it is ad hoc. What could be the functional reason for such connections? The only reason for including these connections in the model is to account for semantic interference effects. More importantly, after examining the performance of the discrete model through computer simulations, Jonkersz (2004) noted that "the interaction between semantic and phonological context effects reported by Starreveld and La Heij (1996) could not be simulated" (p. 116). This means that the discrete name retrieval model does not explain the findings that motivated the development of the model by Starreveld and La Heij (1996). Elsewhere, I made a case for cumulative computational modelling (Roelofs, 2005b). It makes little sense to propose an 'improved' version of a model, as Bloem and La Heij (2003) intended to do, if the new model does not preserve the explanatory power of the old model.

To conclude, there are at least four problems with the assumption that only selected concepts activate their phonological forms. First, models that do not make the assumption can also account for the semantic relatedness paradox. Second, the assumption is refuted by empirical evidence (Finding 10). Third, the assumption requires an ad hoc assumption to account for semantic interference effects. Fourth, the interaction between semantic and phonological context effects in picture naming (Finding 5) is no longer explained.

SUMMARY AND CONCLUSIONS

I have presented an evaluation of two simple name-retrieval models of spoken word planning (Bloem & La Heij, 2003; Jonkersz, 2004; Starreveld, 1997; Starreveld & La Heij, 1996) with respect to their ability to account for relevant data. The models claim (1) that conceptual representations are directly mapped onto lexical phonological representations by spreading activation, and (2) that planning words in both object naming and oral reading involves the selection of lexical phonological representations. The model proposed by Starreveld and La Heij (1996; Starreveld, 1997) assumes that activation cascades from the conceptual to the phonological level, whereas the model proposed by Bloem and La Heij (2003; Jonkersz, 2004) assumes that only selected concepts activate their phonological forms.

The evaluation suggests that the cascade name-retrieval model of Starreveld and La Heij (1996) does not do a good job in accounting for classic facts about speech errors, such as mixed error bias (Finding 1), lexical bias (Finding 2), and the two types of morpheme errors (Finding 3). To account for the error findings, the model may include levels of phonemes and lemmas. But by changing the model this way, it becomes equivalent in relevant respects to more complex models (e.g., Dell, 1986; Dell et al., 1997; Foygel & Dell, 2000; Levelt et al., 1999; Rapp & Goldrick, 2000; Roelofs, 1992, 1997, 2003).

The evaluation further suggests that the name retrieval model does not account well for findings on context effects in Stroop-like experiments. The model captures phonological and semantic effects of word distractors (Finding 4) and their interaction (Finding 5) in picture naming. However, the model is challenged by the finding that the interaction of semantic and phonological relatedness may occur before the onset of pure phonological facilitation (Finding 6). Moreover, although the model can explain the absence of Stroop-like and semantic effects of picture distractors in word reading (Finding 7), it fails to explain the Stroop-like effects of word distractors in word reading (Finding 8). To account for the Stroop-like findings, the model may include a level of lemma representations intermediate between concepts and phonological word forms, and assume that this intermediate level is critically involved in picture naming but not in word reading. Moreover, a level of phoneme nodes may be added. But by adding these levels of nodes, the name retrieval model becomes equivalent to the more complex models (e.g., Dell, 1986; Dell et al., 1997; Foygel & Dell, 2000; Levelt et al., 1999; Rapp & Goldrick, 2000; Roelofs, 1992, 1997, 2003).

The evaluation finally suggests that the discrete name-retrieval model proposed by Bloem and La Heij (2003) does not account well for relevant findings. This model can explain the semantic facilitation of distractor pictures in conceptually driven responding to words (Finding 9), but it is challenged by the finding that distractor pictures yield semantic facilitation and gender congruency effects in generating gender-marked noun phrases in response to words (Finding 10). Moreover, the results of new distributional analyses suggest that context effects of pictures in noun phrase production do not arise because of an erroneous activation of the distractor picture name on some of the trials, as suggested by Bloem et al. (2004). Finally, the interaction between semantic and phonological context effects in picture naming (Finding 5) is no longer explained.

To conclude, existing data challenge the name retrieval models. Modifications that resolve the discrepancies between the name retrieval models and the empirical findings appear to make the models equivalent in relevant respects to the more complex models in the literature. Thus, by adopting the proposed modifications, the name retrieval models lose a major appeal, namely that they seemed to provide a simpler account of the data than the other models in the literature.

REFERENCES

Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, *48*, 468–488.

Bloem, I., Van den Boogaard, S., & La Heij, W. (2004). Semantic facilitation and semantic interference in language production: Further evidence for the conceptual selection model of lexical access. *Journal of Memory and Language*, *51*, 307–323.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*, 407–428.

Damian, M. K., & Martin, R. C. (1999). Semantic and phonological codes interact in single word production. *Journal of Experimental Psychology, Learning, Memory, and Cognition*, *25*, 345–361.

De Jong, R., Berendsen, E., & Cools, R. (1999). Goal neglect and inhibitory limitations: Dissociable causes of interference effects in conflict situations. *Acta Psychologica*, *101*, 379–394.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *93*, 283–321.

Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, *104*, 801–838.

Foygel, D., & Dell, G. S. (2000). Models of impaired lexical access in speech production. *Journal of Memory and Language*, *43*, 182–216.

Garrett, M. F. (1975). The analysis of sentence production. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 133–177). New York: Academic Press.

Garrett, M.F. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production: Speech and talk* (Vol. 1, pp. 177–220). London: Academic Press.

Garrett, M.F. (1988). Processes in language production. In F. J. Newmeyer (Ed.), *Linguistics: The Cambridge survey* (pp. 69–96). Cambridge, MA: Harvard University Press.

Glaser, W. R., & Düngelhoff, F.-J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 640–654.

Glaser, M. O., & Glaser, W. R. (1982). Time course analysis of the Stroop phenomenon. *Journal of Experimental Psychology: Human Perception and Performance*, *8*, 875–894.

Glaser, W. R., & Glaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, *118*, 13–42.

Humphreys, G. W., Lamote, C., & Lloyd-Jones, T. J. (1995). An interactive activation-competition approach to object processing: Effects of structural similarity, name frequency and task in normality and pathology. *Memory*, *3*, 535–586.

Jonkersz, I. (2004). *Semantic interference and facilitation in word production: Explaining the semantic relatedness paradox*. Unpublished doctoral dissertation, University of Leiden, The Netherlands.

La Heij, W. (1988). Components of Stroop-like interference in picture naming. *Memory and Cognition*, *16*, 400–410.

Levelt, W. J. M, Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1–38.

Levelt, W. J. M., Schriefers, H., Vorberg, D., Meyer, A. S., Pechmann, Th. & Havinga, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review*, *98*, 122–142.

Morsella, E., & Miozzo, M. (2002). Evidence for a cascade model of lexical access in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 555–563.

Navarrete, E., & Costa, A. (2005). Phonological activation of ignored pictures: Further evidence for a cascade model of lexical access. *Journal of Memory and Language*, *53*, 359–377.

Rapp, B., & Goldrick, M. (2000). Discreteness and interactivity in spoken word production. *Psychological Review*, *107*, 460–499.

Ratcliff, R. (1979). Group reaction time distributions and an analysis of distribution statistics. *Psychological Bulletin*, *86*, 446–461.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Roelofs, A. (1993). Testing a non-decompositional theory of lemma retrieval in speaking: Retrieval of verbs. *Cognition*, *47*, 59–87.

Roelofs, A. (1997). The WEAVER model of word-form encoding in speech production. *Cognition*, *64*, 249–284.

Roelofs, A. (2003). Goal-referenced selection of verbal action: Modeling attentional control in the Stroop task. *Psychological Review*, *110*, 88–125.

Roelofs, A. (2004a). Error biases in spoken word planning and monitoring by aphasic and nonaphasic speakers: Comment on Rapp and Goldrick (2000). *Psychological Review*, *111*, 561–572.

Roelofs, A. (2004b). Seriality of phonological encoding in naming objects and reading their names. *Memory and Cognition*, *32*, 212–222.

Roelofs, A. (2005a). The visual-auditory color-word Stroop asymmetry and its time course. *Memory and Cognition*, *33*, 1325–1336.

Roelofs, A. (2005b). From Popper to Lakatos: A case for cumulative computational modeling. In A. Cutler (Ed.), *Twenty-first century psycholinguistics: Four cornerstones* (pp. 313–330). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Roelofs, A. (2006a). Functional architecture of naming dice, digits, and number words. *Language and Cognitive Processes*, *21*, 78–111.

Roelofs, A. (2006b). Context effects of pictures and words in naming objects, reading words, and generating simple phrases. *Quarterly Journal of Experimental Psychology*, *59*, 1764–1784.

Roelofs, A. (2007). *Tracing attention and the activation flow in spoken word planning using eye movements*. Manuscript submitted for publication.

Roelofs, A., Meyer, A. S., & Levelt, W. J. M. (1996). Interaction between semantic and orthographic factors in conceptually driven naming: Comment on Starreveld and La Heij (1995). *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 246–251.

Roelofs, A., Meyer, A.S., & Levelt, W. J. M. (1998). A case for the lemma-lexeme distinction in models of speaking: Comment on Caramazza and Miozzo (1997). *Cognition*, *69*, 219–230.

Roelofs, A., & Verhoef, K. (2006). Modeling the control of phonological encoding in bilingual speakers. *Bilingualism: Language and Cognition*, *9*, 167–176.

Ruml, W., Caramazza, A., Shelton, J. R., & Chialant, D. (2000). Testing assumptions in computational theories of aphasia. *Journal of Memory and Language*, *43*, 217–248.

Schriefers, H., Meyer, A., & Levelt, W. J. M. (1990). Exploring the time-course of lexical access in language production: Picture-word interference studies. *Journal of Memory and Language*, *29*, 86–102.

Starreveld, P. A. (1997). *The time it takes to name a cat: Context effects in naming tasks*. Unpublished doctoral dissertation, University of Leiden, The Netherlands.

Starreveld, P. A. (2000). On the interpretation of onsets of auditory context effects in word production. *Journal of Memory and Language*, *42*, 497–525.

Starreveld, P. A., & La Heij, W. (1996). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 896–918.

Stemberger, J. P. (1985). An interactive activation model of language production. In A. W. Ellis (Ed.), *Progress in the psychology of language* (Vol. 1, pp. 143–186). Hove, UK: Lawrence Erlbaum Associates Ltd.

Vigliocco, G., & Hartsuiker, R. J. (2002). The interplay of meaning, sound, and syntax in sentence production. *Psychological Bulletin*, *128*, 442–472.