Semantic effects in the word-word interference task: a comment on Roelofs, Piai, and Schriefers (2013)

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Abstract

Roelofs, Piai, and Schriefers (2013, Language and Cognitive Processes) test both the WEAVER++ model of word production and the response-exclusion account of performance in Stroop-like tasks against data from the word-word interference task, and conclude that whereas the WEAVER++ successfully accounts for those data, the response-exclusion hypothesis fails. Here we show that once recent data from the word-word interference task are considered, both models fail.

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In the word-word interference (WWI) task, participants are instructed to read aloud one of two simultaneously presented printed words while ignoring the other. Roelofs, Piai, and Schriefers (2013) use data from this task to test two models: the WEAVER++ (Levelt, Roelofs, and Meyer, 1999), a model of word production, and the response-exclusion hypothesis (REH, Finkbeiner and Caramazza, 2006a), a model of performance in Stroop-like tasks (both described below). Roelofs et al. (2013) conclude that whereas the WEAVER++ accounts for the performance in the WWI task, the REH fails. Here we will demonstrate that, instead, both the WEAVER++ and the REH fail to account for the results typically obtained in WWI tasks. Then, we will list a few basic theoretical issues any model of performance in WWI must consider.

Semantic effect in WWI

Roelofs et al. (2013) list three findings obtained with the WWI task: a) it takes longer to read aloud a word when it is accompanied by another (unrelated) word than when it is accompanied by a neutral orthographic string (e.g. a row of Xs), thus a distractor word has a 'general interference effect' on the reading of the target word; b) it takes less time to read aloud a word when it is accompanied by an identical word than when it is accompanied by a neutral orthographic string, thus a distractor identical to the target facilitates target reading; c) with respect to an unrelated word condition, a semantically related distractor neither interferes with nor facilitates target reading, that is, 'semantic effects' are absent in WWI tasks (Glaser and Glaser, 1989; La Heij, Happel, and Mulder, 1990; Roelofs, 2006). The authors use this set of findings to test the two models. Of course, if one of these findings were inexact, the outcome of Roelofs et al.'s evaluation should be reconsidered. And one finding is inexact, namely, the third.

In fact, Mulatti, Ceccherini, and Coltheart (2014, Experiment 4) found that semantically related distractor words significantly facilitate target word reading aloud: reaction times are shorter when targets are presented along with related than unrelated distractor words (the effect is of 29 ms).

Why did the studies mentioned by Roelofs et al. fail to find such a facilitatory effect of semantic relatedness? A methodological issue is likely responsible for the null effect. In the study of Glaser and Glaser (1989), each participant was presented with 360 trials, but only 9 targets were used: this implies that each target was read aloud 40 times by each participant. In the experiment of La Heij et al. (1990) there were 288 trials, but they used only 6 targets. So each subject read aloud each target 48 times. In the study of Roelofs (2006) there were 384 trials and 32 targets, which were therefore read aloud 12 times each. These substantial repetitions of the targets within the experiment might well have hidden any effect of semantic relatedness. Indeed, it has been shown that semantic effects may be reduced or suppressed with many repetitions of target words (cf., e.g., Renoult, Wang, Mortimer, & Debruille, 2012) and it is usually recommended to avoid massive repetition in studies exploring semantic effects, especially when word reading is involved (Renoult et al., 2012; McNamara, 2005). In the experiment of Mulatti et al. (2014), each target is presented only twice to each participant, once with a semantically related distractor and once with an unrelated distractor.

In Mulatti et al. (2014), the target is defined as a function of the position it occupies with respect to the centrally presented distractor (as in La Heij et al., 1990), the stimuli are Italian words, and the participants have Italian as their first language. So, one could argue that the semantic effect they find is limited to a specific language or to a particular methodology. However, a significant semantic effect in WWI task is also reported in Weachter, Besner, and Stolz (2011). The effect is a facilitation for the related pairs over the unrelated (16 ms). Noteworthy, in that study the stimuli are English words and the target is distinguished from the distractor by the color of the ink. As in Mulatti et al., each target is presented only twice to each participant.

Moreover, it is worth noting that, while in Mulatti et al. the relatedness proportion is .5 (i.e., 50% of the pairs are semantically related), in Weachter et al. it is .25. It is thus unlikely that in the latter study the semantic effect is due to strategic processes (see Neely, 1991).

Two further results reported in Mulatti et al. will be useful later: 1) as underlined by Roelofs et al. (2013), unrelated distractor words yield 'general interference', but an unrelated low frequency distractor word interferes more than an unrelated high frequency distractor, and 2) distractor frequency and target frequency exert additive effects.

Below, the WEAVER++ and the REH will be tested against this set of results.

WEAVER++ and WWI

According to WEAVER++, picture naming involves the activation of a fixed sequence of representations in memory: concepts, lemmas, morphemes, phonemes, and syllables. So, pictures have indirect access to word forms and direct access to concepts. Instead, printed words have direct access to word form, i.e. input word forms (the orthography of the printed words) are directly mapped into output word forms (morphemes and phonemes). In other words, whereas pictures require concept selection, words can be read aloud without concept selection, i.e. "without engaging concepts and lemmas" (Roleofs et al., 2013, p.667). "According to the WEAVER++, when lemmas are not selected to accomplish the task [as in the WWI task], response selection takes place at the [output] form level, where one morpheme is competitively chosen over another" (Roelofs et al., 2013, p.668). The fact that the morpheme of target and distractor competes for selection explains why general interference is observed in WWI. However, the fact that selection occurs at the word form level without engaging concepts and lemmas predicts absence of semantic effects: "Although perceived [printed] distractor words activate their lemmas and corresponding concepts in the network, this activation does not […] affect the reading response […]. Thus, semantic influences do not reach form selection" (Roelofs et al.,

2013, p.668). However, we now know that there are significant semantic effects in the WWI task, and thus the WEAVER++ makes the wrong prediction here.

It is not obvious how to fix the model. The most intuitive solution is that of allowing lemmas and concepts to affect form selection, but this leads to a wrong prediction: the word form of a semantically related distractor would be more activated than the word form of an unrelated distractor - because of the target conceptually priming the distractor - and therefore a semantically related distractor would interfere with target reading more than an unrelated distractor, which is not the desired result.

In WEAVER++ the distractors are reactively blocked, and given that unrelated high frequency distractors get activated faster than unrelated low frequency distractor (Roelofs, Piai, & Schriefers, 2011), the model correctly predicts the distractor frequency effect in WWI reported in Mulatti et al. (2014). However, given that in WEAVER++ the selection point depends upon a relative ratio of target and distractor activation, it is hard – in absence of an actual simulation – to establish whether or not the model would produce additive effects of target and distractor frequency.

REH and WWI

The REH is a model of human performance in Stroop-like tasks (Finkbeiner and Caramazza, 2006a; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007). Here, the response to the distractor and the response to the target – generated within a non-competitive, forward, lexical-semantic network – compete for accessing a single output channel, acting as a buffer over which a response selection mechanism operates. According to the REH, written words have a privileged access to the articulators (Finkbeiner and Caramazza, 2006a). When the distractor is a word and the target is not (e.g., it is a picture), the distractor engages the articulators before the target. The distractor needs to be excluded from the articulatory buffer in order for the target to be pronounced and the decision process responsible for the exclusion is assumed to operate on the basis of semantic information. That accounts for the

semantic interference effects usually observed in picture-word tasks (e.g., La Heij, 1988).

It has already been shown that, because of structural limits, the REH is not a viable model of either picture-word interference task (Mulatti and Coltheart, 2012) or color-naming of non-color colored word task (Mulatti and Coltheart, 2014). Here, we will establish whether the REH accounts for performance in the WWI task.

As previously underlined, prior to the study by Mulatti et al. (2014), it was quite widely believed that no semantic effects occur in WWI tasks. According to Mahon et al. (2007), "The notion of privileged access also accounts for the lack of semantic interference for modally pure word–word stimuli. If there is no task uncertainty as to which element of the display is the target word and which is the distractor word, then the target word will gain direct access to the articulators. The result is that the bottleneck on the output will already be occupied by the target, and there will thus be no representation that must be excluded or blocked in order for articulation of the target to proceed" (p. 526).

Even if a distractor word occupies the articulatory buffer, the response to the target word would overwrite it with no additional costs: "We assume that written words have privileged access to the articulators such that words obligatorily engage the articulators. […] In the case of the word-word paradigm, […] non-target responses […] are overwritten, directly and obligatorily, by the target word stimulus" (Finkbeiner and Caramazza, 2006b, p.1034).

Therefore, the REH does not clearly provide for semantic effects in the WWI paradigm. However, we know from Mulatti et al. (2014) and Weachter et al. (2011), that a semantic effect in WWI tasks does occur, and that this effect is a facilitation of semantically related target-distractor pairs over unrelated pairs.

A further data to account for is the distractor frequency effect, that is the fact that, in WWI, low frequency distractors interfere more than high frequency distractors. Again, the REH fails. Actually, as underlined by Roelofs et al. (2013), the model does not predict the occurrence of any interference effect. Whether the

distractor is of high or low frequency, it will have no effect: it will simply be overwritten.

In order to account for the general interference effect usually observed in WWI tasks (i.e., slower responses when the target word is accompanied by another word compared to the neutral condition), Janssen (2013) proposed that the overwriting of non-target responses is not cost-free and that "the general interference effect may reflect a disengagement of those articulators that were engaged by the distractor word for the production of the target" (Janssen, 2013, p.674) . However, even if such a proposal might explain the interference effect produced by distractor words, the REH still does not account for the modulation of this effect by the distractor word frequency. Indeed, the available evidence rules out possible effects of word frequency on the articulatory stage (Monsell, Doyle, and Haggard, 1989; Savagea, Bradley & Forster, 1990).

To conclude, the REH accounts for neither semantic effects nor distractor frequency effects in WWI tasks.

WWI: four theoretical issues

Mulatti et al. (2014) develop an empirically driven model of how attentional filtering mechanisms work when two visual word stimuli, a target and a distractor, are simultaneously presented. This model accounts for the occurrence of both the distractor frequency effect and the semantic facilitation effect in WWI tasks. It incorporates the general architecture and dynamic of activation of the Dual Route Cascaded computational model of visual word recognition and reading aloud (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), and rests on a mechanism that construes temporary, episodic traces of the nominal identity of stimuli bound with their visual, pre-categorical features (Allport, 1977). We will not reiterate the description of the model in this commentary. However, while developing that model, the authors had to solve four different, basic theoretical issues that any attempt of

modeling performance in WWI must consider, and that therefore are worth mentioning here:

(1) The nominal identities of the stimuli, i.e. their lexical representations, need to be linked to the task-relevant, pre-categorical, perceptual feature (i.e., the feature that indentifies a word stimulus as the target and the other stimulus as the distractor; e..g. the location of the stimuli or their colors). Only once the pre-categorical and nominal aspects of the stimuli are bound can the system know which is the target and which is the distractor. Thus, the first issue that any WWI model should address is how this binding occurs.

(2) A further issue to be addressed is how the two word stimuli presented in WWI tasks contact the representations stored in memory, that is how the two stimuli activate the two separate sets of letters they comprise.

(3) Since two stimuli are presented and that both are printed words, a third issue to be addressed is the relative dynamics of activation of the corresponding orthographic and phonological lexical representations.

(4) If the two stimuli activate their lexical representations, then their semantic representation should also been activated at a given time, and therefore a further issue is to account for how the semantic representations of the target and of the distractor interact.

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