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Semantic interference in language production is due to graded similarity, not response relevance

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ABSTRACT

There is an ongoing debate on the question whether semantic interference effects in language production reflect competitive processes at the level of lexical selection or whether they reflect a post-lexical bottleneck, occupied in particular by response-relevant distractor words. To disentangle item-inherent categorical relatedness and task-related response relevance effects, we combined the picture–word interference task with the conditional naming paradigm in an orthogonal design, varying categorical relatedness and task-related response relevance independent of each other. Participants were instructed to name only objects that are typically seen in or on the water (e.g. canoe) and refrain from naming objects that are typically located outside the water (e.g. bike), and vice versa. Semantic relatedness and the response relevance of superimposed distractor words were manipulated orthogonally. The pattern of results revealed no evidence for response relevance as a major source of semantic interference effects in the PWI paradigm. In contrast, our data demonstrate that semantic similarity beyond categorical relations is critical for interference effects to be observed. Together, these findings provide support for the assumption that lexical selection is competitive and that semantic interference effects in the PWI paradigm reflect this competition.

1. Introduction

Selecting words from the mental lexicon that express an intended message appropriately is a core component of the speech production system. This process involves a spread of activation within and between different levels of speech planning. For instance, upon naming an object, activation spreads to semantically related nodes at the conceptual level where the pre-verbal message is generated. These nodes in turn activate their corresponding entries at the lexical level. As a result of this multi-level spreading activation, the activation of the target word is flanked by concomitant activation of related words. Thus, even for basic and simple instances of speech production such as the naming of visually depicted objects (e.g., chair), semantically related concepts and their lexical entries (e.g., *table*, *wardrobe*) are concurrently activated.

In this paper we explore the consequences of lexical co-activation for word production. We ask whether lexical selection is characterized by competition from co-activated entries or unaffected by the activation status of potential alternatives. Inhibitory effects of semantic contexts on production latencies have long been taken to reflect competition at the level of lexical selection. For instance, when pictures of objects are named in the presence of visually or auditorilly presented distractor words in the picture–word interference (PWI) paradigm, a semantic interference effect is observed: naming is slowed in the presence of categorically related relative to unrelated words (e.g., Schriefers, Meyer, & Levelt, 1990). Likewise, repeated naming is slowed in blocks of trials consisting of categorically or associatively related objects (semantically homogeneous blocks) relative to heterogeneous blocks consisting of unrelated objects in the blocking paradigm (e.g. Abdel Rahman & Melinger, 2007; Belke, Meyer, & Damian, 2005; Damian, Viglocco, & Levelt, 2001; Kroll & Stewart, 1994).

Many models of speech production account for semantic interference effects by assuming that lexical selection is a competitive process (e.g. Bloem & La Heij, 2003; Bloem, van den Boogaard, & La Heij, 2004; La Heij, Kuipers, & Starreveld, 2006; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992, 2003). For example, according to Levelt and colleagues (e.g. Levelt et al., 1999; Roelofs, 1992) semantic interference effects in the PWI paradigm arise because semantic alternatives are co-activated by the target picture and distractor word at the conceptual and lexical level. Co-activated lexical entries compete with the target for selection, thus delaying the naming response. In contrast, when unrelated words are presented, activation spread by target and distractor word diverges onto different lexical entries, and lexical competition is reduced.

An alternative proposal suggests that lexical selection is non-competitive (Costa, Alario, & Caramazza, 2005; Finkbeiner & Caramazza, 2006a, 2006b; Janssen, Schirm, Mahon, & Caramazza, 2008; Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Miozzo & Caramazza, 2003). According to the response exclusion hypothesis (REH) by Mahon et al. (2007) semantic interference effects in the PWI task are localized

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at the post-lexical stage of the articulatory output buffer. Distractor words have privileged access to the articulators, and the output buffer forms a bottleneck stage that can be engaged with only one process at a time. Thus, the distractor must be removed from the buffer before the target word can be articulated. The speed of this exclusion process is determined by response relevant criteria. Words that can be quickly dismissed as potentially relevant responses (e.g. unrelated words from different semantic categories) can be excluded faster than words that satisfy response relevant criteria (e.g. semantic category members: when naming a dog the distractor cat fulfills the response relevant criterion of belonging to the same broad category of animals).

Even though the decision mechanism on the response relevance of distractors as such yields discrete results (a distractor is a relevant response or it is not), what counts as a criterion for response relevance is not exclusively determined by semantic category membership. Depending on the goals of the task at hand, different item-inherent or task-related criteria can determine the response relevance of a distractor. This assumption is explicitly formulated in Mahon et al.'s work (2007; p. 512): "There are, in principle an indefinite number of response-relevant criteria, because such criteria are, in part, a product of task constraints decided by the experimenter". Thus, constraints that determine the response relevance of distractors, rather than competitive lexical selection mechanisms, are assumed to be the major source of semantic interference effects.

Evidence in favor of the response exclusion hypothesis stems among others from observed exceptions from classic categorically induced interference effects in the PWI paradigm. For instance, semantically related verb distractors (Mahon et al., 2007), distractors that have a part-whole relation with the target (Costa et al., 2005) and associatively related distractors (Alario, Segui, & Ferrand, 2000; Abdel Rahman & Melinger, 2007; but see Aristei, Melinger, & Abdel Rahman, 2010) induce facilitation, rather than interference. One common element between these types of distractors can be seen in terms of response relevant criteria: given the task at hand (naming whole objects by producing nouns; e.g., target: camel) verb distractors (e.g., ride) can quickly be excluded as potential responses based on their grammatical class membership; likewise, distractors referring to parts of objects (e.g. hump) can be excluded because the implicit task criterion is to name whole objects, and associates (e.g., pyramid) can be excluded because they are not semantic category members. Thus, exclusion times for these types of response irrelevant distractors should be comparable to unrelated words. However, because all of these distractors are semantically related to the target, facilitation due to semantic priming is observed (but see e.g., Roelofs, Piai, & Schriefers, 2012 for a critical review and alternative interpretations of these findings; Abdel Rahman & Melinger, 2009a, 2009b; Kuipers, La Heij, & Costa, 2006; for alternative accounts of semantic facilitation and interference effects that maintain the assumption of lexical competition).

According to the response exclusion hypothesis a semantic priming mechanism at the lexical level is assumed to facilitate naming. In contrast to the discrete response exclusion mechanism responsible for the interference effects, the priming mechanism is graded, varying with the semantic distance between target and distractor. Specifically, given equivalent levels of response relevance, semantically close words (e.g., target: horse, distractor: donkey) are assumed to yield stronger priming effects at the lexical level than more distant words (e.g., target: horse, distractor frog; Mahon et al., 2007). Three experiments run by Mahon et al. (2007) confirmed this hypothesis, although results were not always clear cut. In fact, across the three experiments there are internal discrepancies that were not further discussed by the authors. For instance, semantically close distractors did not always induce interference effects relative to unrelated distractors despite their response relevant status. Furthermore, an SOA manipulation yielded semantic distance effects only at a negative SOA (−160 ms) but not at zero SOA, at which semantic facilitation has been reported for, e.g., part-whole relations (Costa et al., 2005). There is in our view no apparent common element that could explain both supportive and discrepant findings within the study, but these inconsistencies together with no available replication of the effects (see Lee & de Zubicaray, 2010; Vieth, McMahon, & Zubicaray, 2012) invite caution in the interpretation of these results.

Additionally, Mahon et al.'s results contrast with the majority of studies on semantic similarity effects conducted so far, which demonstrated that close relations are associated with stronger interference than more distant relations in semantic blocking and PWI paradigms (Vigliocco, Vinson, Damian, & Levelt, 2002; Vigliocco, Vinson, Lewis, & Garrett, 2004; Lee & de Zubicaray, 2010; Abdel Rahman, Aristei, & Melinger, 2010; see also Aristei et al., 2010).

1.1. Aim of the present study

The discussed examples for different types of distractor words in different experimental settings (see above) suggest that response relevance is not solely determined on the basis of item-inherent features and coarse semantic information, but depends to a large degree also on experimental contexts and task constraints (Mahon et al., 2007). In its current formulations the response exclusion hypothesis does not provide explicit information about the individual contributions of response relevant criteria explicitly defined in task instructions and of those derived from the target stimuli (e.g. categories), nor about the dynamics of their potential interplay. Nonetheless, it is clear in the literature (e.g., Mahon, Garcea, & Navarrete, 2012; Mahon et al., 2007) that explicitly defined and implicitly derived rules are both driving forces of the response exclusion mechanism in terms of response relevance.

In this study we go further in testing response relevance effects in speech production. Until now, relevant semantic item-inherent information was manipulated mainly by means of the selected target categories (e.g., Costa et al., 2005; Mahon et al., 2007), thus, its extraction occurred more implicitly and with dependence on individual response strategies. Here, we investigate response relevance effects by introducing relevant item-inherent semantic information in the task instructions. To do so, we employed the conditional naming paradigm in which picture naming is conditional on a classification of the object as belonging to a pre-specified category (Job & Tenconi, 2002; Mulatti, Lotto, Peressotti, & Job, 2010). For instance, Job and Tenconi (2002) presented a series of living and non-living objects and instructed their participants to name only living things and to withhold the naming response when non-living objects were presented (and vice versa). Interestingly, the authors demonstrated that conditional naming, albeit including an additional semantic classification, is not associated with additional costs compared to unconstrained free naming of all pictures (but see Mulatti et al., 2010). While the specific mechanisms giving rise to this no-cost phenomenon are yet to be fully identified (e.g., Aristei, Abdel Rahman, Sommer, Kiefer, & Job, 2009; Aristei, Kiefer, & Job, 2007), the paradigm is well-suited to explore distractor response relevance.

Here, we combined the conditional naming procedure with the picture–word interference paradigm. Participants were instructed to name only those objects that are typically located in or on the water (e.g., canoe), and to refrain from naming objects that are typically located outside the water (e.g., bike), and vice versa. Object pictures were presented simultaneously with categorically related or unrelated distractor words, that can equally be located in or outside the water (see example below). Thus, by combining conditional naming with the PWI paradigm we can isolate the effects of categorical relatedness and the task-dependent response relevant status of distractor words. For instance, when naming is conditional on the object being typically found in or on the water (e.g. target: "carp"), only items that satisfy this criterion are potentially relevant responses, irrespective of their semantic category membership. For instance, the categorically related distractor *herring* is response relevant (only objects typically located in the water should be named), whereas the categorically related