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The persistence of cumulative semantic interference during naming

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ABSTRACT

Naming semantically related pictures (e.g., "goat" "cow" "mouse") becomes increasingly slower when repeatedly naming from a semantic category even when several unrelated trials intervene (Howard, Nickels, Coltheart, & Cole-Virtue, 2006). The aim of this study was to test whether cumulative semantic interference is independent of time and unrelated trials between naming occurrences as predicted if interference is the result of learning reflected by persistent changes to semantic–lexical connection strength (Oppenheim, Dell, & Schwartz, 2010). Consistent with this account, changes in response stimulus intervals did not affect cumulative interference, allowing rejection of a temporary residual activation account of interference, suggesting that persistence of cumulative interference in this paradigm is similar to when exemplars are repeatedly named in the blocked-cyclic naming paradigm. However, cumulative interference disappeared when intervening unrelated trials increased (8–50) except when a short lag occurred (2) in the sequence. Critically, when a short lag occurred in the sequence, interference extended to new categories separated by long lags (8–14) which were not previously named. To account for results, modifications of learning models of naming should include a mechanism by which interference dissipates, and a mechanism which biases learning to create persistence in contexts where semantic relationships are amplified.

Introduction

Producing words becomes slower if the words are from the same semantic category (e.g., dog, elephant, goat; Damian, Vigliocco, & Levelt, 2001; Howard, Nickels, Coltheart, & Cole-Virtue, 2006; Kroll & Stewart, 1994). This slow-down, referred to as semantic interference occurs even when unrelated trials occur between related trials (Brown, 1981; Damian & Als, 2005; Howard et al., 2006; Vitkovitch, Rutter, & Read, 2001; Wheeldon & Monsell, 1994). Because the interference remains relatively stable for several unrelated trials, interference is thought to arise because of learning as the result of persistent changes in the strength of connections between semantic and lexical representations (Damian & Als, 2005; Howard et al., 2006; Oppenheim, Dell, & Schwartz, 2010; Schnur, Schwartz, Brecher, & Hodgson, 2006). The aim of this study was to test whether semantic interference in naming is impervious to long delays, a critical prediction if learning (i.e., long-lasting changes in connections) is the cause of semantic interference in naming. Understanding the dynamics of how semantic interference arises and dissipates when producing a series of words is an important step forward in understanding how word production is affected by context, a situation that routinely occurs in real-world speech.

Previous research across several paradigms shows that naming a picture is slower and more error-prone if semantically related words were produced in the past. For example, when pictures are named in blocks of semantically related items, naming is slower than when naming the

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exact same items organized in unrelated blocks (blocked naming; Brown, 1981; Kroll & Stewart, 1994), and when naming items repeatedly in related and unrelated blocks (blocked-cyclic naming; Belke, 2008; Belke, Meyer, & Damian, 2005; Damian, 2003, Experiment 2; Damian et al., 2001; Maess, Friederici, Damian, Meyer, & Levelt, 2002; Navarrete, Del Prato, & Mahon, 2012; Schnur et al., 2009). Seen in speakers with language disorders such as aphasia, naming errors increase over naming repetitions when naming semantically-related pictures vs. unrelated pictures (McCarthy & Kartsounis, 2000; Schnur et al., 2006; Wilshire & McCarthy, 2002), where these errors are names of recent previously named items (Hsiao, Schwartz, Schnur, & Dell, 2009). The semantic interference in blocked-cyclic naming generally does not diminish if responses are separated by increasing time intervals (response-stimulus interval changes; Schnur et al., 2006; cf. McCarthy & Kartsounis, 2000), nor when separated by an intervening unrelated naming trial or even an unrelated spatial task trial (Damian & Als, 2005; Navarrete et al., 2012). Semantic interference in blocked naming thus exhibits itself in slower response times and an increase in number and types of errors when pictures are blocked by semantic category.

Although semantic interference is demonstrated when repeatedly naming pictures, interference also occurs in a subtler manipulation of semantic context when naming items only once (Belke, 2013; Belke & Stielow, 2013; Brown, 1981; Costa, Strijkers, Martin, & Thierry, 2009; Howard et al., 2006; Kroll & Stewart, 1994; Navarrete, Mahon, & Caramazza, 2010; Vitkovitch et al., 2001; Wheeldon & Monsell, 1994). For example, Wheeldon and Monsell (1994) provided definitions to name (what is the largest animal in the sea?) and speakers were slower to name a related picture name (octopus) two unrelated trials later. Further, semantic interference in naming is cumulative, growing across multiple retrievals of different items from the same category, linearly increasing across five naming attempts within a category, and this effect does not change whether two, four, six, or eight intervening trials occurred (Howard et al., 2006). The increase in semantic interference occurs even when naming the same items from the semantic category (Navarrete et al., 2010), and appears across most semantic categories (Alario & Moscoso del Prado Martin, 2010). Thus, whether naming semantically related items in blocks or separated by unrelated trials or tasks, naming is slower, more error-prone and is generally not diminished by time or small numbers of intervening trials.

Semantic interference in continuous and blocked naming paradigms has been attributed to a delay to select the appropriate word for production because of increased activation levels of lexically specified representations. More time is required to distinguish the target's activation from competitors' activation (Luce ratio choice rule; Luce, 1959) due to a spread of activation between semantically related competitor items (Belke et al., 2005; Damian et al., 2001; Howard et al., 2006; Vitkovitch & Humphreys, 1991). Semantic interference is thought to arise at a lexical as opposed to semantic or phonological level for several reasons. For example, semantic interference in blocked naming is not likely a conceptual effect given that when pictures are categorized but not named interference disappears (Belke, 2013; Damian et al., 2001) and electrophysiological evidence places the effect at a post-semantic level (Costa et al., 2009; cf. Janssen, Carreiras, & Barber, 2011). Semantic interference in naming is not likely a phonological effect given that it disappears when words are simply read (Belke, 2008; Damian et al., 2001), but reappears when words are read with their gender-specified determiners in a gender-marked language like German (Damian et al., 2001; cf., Belke, 2013; Navarrete et al., 2010). Thus, cumulative semantic interference effects are generally thought to occur because of increased activation of competitors vis à vis the target, at a post-semantic but pre-phonological level in the production system.

However, the fact that interference is generally impervious to small time intervals, small numbers of intervening unrelated trials and tasks suggests that activation levels cannot account for all of semantic interference. The relatively long-lasting semantic interference effect is inconsistent with a temporary change in activation levels given that activation changes during language production are theorized to decay automatically and quickly (e.g., Bock & Griffin, 2000; see also traditional activation models such as Anderson (1976) and Collins and Loftus (1975) where rapid changes are implemented via activation levels). Instead, interference is proposed to be the result of persistent changes in connection weights from semantic features to the target (Damian & Als, 2005; Howard et al., 2006; Oppenheim et al., 2010; Schnur et al., 2006). Changes in connection weights, as opposed to temporary activation levels are proposed to better account for long-lasting semantic interference effects.[1]

Two recent computational models implement semantic interference effects in naming by modeling the interference as a result of changes in connection weights (Howard et al., 2006; Oppenheim et al., 2010). Howard et al. (2006) proposed that interference in the continuous naming paradigm arises under three required scenarios. First, activation spreads between semantically related representations and/or their features. Second, upon naming an item, the connection strength is increased from the semantic representation and/or its features to the lexical representation. For example, after naming a target like "cow", connections from its semantic features (e.g., "four legs" "fur") to the lexical representation are strengthened to support future successful naming of the item. Lastly, lexical selection is achieved via competition either by lateral inhibition between representations (selected via an absolute threshold) or via a Luce choice rule (Luce, 1959). By applying modifications to this model, Oppenheim et al. (2010) were able to account for the response time evidence in continuous (Howard et al., 2006) and blocked-cyclic naming paradigms (Belke et al., 2005; Schnur et al.,

[1] That activation levels are subject to rapid decay whereas connection weights generally are not is also used to explain persistent effects in visual word recognition (Bowers, Damian, & Havelka, 2002), repetition priming (Monsell, Matthews, & Miller, 1992), syntactic priming (for a review see Pickering & Ferreira, 2008), and is implemented in neural network models (e.g., Gupta & Cohen, 2002).