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Facilitation and interference in naming: A consequence of the same learning process?

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ABSTRACT

Our success with naming depends on what we have named previously, a phenomenon thought to reflect learning processes. Repeatedly producing the same name facilitates language production (i.e., repetition priming), whereas producing semantically related names hinders subsequent performance (i.e., semantic interference). Semantic interference is found whether naming categorically related items once (continuous naming) or multiple times (blocked cyclic naming). A computational model suggests that the same learning mechanism responsible for facilitation in repetition creates semantic interference in categorical naming (Oppenheim, Dell, & Schwartz, 2010). Accordingly, we tested the predictions that variability in semantic interference is correlated across categorical naming tasks and is caused by learning, as measured by two repetition priming tasks (picture-picture repetition priming, Exp. 1; definition-picture repetition priming, Exp. 2, e.g., Wheeldon & Monsell, 1992). In Experiment 1 (77 subjects) semantic interference and repetition priming effects were robust, but the results revealed no relationship between semantic interference effects across contexts. Critically, learning (picture-picture repetition priming) did not predict semantic interference effects in either task. We replicated these results in Experiment 2 (81 subjects), finding no relationship between semantic interference effects across tasks or between semantic interference effects and learning (definition-picture repetition priming). We conclude that the changes underlying facilitatory and interfering effects inherent to lexical access are the result of distinct learning processes where multiple mechanisms contribute to semantic interference in naming.

1. Introduction

Whether it is throwing a perfect curveball, learning multiplication tables, or remembering where we parked the car, our abilities are enhanced with practice. Repetition improves performance, as each time we repeat an action we update our knowledge by strengthening connections for more efficient access in the future (i.e., incremental learning). These changes are fundamental to performance across many domains including perceptual learning (e.g., Petrov, Dosher, & Lu, 2005), belief updating (e.g., Nassar, Wilson, Heasly, & Gold, 2010), and language adaptation and learning (for a review see Chang, Janciauskas, & Fitz, 2012). Generally, we consider these changes to be positive effects, as they improve our future performance. However, there are negative consequences of learning. For example, if after repeatedly parking in one space we change parking locations, we may find ourselves wandering back to the original space, even though it is the wrong location, because we "learned" it so well. Thus, although repetition and learning through practice generally engender positive consequences, these consequences hurt us if we need to change our actions.

Language processes follow this same pattern, as our ability to produce speech quickly and accurately depends on our prior language production experiences. For example, naming a previously named picture results in faster and more accurate naming (repetition priming, e.g., Mitchell & Brown, 1988). Repetition priming results from a speech production system that uses each naming event as a "learning experience" to ensure future efficiency and accuracy (e.g., Mitchell & Brown, 1988; Oppenheim, Dell, & Schwartz, 2010). However, all priming effects are not facilitatory, as naming pictures primed by semantically related items results in longer naming latencies (e.g., Brown, 1981). This semantic interference effect is thought to reflect the same long-lasting learning experience that facilitates naming (Oppenheim et al., 2010), since interference occurs regardless of whether semantically related pictures are presented consecutively (blocked/blocked cyclic naming; Abdel Rahman & Melinger, 2007, 2011; Belke, 2008; Belke, Meyer, & Damian, 2005; Damian & Als, 2005; Damian, Vigliocco, & Levelt,

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2001; de Zubicaray, Johnson, Howard, & McMahon, 2014; Kroll & Stewart, 1994; Maess, Friederici, Damian, Meyer, & Levelt, 2002; Meinzer, Yetim, McMahon, & de Zubicaray, 2016; Navarrete, Del Prato, & Mahon, 2012; Schnur, Schwartz, Brecher, & Hodgson, 2006; Vigliocco, Lauer, Damian, & Levelt, 2002) or non-consecutively, with anywhere from two to eight intervening semantically unrelated items (i.e., continuous naming; e.g., Belke, 2013; Canini et al., 2016; Howard, Nickels, Coltheart, & Cole-Virtue, 2006; Navarrete, Mahon, & Caramazza, 2010; Runnqvist, Strijkers, Alario, & Costa, 2012; Schnur, 2014). The aim of this study was to test the assumptions of Oppenheim et al.'s (2010) computational model of language production (henceforth, Dark Side Model) which implements both positive and negative effects of the "learning experience" in the same way when naming and successfully simulates naming performance in blocked cyclic and continuous naming. Testing whether interference in naming across different contexts is similar and arises from a learning mechanism will provide insight about the facilitatory and interfering processes inherent to lexical access as well as how these processes reflect the general and ubiquitous cognitive principle of learning.

Semantic interference effects in naming are widely replicated across two different types of naming contexts. In blocked cyclic naming, pictures appear either in semantically related (e.g., *cat, dog, bird*) or unrelated groups (e.g., *cat, truck, lamp*) called blocks for a number of repetitions (cycles), each with a different picture order (e.g., Damian & Als, 2005). Semantically related, as compared to unrelated contexts increase response latencies across the block (semantic *blocking effect*), and the difference in response latencies (Related - Unrelated) increases across cycles (*growth effect*; e.g., Schnur et al., 2006; cf. Belke & Stielow, 2013; Damian & Als, 2005). Overall, performance improves when repeating items (i.e., repetition priming), but this benefit is attenuated in the semantic context. In the continuous naming paradigm, each category exemplar is named once with no two pictures from the same category appearing consecutively, and the position of a picture within its semantic category members is called its ordinal position. Naming times increase linearly across ordinal positions (*ordinal slope effect*), and this increase is unaffected by intervening unrelated items (e.g., Howard et al., 2006; Navarrete et al., 2010; cf. Schnur, 2014). Across both blocked cyclic and continuous naming, repeatedly naming from the same semantic category increases response times, resulting in significant semantic interference.

The computational Dark Side Model (Oppenheim et al., 2010) assumes a learning mechanism underpins word production processes. This mechanism reflects our "learning experience" and operates over the connections between semantic features (e.g., *four legs, fur, tail*) and corresponding lexical representations (e.g., "cat" or "dog"). Repeating a word facilitates naming, as learning strengthens the semantic-to-lexical connections (hereafter, lexical-semantic connections) after correctly producing the name of the intended target. At the same time, the learning mechanism ensures that non-target items sharing semantic features with the named target will not be strong competitors in the future by weakening the lexical-semantic connections to those semantic features they share with the named target. Consequently, naming latencies increase with each additional category item due to previous weakening of some lexical-semantic connections to that item, resulting in the blocked cyclic naming *blocking* and *growth effects* (e.g., Schnur et al., 2006) and the linear *ordinal slope effect* in continuous naming (e.g., Howard et al., 2006). In sum, the learning process both helps and hinders naming performance due to lexical-semantic connection weight changes.

With the assumptions that semantic interference effects in blocked cyclic and continuous naming contexts reflect the same phenomenon, and a learning mechanism drives semantic interference during naming, the Dark Side Model's architecture (Oppenheim et al., 2010) generates two predictions about individuals' performance across semantic interference tasks. First, because individuals vary in their susceptibility to semantic interference (Maess et al., 2002), based on the first assumption, the Dark Side Model predicts that individual variability in the semantic interference effect observed in blocked cyclic naming should pattern with that in continuous naming. As such, when examining individual differences in naming performance, we expect to find significant correlations between semantic interference effects in blocked cyclic and continuous naming. Second, as individuals vary in their learning abilities (e.g., Woltz & Shute, 1993), based on the second assumption, if a learning mechanism underlies the interference effects observed in blocked cyclic and continuous naming, then individual learning mechanism strength should predict performance in both tasks. Therefore, we expect to find significant correlations between individually measured learning mechanism strength and the semantic interference effects in blocked cyclic and continuous naming. Thus, an individual differences approach is a powerful method not only to examine these predictions but also because it has the potential to reveal the processing dynamics of the language system.

Whether the processes behind semantic interference effects in blocked cyclic and continuous naming are served by the same mechanism, and whether this mechanism is the same as that which causes facilitation in repetition priming (as proposed by Oppenheim et al., 2010), to our knowledge has never been empirically tested. Additionally, given that each task differs in how it elicits semantic interference (organization of related items, repetition of items) and differs in the degree to which it recruits working memory resources (Belke, 2008; Belke & Stielow, 2013), there is further question as to whether these tasks are as similar as has been proposed (see also Belke, 2013; Navarrete, Del Prato, Peressotti, & Mahon, 2014; Navarrete et al., 2012; Riley, McMahon, & de Zubicaray, 2015). Understanding whether semantic interference is caused by the same mechanism is important because these paradigms and semantic interference effects in general are used to test theories of the cognitive architecture in language production (e.g., Dell, Oppenheim, & Kittredge, 2008; Levelt, Roelofs, & Meyer, 1999; Rapp & Goldrick, 2000; Schnur et al., 2006), comprehension (e.g., Campanella & Shallice, 2011; Crutch, Connell, & Warrington, 2009; Wei & Schnur, 2016) and deficits in executive control (e.g., Biegler, Crowther, & Martin, 2008; Harvey & Schnur, 2015; Jefferies, Baker, Doran, & Ralph, 2007; Ries et al., 2015; Schnur et al., 2009).

To address these questions, we compared interference effects within individuals across the two semantic interference naming paradigms simulated by the Dark Side Model (Oppenheim et al., 2010) in Experiments 1A, 2A (blocked cyclic naming) and Experiments 1B, 2B (continuous naming). We examined the *blocking* and *growth effects* in blocked cyclic naming as individual measures of semantic interference because both are simulated by the Dark Side Model (Oppenheim et al., 2010) and both are typical measures of semantic interference (e.g., Belke, 2008; Navarrete et al., 2012; Schnur et al., 2006; Schnur et al., 2009). Second, we wanted to test Oppenheim et al.'s (2010) proposal that the mechanism by which lexical-semantic weights are weakened (semantic interference) is the same mechanism which governs connection weight strengthening (facilitation) in repetition priming. In an attempt to best capture individual learning strength at the lexical-semantic level we measured individual learning strength with both a picture-picture repetition priming paradigm (e.g., Cave, 1997; Durso & Johnson, 1979; Woltz & Shute, 1993; Experiment 1C) and a definition-picture repetition priming paradigm (e.g., Wheeldon & Monsell, 1992; Experiment 2C). We then investigated whether an