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Aligning Language and Memory Accounts of Semantic Interference

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Abstract

Parallel accounts of interference resulting from the generation of related words can be found in the retrieval-induced forgetting (RIF) and the cumulative semantic interference literatures. Recent work on the language production side suggests that the same adaptive learning process may underlie both. However, the literatures remain separate. They use different procedures and dependent measures, and theoretical accounts focus on underlying conceptual representations (memory research) vs. conceptual-lexical links (language research). We propose that the accounts should be reconciled. As an initial step toward this goal we combined a retrieval/generation procedure with a continuous picture-naming test phase to assess their combined effects on interference. We observed both costs and benefits in error data. There were more naming errors (including many time-outs) for non-generated items from activated categories and fewer for previously generated items. Perhaps due to a too-severe cutoff, naming times did not show a RIF influence, only a marginal facilitation effect for generated items. However, naming time showed typical cumulative interference within the picture-naming phase independent of previous retrieval experience. Future work will investigate the locus of interference in conceptual memory representations versus in links to word representations with the goal of producing a unified account of semantic interference.

Keywords: semantic interference; retrieval-induced forgetting; word production; incremental learning; cued recall

Introduction

Semantic relatedness is a well-studied modulator of cognition. When implemented in a semantic priming task, such as the lexical decision task, a shared semantic component can aid processing (e.g., Joordens & Becker, 1997). However, word generation suffers interference when one or more related words have recently been retrieved from memory (e.g., Anderson et al., 1994; Howard et al., 2006). In separate memory and language production literatures, recent accounts of interference have implemented error-driven incremental learning mechanisms to model how the accessibility of semantic representations varies as a function of recent experience (Oppenheim et al., 2010; Norman et al., 2007). These accounts target different representations and processes: underlying conceptual representations (memory) or conceptual-lexical links (language).

We suggest that there is much to be gained from integrating theoretical accounts of semantic interference across memory and language production research. Specifically, and in line with other researchers (Oppenheim et al., 2010; Navarrete et al., 2010; Navarrete et al., 2021; Jeye et al., 2021), we suggest that both semantic interference and retrieval-induced forgetting involve incremental learning. Moreover, both may engage a domain general network that supports certain control and forgetting processes (Anderson & Hulbert, 2021, Anderson, 2003; Nozari & Novick, 2017). Despite these commonalities, there has been little movement toward integration of these parallel accounts. Language production models refer to changes in memory access but do not address current memory models. In turn, memory researchers often disregard the linguistic interfaces that are inherent in word retrieval, and they typically use accuracy measures rather than potentially more sensitive latencies. We suggest that aligning both the theoretical claims and empirical findings in the semantic interference and retrieval-induced forgetting literatures will strengthen both and deepen our understanding of the adaptive learning mechanisms thought to underlie both conceptual memory changes and ease of word production.

Semantic Interference

Semantic interference is the phenomenon in which it takes longer to retrieve and produce words after having recently retrieved (generated) related words (e.g., Abdel Rahman & Melinger, 2011; Damian & Spalek, 2014). It is often studied through timed picture-naming tasks that require generation of names from memory. Increased naming latency is observed in repeated naming of small sets of related compared to unrelated items, and as a function of ordinal position of related items in continuous sequences. This increased latency is attributed to coactivation of related conceptual-lexical networks during production of each item. In some accounts, semantic interference is the result of immediate competitive processes during lexical selection, whereas in others competition is expressed as the result of adaptive learning (e.g., Mahon et al., 2007; Oppenheim & Nozari, 2021). Because these possibilities are not mutually exclusive, we suggest that competitor coactivation may induce both in-the-moment naming difficulty and long-term modulations of lexical access as the system attempts to optimize future production efficiency (see Oppenheim et al., 2010).

The continuous picture-naming procedure highlights the long-term component of semantic interference. Participants

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name pictures in a continuous sequence. The sequence is made up of groups of related items that have been internally structured such that related items are dispersed throughout the sequence, making it possible to assess the effect of ordinal position (Howard et al., 2006). Typically, there is a linear increase in naming time across ordinal positions, such that the time it takes to name an item depends on the number of related items previously produced (Howard et al., 2006; Oppenheim et al., 2010; Rose & Abdel Rahman, 2018). In this paradigm, the changes in naming latency for widely separated items cannot be explained by short-term competitive processes and are better accounted for by an incremental learning mechanism (Oppenheim et al., 2010; Oppenheim & Nozari, 2021). Specifically, Oppenheim et al.'s (2010) 'Dark Side' model of incremental learning posits that access to items that are activated and selected for production is strengthened, while access to related items that were activated but not selected for production is weakened, thereby downregulating the future accessibility of the related items. Note that Oppenheim et al. (2010) and Oppenheim & Nozari (2021) also posit that incremental learning can account for the short-term interference effects typically attributed to lexical competition (but see Belke & Stielow, 2013). Regardless, it is critical to highlight that this model posits that prior retrieval experiences drive the semantic interference observed in continuous naming.

Retrieval-Induced Forgetting

Retrieval-induced forgetting (RIF) is the phenomenon in which it is more difficult to recall an item from memory after related memory items have been retrieved (Anderson et al., 1994). It has been extensively studied using the *retrieval practice* paradigm (Anderson et al., 1994). In this design, participants are familiarized with an extensive list of category-exemplar pairs (e.g., FRUIT-apple, FRUIT-orange, PET-cat) with multiple items in each category. In a subsequent retrieval phase, half of the items from a subset of the categories are generated using stem-completion cues (e.g., FRUIT-a____). The participant then engages in a distractor task before completing a final recall task. This final task may involve category-cueing or free recall of all items. This creates three conditions containing different items[1]: 1) items from a given category that were generated during the retrieval phase (RP+/Activated-Generated, e.g., FRUIT-apple); 2) items from the same categories that were not generated themselves (RP-/Activated-NonGenerated, e.g., FRUIT-orange); and 3) items from categories that were not generated at all during the retrieval phase (NRP/NonActivated, e.g., PET-cat; see Anderson, et al,, 1994). Note that throughout the paper we will use the self-explanatory alternative labels proposed here rather than the acronyms used in the RIF literature.

As one might expect, items that underwent retrieval are recalled best at the final test. However, the comparison of interest is between Activated-NonGenerated and NonActivated items. Typically, Activated-NonGenerated items are recalled at a significantly lower rate than NonActivated items, suggesting that the generation of categorically related items during the practice phase dampens subsequent memory access to Activated-NonGeneated items. This retrieval-induced forgetting effect (RIF) has been attributed to long-term inhibitory mechanisms that suppress the representations of the related concepts that compete with the generated items during the retrieval practice phase (Anderson et al., 1994). This account was further refined by Anderson & Spellman (1995) into the feature suppression account. According to this account, concepts are represented as distributed features, such that activation of overlapping units results in the coactivation of linked representations. During retrieval, the features corresponding to a target concept are strengthened, whereas the nonoverlapping features of the coactivated competitors are weakened. Though the implementation is different, functionally this is quite similar to the incremental learning account of cumulative interference in language production (Oppenheim et al., 2010).

Other researchers have called into question whether RIF is necessarily due to long-term inhibition, suggesting it might be better explained by contextual cueing or associative blocking mechanisms that act through competitive processing during the final test (Murayama et al., 2014; Jonker et al., 2013; Jonker et al., 2015). Contrary to these accounts, RIF has been replicated across a variety of tests specifically designed to limit the influence of contextual factors, including variations in which a new cue word without any relation to the practiced cues is used to trigger recall of the Activated-NonGenerated items at the final test (i.e., cue-independence, Anderson & Spellman, 1995; Hulbert et al., 2012). In any case, it is notable that both semantic interference and RIF have been described by models that rely on in-the-moment, competitive processing and by models that point to long-term changes in retrievability (Roelofs, 2018; Jonkers et al., 2013; Anderson & Spellman, 1995; Oppenheim et al., 2010; Norman et al., 2007).

Bridging the Literatures

There has been markedly little bridging of the two research domains even while several language researchers, in essence, view semantic interference as a form of retrieval-induced forgetting (Oppenheim et al., 2010; Navarrete et al., 2021). One study by de Zubicaray et al. (2015) examined brain regions typically associated with RIF (hippocampus, rIFG, ACC) during a phase of continuous picture-naming but did not find significant activation. However, this study did not directly measure and compare patterns of activation in a RIF condition, and other studies have shown that key brain regions for RIF (e.g., the ACC) are also critical for monitoring and control in language production (Nozari & Novick, 2017). In the absence of more comparative work,

[1] RP+ = Practiced Items, RP- = Unpracticed Items from Practiced Categories, NRP = No Retrieval Practice

there are parallel findings along either side of the empirical divide that suggest that similar learning mechanisms are involved in both phenomena. For example, both RIF and semantic interference strengthen target access and weaken competitor access only in the context of active retrieval processes. In addition, they are associated with similar coactivation contingencies in which the relative magnitude of coactivations during retrieval determines the net effect on later accessibility (Levy & Anderson, 2002; Chan, 2009; Finkbeiner & Caramazza, 2006).

Generation Is Essential

Both RIF and semantic interference posit that interference only arises following retrieval of targets from memory. Indeed, the claim that active retrieval is a necessary condition for the forgetting of related items is one of the key tenets of RIF (Levy & Anderson, 2002). In the RIF literature, studies have repeatedly shown that it is not enough to simply study (or read) items; rather, they must be actively retrieved from memory in order for forgetting of related items to occur (Murayama et al., 2014; Hulbert et al., 2011; Anderson et al.,1994; Blaxton & Neely, 1984).

Studies have likewise shown the necessity of lexical generation in semantic interference (e.g., Gauvin et al., 2018). A study in our own lab presented picture targets with or without labels in a continuous naming procedure, thereby making the task either word naming (which does not require lexical retrieval) or picture name generation. We found cumulative interference (for both thematic and taxonomic materials) in the generation condition, but no such effect in the word naming condition. Thus, active retrieval (including generation) appears to be essential for the elicitation of both semantic interference and RIF.

Balancing Facilitation and Interference

Interference, at its core, reflects an imbalance between the facilitation that comes with conceptually-based priming and the retrieval difficulty that arises when dealing with current competitors (or adaptations resulting from previous competitor activations). In some cases, benefits outweigh costs and *facilitation* occurs (e.g., Chan, 2009; Chan et al., 2006; Finkbeiner & Caramazza, 2006; Piai et al., 2011). In memory research, several studies have investigated a *retrieval-induced facilitation* effect. For example, Chan (2009) examined the impact of semantic integration on RIF. Using spatio-propositional word-pairs (e.g., the *fork* is in the *nursery*) in a retrieval practice paradigm, they found that generating a subset of items facilitated later recall of non-generated items from the same category, but only when they had been placed in the same spatial location (Chan, 2009; Chan et al., 2006). In line with Anderson & McCulloch (1999), this suggests that an integrative context is protective, such that the strengthening of shared features in the same-location condition led to a net facilitation effect.

In language production studies of semantic interference, several factors appear to influence the balance between interference and facilitation. Similar to the conclusions in memory retrieval studies, the primary factor appears to be the level of non-target coactivation relative to conceptual facilitation. For example, Finkbeiner and Caramazza (2006) investigated semantic interference in a Picture-Word paradigm with visible or masked distractor words. They observed the typical interference effect in the visible condition but found that related distractors facilitated target naming when they were masked (replicated by Damian & Spalek, 2014). Thus, in both RIF and semantic interference, shared semantic features inherently lead to facilitation at the conceptual level and interference only occurs when the activation of non-target representations outweighs this facilitation (cf., Dell et al., 1997).

In sum, both the currently available models and specific empirical findings suggest that semantic interference and retrieval induced forgetting (RIF) operate along similar parameters, and both may arise from the activity of similar incremental learning adaptations. It is plausible that distinct changes may be made selectively to conceptual-lexical links outside of or in addition to conceptual level changes, but distinguishing these is not the purpose of the present study. Rather, whether changes occur at the level of concepts or in conceptual-lexical links, modulations to memory access should also result in modulations to lexical access. Moreover, changes at either locus should build on one another. This claim is the focus of the current work

Experiment: Retrieval and Picture Naming

We report the first in a series of planned experiments designed to explore the commonalities and differences of semantic interference and RIF. In this initial investigation, we sought to make a direct connection between RIF and semantic interference by integrating the respective methodologies. Specifically, we addressed whether the forgetting observed in classic RIF studies would manifest as modulations to picture-name access in the language production procedure. In addition, we examined how retrieval-based modulation to memory accessibility combined with the cumulative interference that is observed in continuous picture naming. The design mirrors the typical retrieval practice paradigm, with the exception that the final recall phase used picture-naming rather than free recall. The experiment had four phases: an initial familiarization phase where participants were presented with each picture alongside its category and name, a phase of repeated category-cued (stem completion) generation for half of the items from some categories, a filler task (15 min), and a final phase of continuous picture-naming containing all items. The results of the final phase of picture-naming are reported here. Of primary interest was the effect of prior retrieval on naming time and errors in the final phase. We predicted longer naming latencies and more errors for ungenerated items from practiced categories compared to unactivated controls. We also predicted cumulative interference over ordinal positions, and that RIF and cumulative interference effects would be additive.

Participants

Based on comparable research, 48 participants were recruited in return for class credit in an introductory psychology course. Four participants were dropped from analysis due to equipment malfunction (N=1) or poor performance in the retrieval phase (> 80% failures, N=3). The remaining 44 participants were included in the analysis.

Materials and Apparatus

Related sets consisted of eight groups of eight taxonomically related items (64 total). We also included two filler sets of five items which always occurred at the beginning and end of the generation phase. The relatedness of items in each set was established using McRae's Associative Norms, USF Association Norms, the Edinburgh Associative Thesaurus, and experimenter discretion (McRae et al., 2005; Nelson et al., 2004; Kiss, 1973). The filler task was a medium level sudoku puzzle.

The experiment was programmed using E-Prime 3.0 and was conducted using a Dell OptiPlex 7020 computer with a 1908FPt 75 DPI monitor with a refresh rate of 80 Hz. Participants were seated approximately 16 inches from the screen. Voice onset times were recorded using a Psychology Software Tools 200A SR box interfaced to an ATR20 Audio-Technica microphone, and audio for the entire session was recorded using a SONY ICD-PX720 recorder. Pictures were centrally presented, clear stock photos resized to 256x192 pixels. Text was presented in 14-point Corsolas font.

Design

Cued Retrieval Phase. This phase comprised a typical retrieval induced forgetting (RIF) manipulation. Participants underwent cued retrieval for half (4) of the items from 5 of 8 related sets. This created a 3-level Memory Condition factor in the continuous picture-naming phase. Categories assigned to the NonActivated versus Activated conditions, and assignment of Activated items to Generated vs. NonGenerated status, were counterbalanced across participants. The four retrieval items in each activated category were dispersed and counterbalanced across positional quartiles. These items comprised the Activated-Generated condition in the final phase.

Continuous Picture Naming Phase. In the final continuous phase, pictures corresponding to all items were presented in a continuous sequence (not including category labels or names). In order to assess the effect of ordinal position, one item from each of the sets was randomly assigned to one of eight octiles. The presentation of items within each octile was randomized, and the order of octiles was counterbalanced across participants. Thus, there are two within-subject factors, Memory Condition (Activated-Generated, Activated-NonGenerated, and NonActivated) and Octile (Ordinal Position, 1-8). In addition, the efficacy of our counterbalancing procedure was assessed prior to analysis. There was no effect of or interactions with the counterbalancing factor and it was thus excluded from analyses.

Procedure

Phase 1: Familiarization. Participants were told that they would be naming a series of everyday objects. All pictures used in later phases were presented with their category and name in a randomized continuous sequence. Presenting the names with the pictures eliminates active lexical retrieval but makes the names available for Phases 2 and 4. On each trial, a fixation cross appeared for 200 ms, followed by the presentation of a picture and designated category-name pair (e.g., INSECTS – beetle) for 1500 ms. The category-name pair was presented below the picture. Participants named each picture aloud with the given name. The experimenter provided feedback on standard pronunciation on the rare occasions where it was necessary. No data were collected.

Phase 2: Cued Retrieval In this phase, participants were asked to generate a subset of the items they had encountered in Phase 1 (see Design). One filler set was presented at the beginning and at the end of the phase to negate possible serial position effects and these were not included in the analysis. Target items (cues) were divided into quartiles and randomly presented three times within each quartile. On each trial, a fixation cross appeared for 200 ms, followed by the central presentation of a stem-completion cue consisting of the category name and the unique first letter of one of the targets (e.g., INSECTS – b____). The display lasted for 8 seconds or until a naming response was registered. If participants did not name the target within the timeframe, a "too slow" message appeared for 500 ms before the next trial began. Latencies were measured. The next trial began 1000 ms after the conclusion of the previous one.

Phase 3: Filler Task. Participants worked on a medium difficulty level sudoku puzzle for 15 minutes.

Phase 4: Continuous Picture-Naming. Participants named all of the pictures in one continuous sequence internally segmented into octiles (see Design). On each trial, a fixation cross was presented for 200 ms followed by a picture target, which was presented for up to 1150 ms or until a naming response was registered. A "too slow" message appeared if the time limit was exceeded. Another trial began 1000 ms after the previous. At the close of the experiment, participants were thanked for their participation and debriefed.

Results

While there is potential in examining the reaction times within the retrieval phase, only the results of the crucial naming phase will be reported here. Error coding was performed off-line using the audio recording from the session. Picture naming trials in which a participant used an incorrect or incomplete name, stuttered, or did not respond (>1150 ms) were coded as errors and excluded from the latency analysis. Trials in which the reaction time was less than 150 ms were coded as an equipment error and excluded from all analyses. For the Activated-Generated condition, we also excluded items that were not successfully retrieved in the previous phase (46%) given previous research indicating that retrieval effects are more potent following successful generation (Patra et al., 2022). We predicted effects of Memory Condition on picture naming latencies and the low error rate that is typical. However, the data show effects in errors and not latencies. Therefore we report the error analysis first and follow with analysis of latencies.

Error Analysis

In the retrieval phase, participants had a rather high error rate (.46 ± .14). In the final continuous naming phase, the overall error rate was .19 ± .10. This relatively high error rate is at least partly attributable to the stringent response cut-off (1150 ms) used in our procedure. In the following analysis, we only included errors that resulted from lack of a response and stutters/hesitations (i.e., incomplete responses). While semantic substitution errors did occur, they were quite rare, and most could be attributed to misidentification rather than semantic intrusions.

Logistic linear mixed model analyses were conducted in R version 4.0.3 using the R function *glmer* (Bates et al., 2007; Jaeger, 2008). Because the error data were relatively sparse within each octile, we used a parsimonious approach to model construction (Bates et al., 2015), such that we only included the fixed factor for Memory Condition and specified only random intercepts for the random factors of subjects and items. There were more errors in the Activated-NonGenerated condition than in the other conditions (see Figure 1). This main effect of Memory Condition was significant (z = 10.63, p < .001). Pair-wise tests indicated more errors in the Activated-NonGenerated than the NonActivated condition (t(43)=2.05, p = .023), a RIF effect. In addition, Activated-Generated items were significantly *less* error prone than NonActivated (t(43)=5.13, p < .001) and Activated-NonGenerated items, t(43)=8.57, p < .001. Together, these results suggest that activating but not generating an item in a previous phase was associated with a greater likelihood of production error, while previous generation of an item was associated with a clear benefit to production accuracy.

Latency Analysis

Linear mixed model analyses were conducted using the *afex* package (Singmann & Kellen, 2019). This package is built around the lme4 package (Bates et al., 2007). A maximal approach was used, in which random intercepts were specified for both participants and items and random slopes were specified for each within-subjects variable and interaction for both participants and items (Barr et al., 2013). The model was incrementally simplified until convergence was achieved. The final model included fixed main effects and the interaction term for both variables (Memory Condition and Octile), random intercepts for both subjects and items, and an uncorrelated slope for Memory Condition within subjects. F-tests for the fixed effects were also conducted using the *afex* package, with Satterthwaite approximations applied to estimate the degrees of freedom (Singmann & Kellen, 2019). Descriptively, Activated-Generated items were named faster than those in the other conditions (see Fig 1). However, there was only a marginally significant main effect of Memory Condition, F (2, 66.22) = 2.65, p = .078. Follow up contrasts showed an overall facilitative trend for the Activated-Generated condition compared to the Activated-NonGenerated and NonActivated conditions, but this trend did not reach significance. Thus we see a marginal repetition priming tendency for generated items, but we do not see the predicted interference in the Activated-NonGenerated condition. As predicted, naming time increased over Octiles (see Fig 2). The effect of Octile was significant (F (7, 1316.44) = 4.33, p < .001), indicating the presence of cumulative interference in which naming time increased with ordinal position. The interaction between Memory Condition and Octile was not significant, F (14, 1606.49) = 1. Thus, cumulative interference in the picture-naming phase was largely independent of previous retrieval phase experience.

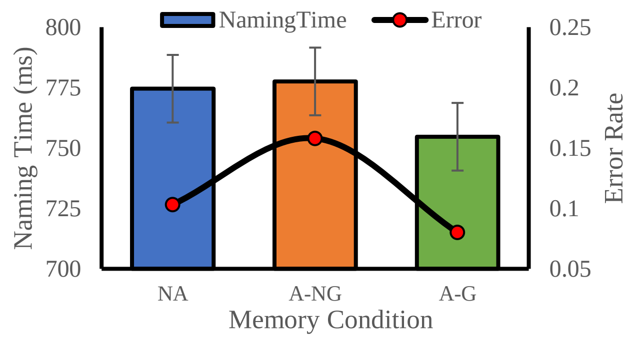

Figure 1. Effect of Memory Condition on naming time and incomplete response (error) rate. NA = NonActivated, A-NG = Activated-NonGenerated, A-G = Activated-Generated. Error bars represent standard errors.

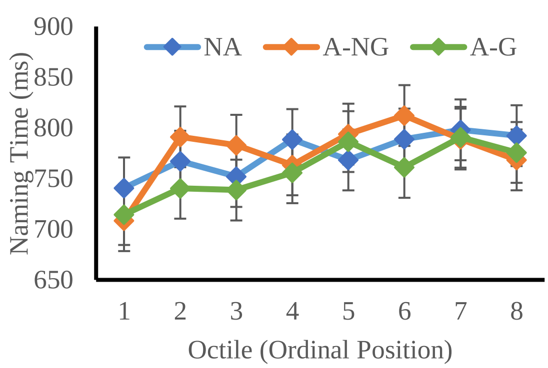

Figure 2. Naming times by Memory Condition over Ordinal Positions in the continuous picture-naming sequence. NA = NonActivated, A-NG = Activated-NonGenerated, A-G = Activated-Generated. Error bars represent standard errors.

Discussion

We propose the case for integrating theories of semantic interference and forgetting (RIF) and report an initial investigation into their commonalities. Specifically, we proposed that retrieval-induced forgetting and semantic interference in language production both involve incremental learning that modulates access to semantic representations based on recent experience. Memory theories postulate direct changes to conceptual representations themselves (Anderson & Spellman, 1995; Norman et al., 2007), whereas an influential language production theory focuses on links between words and conceptual features (Oppenheim et al., 2010). The present experiment examined if retrieval of instances (words) within categories (a variant of the retrieval-practice paradigm of Anderson et al., 1994) affected subsequent naming of corresponding pictures (a continuous naming procedure that provides latency and error data by item; Howard et al., 2006). We hypothesized that they would, regardless of the locus of the effect.

Consistent with this prediction, the error rate was higher for previously non-generated members of activated categories than for non-activated controls, and previously generated items had the lowest rate of error. We did not observe corresponding effects in latencies, suggesting that errors leveled off changes to naming time. We did observe some sensitivity to previous experience, in that latencies to items previously retrieved with word cues were named marginally faster as pictures. This result is in need of replication. Finally, we observed significant cumulative interference over ordinal positions in picture naming, but this was independent of previous cued retrieval (Fig 2).

As is to be expected of an exploratory study, there are several outstanding issues to address in future work. Since there was a rather high degree of error in the retrieval/generation phase, many unrecalled items were dropped from the final naming phase. This may have reduced statistical power. In addition, it is possible that the absence of an effect of retrieval experience on latencies reflects an error trade-off. Third, future work should consider the specific contribution of successful vs. erroneous (but effortful) recall on later lexical access (Storm et al., 2006; Navarrete et al., 2021).

The most important finding of this study is that the pattern of production errors was largely consistent with retrieval-induced forgetting predictions. At least under these conditions, RIF manifested as increased errors rather than in naming times, suggesting that, in the current task, errors reduced the cost to naming latency (cf. Nozari & Hepner, 2019). The absence of a RIF effect in latencies in turn made it impossible to evaluate the combined effects of previous retrieval and new cumulative interference. We suggest that future studies that yield higher production accuracy (e.g., by extending the response deadline in the final naming phase) may result in fewer errors and greater sensitivity in naming latencies.

The study used a 15-minute distractor/retention interval. The majority of studies investigating long-term semantic interference rely on interleaved unrelated items to assess changes in access that occur in the long-term, even if this "long-term" period spans less than a single minute (but see Gaskell et al., 2014). Obviously, this is far removed from the conceptualization of long-term effects within the memory literature, so our understanding of the durability of cumulative interference is currently quite limited. In contrast, the RIF literature has the opposite problem: researchers prioritize long-term effects over in-the-moment competitive processes. RIF paradigms use proportion recall as the chief measure of forgetting rather than reaction time, thereby focusing on the role of previous retrieval history over response-level lexical interference (but see Jonker et al., 2013). We suggest that both short-term coactivation and long-term learning play key roles in both conceptual and lexical retrieval effects and that integration of current methodologies and theories would further both fields.

Although preliminary, the results reported here underscore the broader need to bridge current models of memory and language production. Accounts across the two fields describe highly parallel phenomena that may involve shared stages of processing. The questions addressed in the present study only scratch the surface of the integrative work to be done to develop a comprehensive understanding of experience-driven adaptations within the language and memory components of the cognitive system. Future work will aim to assess the conditions in which adaptations within conceptual representations and adaptations to conceptual-lexical links are responsible for observed interference effects. Lastly, we emphasize that a model of interference including both memory substrates and a lexical interface is needed to fully capture the incremental learning that drives changes in accessibility of conceptual-linguistic meaning.

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