Forgetting the literal: The role of inhibition in metaphor comprehension

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INHIBITION AND METAPHOR COMPREHENSION

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
F	Test Statistic Based on the Fisher-Snedecor Distribution
LSA	Latent Semantic Analysis
M	Mean
η_p^2	Partial eta-squared Measure of Effect Size
N	Number in group
RAT	Remote Associates Test
RIF	Retrieval-Induced Forgetting
SOA	Stimulus Onset Asynchrony
SD	Standard Deviation
T	Test Statistic Based on Gasser's Student Distribution

INHIBITION AND METAPHOR COMPREHENSION

Summary

In order to comprehend figurative language does literal information need to be inhibited?

Previous research using sentence-verification paradigms has found evidence for the inhibition of literal associates after reading metaphorical sentences; however it is problematic to infer inhibition from this research. Moreover, previous work has not distinguished between familiar and novel metaphor processing. In three preliminary experiments using a novel metaphor-induced-literal-forgetting paradigm, participants initially learned word pairs where the cues were potential metaphoric vehicles and the targets were literal associates (e.g., *SHARK*- *swim*). Then, participants read half the vehicles as part of metaphorical sentences which they interpreted (*The lawyer for the defense is a shark*). Subsequent forgetting of the literal associates was greater when vehicles had appeared in metaphorical sentences (Experiment 1), was observed for interpreting both familiar and novel metaphors (Experiment 2), and was observed for *only* novel metaphors when instructed to simply read the metaphors without interpreting them (Experiment 3). These results suggest that forgetting occurs as a function of the amount of effort that a reader needs to put into interpreting metaphoric phrases by inhibiting alternative meanings during the resolution process, as these demands are greater for novel expressions. Experiments 4 and 5 attempted a strong test of this hypothesis by using “impossible” metaphors which subjects are unlikely to resolve with a viable interpretation within a short time frame. While the forgetting effect was weaker in these experiments, some evidence for forgetting associated with processing impossible metaphors was observed. Potential limitations and suggestions for future work are discussed.

1. Introduction

Figurative language may make discourse more interesting, but does it also make comprehension more difficult? Many theories of discourse processing have suggested that figurative language involves additional processing compared with literal language (Bowdle & Gentner, 2005; Searle, 1979). For example, it has been assumed that when one encounters a figurative phrase, literal meaning will first be accessed and a figurative interpretation will only be derived once a literal interpretation has failed (Searle, 1979). Although there are cases where non-literal language can be accessed more directly as in the case of highly familiar non-literal expressions (Glucksberg, Gildea, & Bookin, 1982), this does not speak to more creative and novel uses of language. One common type of figurative language is metaphor. In a metaphorical expression of the typical nominal variety such as “My job is a jail” a metaphor vehicle (e.g., *jail*) is used to illustrate one or more aspects of a topic concept (e.g., *job*). The words *jail* and *job* each have strong associates with other concepts, but are weakly related as a pair. However, they clearly share the semantic feature of confinement, which can be seen as a way to resolve the semantic difficulty presented by this sentence.

Perspectives on metaphor processing generally fall into two broad classes. The first are feature matching accounts. These accounts assume that metaphors are treated as similarity statements that highlight common properties between a topic and vehicle concept. Work by Johnson and Malgady (1979) which found that the degree of rated similarity between a topic and vehicle word was related to ease of metaphor interpretation supports this view. A modified version of feature matching accounts was also proposed by Ortony (1979) that focused on salience imbalance. This account argues that the shared features will only be highlighted when they are of high salience for the vehicle concept, but of low salience for the topic concept. More

recent modeling work using latent semantic analysis (LSA) is also consistent with this view (Kintsch, 2000). However, one issue with feature matching accounts is that there are often a number of common features between the vehicle and topic terms that are not relevant to the metaphoric interpretation. For example, in the metaphor “My lawyer is a shark” both lawyers and sharks are living things. Moreover, the view that metaphor processing is a matter of simple comparison cannot explain why the terms in a metaphor cannot be reversed (e.g., “my jail is a job”).

A second set of accounts treats metaphors as categorization statements, in which the vehicle refers to a superordinate category of which the topic is a member. This involves deriving an abstraction from the vehicle concept and applying it to the topic concept. For the metaphor “my job is a jail” the vehicle concept *jail* specifies a higher-level category of situations that are confining and unpleasant, which includes the *job* concept. This account places emphasis on the role of the vehicle in metaphor processing and implies a strong sense of directionality (i.e., from the base to the topic). The categorization view is supported by results showing that metaphor statements lose comprehensibility when the topic and vehicle terms are reversed (Glucksberg & Keysar, 1990; Glucksberg, McGlone & Manfredi, 1997). Additionally, participants are more likely to judge topic concepts as being a member of the category of the vehicle when following a metaphorical prime than a literal prime (Jones & Estes, 2005). However, one issue with categorization accounts pertains to how metaphorical categories are created when the relevant properties are not identical. For example, in the metaphor “my lawyer is a shark” the kind of aggression that relates to sharks is different from the kind of aggression that relates to law practitioners. Another issue is that the number of potential categories can be very large, and this

could be especially problematic for novel metaphors where the category needs to be constructed *ad hoc* (Barsalou, 1983).

A third alternative approach to metaphor processing which resolves some issues with the previous two models is that of structural alignment. While this view invokes comparison, it emphasizes matching the relational elements within the vehicle and topic, and is closely related to analogy. This view proposes that metaphor processing begins with an initial comparison process in which the topic and vehicle terms are aligned such that relationally similar elements are placed in correspondence in a way that achieves the highest structural consistency. Following this abstraction, further inferences are projected from the vehicle to the topic (Gentner & Wolff, 1997). Thus, this view contrasts with the categorization approach, which focuses on abstracting a category from the vehicle. Support for this claim comes from the fact that priming a metaphor sentence with the vehicle term does not facilitate comprehension any more than priming with the topic term (Gentner & Wolff, 1997). Moreover, it has been found that reversed and normal metaphors were judged as equally comprehensible at early but not late response deadlines, and that reversed metaphors were judged as more comprehensible than scrambled metaphors regardless of deadline (Wolff & Gentner, 2011). This suggests that meaningful processing of metaphors is engaged early on, and that this processing is based on a symmetrical comparison process.

Additionally, an extension of the structure alignment approach has the advantage that it can explain differences between familiar and novel metaphors. In a series of experiments, Bowdle and Gentner (2005), found that novel metaphors were preferred more as simile statements (e.g., “science is like a glacier”), which tend to elicit comparison (horizontal alignment), than as direct metaphorical statements, which are more akin to categorization

(vertical alignment). There was also a comprehension speed advantage for novel metaphors when they were in simile form. However, for more familiar/conventional metaphors (e.g., “a gene is a blueprint”) this pattern was the opposite. Moreover, after repeatedly exposing participants to novel metaphors in their simile form (and thereby conventionalizing their meaning), participants shifted their preference toward the direct metaphorical form. Eventually, metaphors can become lexicalized through repeated use as in the case of “dead” metaphors, where the figurative meaning actually has priority over the literal meaning (e.g., blockbuster). This overall pattern is referred to as the “career of metaphor” hypothesis and it suggests that as metaphoric meanings become more conventional, they tend to be processed more like categorizations, which are more direct than comparisons.

Each of these models involves excluding literal information from the figurative interpretation. In order to understand metaphors, it may be necessary to inhibit features of the vehicle that are not appropriate for the target. Previous research has indeed yielded findings consistent with inhibition of literal associates after reading metaphorical sentences (Gernsbacher, Keysar, Robertson, & Werner, 2001; Glucksberg, Newsome, & Goldvarg, 2001). In these experiments, participants read sentences containing both literal and metaphorical uses of a metaphor vehicle (e.g., “The hammerhead is a shark” vs. “My lawyer was a shark”) before judging the validity of target sentences that were either relevant or irrelevant to the metaphorical meaning (e.g., “Sharks are vicious” vs. “Sharks can swim”). Participants were slower to verify metaphor-irrelevant properties following metaphorical sentence primes than following literal sentence primes, suggesting that inhibition is a mechanism by which irrelevant literal information is filtered out during metaphor comprehension.

However, since these studies relied on probe paradigms that used sentence verification times as the dependent measure, it is not clear whether these findings truly reflect the active suppression of metaphor-irrelevant information during comprehension. One issue with interpreting sentence verification data is identifying a meaningful baseline for response times. Because people were exposed to both literal and metaphorical uses of the vehicles, it is difficult to tell whether participants were slower to verify metaphor-irrelevant literal information after reading metaphors, or if they just tend to be faster to verify information following literal sentences. Another issue with verification probes is that they are subject to context-checking effects. For example, in the Glucksberg et al (2001) study, the metaphor-irrelevant probe “Geese can swim” followed either the metaphor sentence “My lawyer was a shark” or the literal prime sentence “The hammerhead is shark.” The resulting slower reaction time for the metaphor-irrelevant probe sentence following metaphor primes than literal primes could be due to inhibitory processing during comprehension of the metaphor, or it could be due to a lack of congruency between the two sentences and the fact that the probe sentence does not fit well in the context of the first. Once a prime is understood to contain a metaphorical meaning, it is more difficult to then integrate a conflicting literal-relevant target with the preceding meaning than when it is preceded by a literal prime or other baseline prime. The mismatch induces a slowdown and this can be an issue in decision-based probe tasks and priming studies that use recognition decisions to measure activation of information (Forster, 1981; Potts, Keenan, & Golding, 1988; Tipper, 2001; Wiley, Mason & Myers, 2001). Such post-reading probe measures make it difficult to conclude that inhibition must be recruited *during* the act of interpreting a metaphor. These measures only allow one to examine the accessibility of relevant/irrelevant information

once a metaphor is read, rather than examining how active interpretation of a metaphor might affect access to potentially interfering literal information as the metaphor is being processed.

The results of previous studies on the activation and inhibition of literal and metaphoric meanings have also not been completely consistent in their findings. While Gernsbacher et al. (2001) found both an enhancement effect for metaphor-relevant statements and an inhibition effect for metaphor-irrelevant statements, Glucksberg et al. (2001) only found an inhibition effect. This is likely due to their use of independent terms in the target sentences (e.g., “My lawyer was a shark/Geese are vicious.”) whereas Gernsbacher used the same vehicle in her probe sentences “My lawyer was a shark/sharks are vicious”. Moreover, not all metaphor priming studies have found such inhibitory patterns. For example, in a series of studies using lexical decision tasks to assess the activation of word meanings, Blasko and Connine (1993) found similar reaction times for both literal and metaphorical target words after reading metaphorical sentences that had been rated as familiar, suggesting activation of both literal and figurative meanings. This pattern was different for unfamiliar metaphors. For unfamiliar metaphorical sentences, there was also evidence of activation of the literal meaning. However, people were slower to respond to metaphorical targets than unrelated control targets at short SOAs but not at longer SOAs (Blasko and Connine (1993) did not address activation of literal information at these longer SOAs).

Thus, the results of Blasko and Connine (1993) question whether the inhibition of literal associates found in other studies may have depended on the task that was used to measure activation of word meanings. Additionally, they also suggest that metaphor familiarity plays a critical role. As previously mentioned, Bowdle and Gentner (2005) suggested that familiar and novel metaphorical statements rely on different forms of meaning comprehension based on a

series of experiments examining participant preferences and comprehension times for familiar and novel metaphors. Conventional metaphors are more likely to be processed as categorization statements in which the superordinate metaphorical category can be more or less directly accessed. However, novel metaphors tend to be processed more like comparison statements because no superordinate metaphorical category is available from experience, so the two concepts have to be directly compared in order to construct the metaphorical interpretation. In the context of inhibition, this would suggest that for more familiar metaphors there would not be much competition for meaning in the first place, and so not as much inhibition of literal information should be necessary. However, for more novel metaphors any irrelevant literal information brought to mind during the early processing of the metaphorical category would have to be inhibited. This framework may help partially explain the Blasko and Connine (1993) finding of slower responses to metaphorical targets at short SOAs for unfamiliar metaphor sentence primes. Participants may have been caught in the early stages of categorical processing at the short SOA. Additionally, the inhibitory patterns found in the Glucksberg et al. (2001) and Gernsbacher et al. (2001) could be due to a mix of familiar and novel metaphors. The novelty of the stimuli used in both of these two studies is not explicitly addressed. This relates to an important issue of how these previous findings were interpreted with regard to theories of metaphor processing. Gernsbacher et al. (2001) claim that these inhibitory patterns are a reflection of metaphoric category construction. However, one would only expect this to be the case for unfamiliar metaphors that do not have a stored metaphoric category that can be retrieved. However, these studies do not explicitly distinguish between familiar and novel metaphors, which is an important distinction as indicated by the career of metaphor theory.

The goal of the current project was to use an alternative methodological approach to test for competition from and inhibition of literal associates during the metaphor comprehension process. Instead of using response times on post-reading recognition probes that are literal associates of a metaphorical vehicle, the current studies adapt retrieval-induced forgetting paradigms to study metaphor processing. An important second goal of this research was to test whether any forgetting that is observed is more likely to occur or is stronger in its effect when metaphors are novel rather than familiar. This was tested by manipulating the familiarity of metaphors. Finally, a third aim of this research was to provide a strong test for the role of inhibition during metaphor comprehension by exploring the effects of attempts to resolve “impossible” metaphors on memory for literal associates. If inhibition is engaged *during* the attempt at comprehension itself, then one could expect access to literal information to be impaired even when people do not successfully comprehend a metaphor.

2. Experiment 1

The main purpose of Experiment 1 was to employ a new methodology to explore processes underlying metaphor comprehension based in the established retrieval-induced forgetting (RIF) paradigm. Metaphor comprehension can be viewed as a form of selective retrieval from long-term memory during which information (e.g., alternate meanings) competes for access. As such, metaphor-irrelevant information may need to be inhibited in order to resolve this competition. The notion of inhibition during retrieval has commonly been explored in the RIF paradigm (Anderson, Bjork & Bjork, 1994). In these experiments, subjects typically study a list of category exemplar pairs (e.g., FRUIT-banana, FRUIT-lemon, TOOLS-hammer, TOOLS-saw), followed by a period of retrieval practice for half the exemplars from half the categories (e.g., FRUIT-banana). On a test of final recall for all of the word pairs, recall for responses associated with unpracticed categories (e.g., TOOLS) serves as a baseline, and recall for practiced responses from practiced categories (e.g., FRUIT-banana) is enhanced. Critically, recall of unpracticed responses from practiced categories (e.g., FRUIT-lemon) is inhibited (i.e., below baseline). This RIF effect is assumed to be a consequence of competition arising from similar but irrelevant items in memory during retrieval practice, which in turn causes inhibition to be directed toward the competing information. As an alternative to an inhibitory account of RIF, there are several arguments for interference-based forgetting in this paradigm that largely rely on the idea that the cue-response associative strength for practiced pairs blocks or occludes memory for unpracticed pairs (MacLeod, Dodd, Sheard, Wilson & Bibi, 2003). However, several findings support the inhibitory account of RIF (Storm & Levy, 2012). For example, forgetting occurs independent of the retrieval cue used for a response word, it only occurs as a result of retrieval practice and not with repeated study exposure, it occurs when controlling for output

interference, it is moderated by the amount of competition between response items (e.g., by manipulating word frequency of responses), and even occurs with a lack of retrieval success (Storm & Levy, 2012). To the extent that competing or dominant responses such as literal associates are automatically brought to mind during metaphor comprehension, inhibitory mechanisms may be recruited to reduce these responses and should result in a forgetting effect.

A variant of the RIF paradigm has already been extended into the domain of creative problem solving. This “problem-solving-induced forgetting” has been demonstrated to occur during the generation of solutions in creative tasks where subordinate meanings of words, or unusual uses for objects, are required, such as the remote associates test (RAT) or the alternate uses test (AUT). After an initial exposure to a set of word pairs including common associates or conventional uses for items, participants showed reduced recall for these word pairs after they attempted to generate remote or novel solutions, compared with if they did not engage in any problem solving attempts (Storm, Angello, & Bjork, 2011; Storm & Patel, 2014). Moreover, participants who showed more forgetting were more likely to be successful in generating solutions (Koppel & Storm, 2013; Storm et al., 2011). These results are thought to demonstrate that inhibition is an adaptive mechanism that is engaged in order to deal with competition from less creative solutions during creative problem solving attempts.

In the context of metaphor processing, we expect that the same mechanisms would be recruited when a previously-learned literal associate of a metaphor vehicle interferes with the successful interpretation of the vehicle’s figurative meaning. If readers engage in inhibition during the resolution of metaphoric expressions, then participants should also show forgetting in this context, which would result in reduced recall for word pairs consisting of vehicles and their literal associates. To test this hypothesis, an initial experiment was conducted in which

participants studied literal associates of metaphor vehicles (e.g., *SHARK – swim*) before generating interpretations of metaphors that used half of these vehicles (*The lawyer for the defense is a shark*). This initial study relied on the materials of Gernsbacher et al. (2001) so as to demonstrate that an inhibitory effect could be replicated using this methodology.

2.1. Method

2.1.1. Participants

Participants were 23 undergraduates from the University of Illinois at Chicago subject pool. Two participants were excluded from analysis for not meeting the criteria for English language fluency. The criteria for English fluency were that 1) English was the participant's dominant language, or 2) that the participant spoke English and another language equivalently well, and that they had been speaking English for at least 10 years. All participants provided agreement to participate and they received course credit for participation. The design was within-subjects so all participants received word pairs from both metaphor and no-metaphor interpretation conditions. Participants were randomly assigned to one of two conditions that counterbalanced which metaphoric sentences were seen.

2.1.2. Materials

The stimuli consisted of 40 metaphorical sentences taken from a previous study on metaphor comprehension (Gernsbacher et al., 2001). A set of 40 cue-associate word pairs was created using these stimuli, in which the cue was the metaphor vehicle of a sentence, and the target response was a literal associate of the vehicle that did not relate to the figurative meaning (e.g., "SHARK-swim" for the sentence "The lawyer for the defense is a shark"). The single-word literal associates used in the word pairs for this study were based on the Gernsbacher et al. (2001) literal-meaning probes.

To assess base-rate recall of these word pairs, a norming experiment was conducted with eight participants. Participants studied the cue-response pairs on a sheet of paper for 3.5 m, followed by a cue-plus letter stem recall on a sheet of paper for 3.5 m. Average percent recall was 95%. For each individual item, the average percent recall was calculated across subjects. These stimuli were then split into two lists of 20 items that matched the target responses on base-rate of recall, written frequency (Kucera-Francis), number of letters, and number of syllables. The cue words were matched for the number of living things. The recall rates for the two sets are shown in Appendix A.

2.1.3. Procedure

After collecting agreement to participate, there were four phases to the main experiment: Study, Initial Test, Metaphor Interpretation, and Final Recall. First participants studied the word pairs. Participants were given the 40 cue-response word pairs on a sheet of paper with the following instructions:

“Welcome to the experiment. The following pages contain pairs of words. The first word is the cue. The second word is the response. For example: DOG: leash. Your job is to study each word pair so that when given the cue word, you can recall the response word. There are 40 word pairs listed on two pages. You will have 3.5 minutes to study the word pairs.”

The order of items was randomized for each participant. They had 3.5 m to study this list before it was collected.

Immediately following the study period, participants were given a list of the 40 cue words along with the first letter of the response word on a sheet of paper in a new random order with the following instructions:

“There will now be a fill in the blank recall test. The following pages contain all of the cue words, along with the first letter of the response word that went with it. Your job is to think of the response word that went with it, and write it down on the blank line. You will have 3.5 minutes.”

They had 3.5 m to write down the correct response to each cue before it was collected. This procedure ensured strengthening of the cue-response pair in memory.

Following the initial test, participants completed a metaphor interpretation task via E-Prime. Participants were presented with one of the two lists of 20 metaphorical sentences in which the vehicle was a cue from the previously studied word pairs (metaphor interpretation condition). The other half of the cue words did not appear in any sentences (no-metaphor condition). Participants were given the following instructions:

“In the next part of the experiment, you will be presented with some sentences. These sentences will be in the form of metaphors. A metaphor is a figure of speech in which a word suggests a likeness or analogy between two things. For example, when we say, ‘My little brother is a pig’ we do not mean that he is literally a pig; we mean that there are similarities between my little brother and a pig. Your task is to think of what each metaphorical sentence means and type it in. The sentences will be presented one at a time. You will be given up to 20 seconds think about what the sentence could mean. Remember that the meaning of the sentence is always metaphorical, and never literal. Once you know what the sentence means, press the space bar and you'll have 20 seconds to type in your full response in the box.”

The sentences were presented one at a time. For each sentence, participants had up to 20 s to read and come up with the metaphorical interpretation, which they indicated by pressing the space bar. The computer logged the reaction time for this space bar press. After pressing the space bar, they had up to 20 s to type the interpretation in a response box. After 20 s elapsed, participants were automatically presented with the next sentence.

Following the metaphor interpretation task, participants received a surprise final recall test of all 40 cue-response pairs via E-Prime. The order of items was randomized across participants. Each trial began with the presentation of a fixation cross for 500 ms, followed by the presentation of the cue word along with a blank response box for 5 s. Participants were instructed to type the correct response into the response box. After 5 s, the next trial began. The instructions for the final recall task were as follows:

“There will now be a final fill in the blank recall test. You will be presented with each cue word, but this time the first letter of the response word is not there. Your job is to think of the response word that went with it and type it into the response box. You will have 5 seconds to type in each word.”

After completing the tasks, participants were given a brief demographic form which included information on language background and a debriefing sheet.

2.2. Results

The pattern of final recall is shown in Table 1. The percentage of correct responses on the final recall test was computed separately for the metaphor interpretation and no-metaphor conditions to create recall accuracy scores for each condition. Misspellings and pluralizations were accepted as correct. These values were entered into a repeated-measures analysis of variance (ANOVA). More forgetting of the literal associates was seen in the metaphor-

interpretation condition than in the no-metaphor condition, $F1(1, 21) = 12.05, p < .01, \eta_p^2 = .37$; $F2(1, 39) = 20.74, p < .01, \eta_p^2 = .35$, suggesting metaphor-induced forgetting. There were no differences in initial recall for either subject or item analyses ($F1 < 1, F2 < 1$) ($M = 91\%$).

Table I.

Final recall for the metaphor interpretation and no-metaphor conditions

Interpretation condition	<i>M</i>	<i>SD</i>
Metaphor Interpretation	76%	19%
No Metaphor	85%	16%

2.2. Discussion

The finding that there is forgetting of literal associates of metaphoric vehicles as a result of generating their figurative interpretations is consistent with the notion that inhibition of literal information is involved in metaphor processing (Gernsbacher et al., 2001; Glucksberg et al., 2001). These results also show that a RIF-based method may be useful for understanding when inhibition may be involved in metaphoric processing.

3. Experiment 2

The results of Experiment 1 suggest that inhibition of literal associates may be occurring as part of metaphor comprehension. However, a great deal of research has suggested that there may be an important distinction between the processing of familiar and novel metaphors (Blasko & Connine, 1993; Bowdle & Gentner, 2005). Familiar metaphors may be processed more like categorical statements (e.g., “A bear is a mammal”), while novel metaphors may require an initial comparison process in order to arrive at an appropriate metaphorical alignment.

The Gernsbacher et al. (2001) and Glucksberg et al. (2001) studies do not make such a distinction. A novel metaphor vehicle is not as likely to have a stored figurative representation or associated metaphorical category as a familiar metaphor vehicle. As such, this should make processing more challenging, and may require more inhibitory processing in order to overcome the literal meaning. If novel metaphors require greater effort to overcome the literal meaning, they should produce even more forgetting of literal associates than more familiar or conventional metaphors.

3.1. Method

3.1.1. Participants

Participants consisted of 36 fluent English-speaking undergraduates from the University of Illinois at Chicago subject pool. Participants provided agreement to participate and were given course credit for participation. Six participants were excluded for not meeting the criteria for English language fluency (same criteria as Experiment 1). Participants provided agreement to participate and were given course credit for participation.

3.1.2. Design

Experiment 2 used a 2 x2 design with metaphor processing condition (metaphor interpretation vs. no-metaphor) and familiarity condition (familiar vs. novel metaphors) fully crossed within subjects.

3.1.3. Materials

The original 40 metaphorical sentences from Gernsbacher et al. (2001) stimuli along with 30 new sentences selected from the literature that were characterized as novel (Blasko & Briihl, 1997; Gentner & Wolff, 1997; Glucksberg & Haught, 2006; Jones & Estes, 2005; Jones & Estes, 2006; Katz & Paivio, 1988; Mashal & Faust, 2008) were rated on familiarity by seven raters along a 1 - 7 scale (1 = not all familiar, 7 = highly familiar). As shown in Appendix B, from this sample we selected 20 metaphors with the lowest familiarity ratings to serve as stimuli for the novel metaphor condition, and 20 metaphors with high familiarity ratings to serve as stimuli for the familiar metaphor condition. A set of 40 cue-response word pairs were created using these stimuli, in which the cue word is the metaphor vehicle of the sentence, and the target response is a literal associate of the vehicle that does not relate to the figurative meaning. The assessment of base-rate recall for the target responses was tested in a norming study with 10 participants, following the same base-rate assessment procedure as the norming study used for Experiment 1, with the addition of a second recall phase administered via E-prime, which was identical to the final recall procedure of Experiment 1. This ensured that words in appearing in the different conditions were matched not just according to initial recall rate, but also according to recall rate on a second test without any intervening task. As shown in Appendix B, the stimuli were split into two lists of 20 items (A and B), each list containing 10 items associated with novel metaphors and 10 items associated with familiar metaphors. Each of the 4 sets of 10 items were

matched for rate of recall on the second test, written frequency (Kucera-Francis), number of letters, and number of syllables. The cue words were matched on the number of living things.

3.1.4. Procedure

The procedure and scoring of the final recall test was identical to that of Experiment 1.

3.2. Results

Analysis of reaction times revealed that participants spent longer thinking of interpretations of novel metaphors ($M = 7.6$ s, $SD = 2.6$ s) than familiar metaphors ($M = 4.9$ s, $SD = 1.6$ s), $F(1, 29) = 72.26$, $p < .01$, $\eta_p^2 = .71$, suggesting greater processing difficulty for novel metaphors.

An examination of average initial recall for all items revealed one outlier that was more than three standard deviations below the mean, so this item was dropped from analyses. The percentage of correct responses on the initial and final recall test were computed separately for the familiar and novel metaphor conditions, and the two no-metaphor conditions to create four recall accuracy scores for each subject for both initial and final tests. When the initial recall scores were entered into a two-way repeated measures ANOVA, no differences were seen due to either metaphor condition or familiarity (All F s < 1 , $M = 97\%$).

As shown in Table 2, when the final recall scores were entered into a two-way repeated measures ANOVA, there was a main effect of metaphor condition $F(1, 29) = 11.33$, $p < .05$, $\eta_p^2 = .28$; $F(1, 37) = 7.53$, $p < .05$, $\eta_p^2 = .17$ such that recall for items appearing in metaphors was lower than recall for items not appearing in metaphors. There was also a main effect of familiarity $F(1, 29) = 13.67$, $p < .05$, $\eta_p^2 = .32$; $F(1, 37) = 4.51$, $p < .05$, $\eta_p^2 = .11$ such that recall for response words associated with novel vehicles was lower than for words associated with familiar vehicles. The interaction was not significant, $F < 1$, as the two main effects fully

accounted for the pattern of means showing that the most forgetting occurred for novel metaphors.

Table II.

Final recall for metaphor interpretation and no-metaphor conditions for familiar and novel metaphors

Metaphor condition	Familiar		Novel	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Metaphor Interpretation	86%	13%	78%	15%
No Metaphor	92%	10%	86%	12%

3.3. Discussion

The results of Experiment 2 help to reinforce the findings of Experiment 1, while demonstrating that the forgetting effect linked to metaphor processing is stronger when the metaphors are novel. Consistent with other research, these results show that people take longer to process novel than familiar metaphors. These results also suggest that the necessity to overcome competition from irrelevant information is greater for novel than familiar metaphors. Because there is no strong figurative concept or metaphoric category previously associated with novel metaphors, it seems that it is more difficult for readers to overcome the irrelevant literal information and arrive at the metaphor's interpretation.

However, a forgetting effect was still seen even for familiar metaphors. One explanation might be the methodology that was used in this study. Requiring participants to explicitly type in an interpretation of a familiar metaphor might cause interference with access to the initially learned associates. This suggestion is explored by changing the methodology in Experiment 3 so that participants are only asked to read the metaphoric statements, and not to interpret them.

4. Experiment 3

In Experiment 2, novel metaphors were found to produce more forgetting than familiar metaphors. However, a concern about the methodology used in the first two experiments is that the metaphor processing condition prompted both reading the metaphoric sentences, as well as interpreting them. To determine if forcing participants to produce a written interpretation for each metaphor was responsible for the forgetting, Experiment 3 attempted to replicate effects by exposing participants to metaphors simply by reading them. Instead of generating written interpretations of the metaphoric sentences, participants were simply told to press a key when they were done reading the sentences. A reading-only condition allows us to see forgetting patterns in a more natural reading context (without the explicit requirement of typing in an interpretation). If the forgetting observed in Experiments 1 and 2 is a result of interference caused by the generation of the metaphoric interpretation and not due to inhibition of literal associates as part of normal reading processes, then there should be less metaphor-related forgetting in the read-only condition.

4.1. Method

4.1.2. Participants

Participants consisted of 26 fluent English-speaking undergraduates from the University of Illinois at Chicago subject pool. Participants provided agreement to participate and were given course credit for participation. Participants provided agreement to participate and were given course credit for participation.

4.1.3. Design

Experiment 3 used a 2 x 2 design with metaphor processing condition (read metaphor vs. no-metaphor) and familiarity condition (familiar vs. novel metaphors) fully crossed within subjects.

4.1.4. Materials

The same materials were used as in Experiment 2.

4.1.5. Instructional Task Manipulation

The instructions were similar to previous studies except the interpret instructions were replaced with the following underlined text:

“In the next part of the experiment, you will be presented with some sentences. These sentences will be in the form of metaphors. A metaphor is a figure of speech in which a word suggests a likeness or analogy between two things. For example, when we say, ‘My little brother is a pig’ we do not mean that he is literally a pig; we mean that there are similarities between my little brother and a pig. Your task is to read each metaphorical sentence carefully to yourself. The sentences will be presented one at a time. Once you have read the sentence, press the space bar to advance to the next sentence.”

4.2. Results

Examination of reading times revealed that one participant’s reading time (18.10 s) was over 3 SDs above the mean. After excluding this participant, participants took 3.90 s ($SD = 1.60$) to read familiar metaphors and 4.74 s ($SD = 1.74$) to read the novel metaphors $F(1, 25) = 24.22$, $p < .01$, $\eta_p^2 = .50$, indicating that metaphor novelty still impacted processing time, despite the lack of a requirement to generate an interpretation.

Initial recall scores were entered into an ANOVA crossing metaphor condition and familiarity. There were no effects of metaphor condition ($F < 1$), familiarity $F(1, 24) = 2.41, p = .13, \eta_p^2 = .09$, nor an interaction $F(1, 24) = 1.70, p = .20, \eta_p^2 = .06$. For the final recall data, the ANOVA revealed a main effect of metaphor condition $F(1, 24) = 7.19, p < .05, \eta_p^2 = .23, F(1, 38) = 3.45, p = .07, \eta_p^2 = .08$ with more forgetting in the metaphor condition ($M = 79\%, SD = 14\%$) than the no metaphor condition ($M = 84\%, SD = 12\%$), a marginal effect of familiarity $F(1, 24) = 3.69, p = .07, \eta_p^2 = .13, F(1, 38) = .83, p = .38, \eta_p^2 = .02$ with greater forgetting associated with novel ($M = 79\%, SD = 14\%$) than familiar metaphors ($M = 83\%, SD = 13\%$). The interaction of metaphor condition and novelty was also significant $F(1, 24) = 4.81, p < .05, \eta_p^2 = .17, F(1, 38) = 4.58, p < .05, \eta_p^2 = .11$. As shown in Table 3, there was strong forgetting of literal associates from having read novel metaphors $F(1, 24) = 10.00, p < .01, \eta_p^2 = .29, F(1, 19) = 6.12, p < .05, \eta_p^2 = .24$, but not familiar metaphors ($F(1, 24) < 1, F(1, 19) < 1$).

Table III.

Final recall for metaphor and no-metaphor conditions for reading familiar and novel metaphors

Metaphor condition	Familiar		Novel	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Read Metaphor	84%	16%	74%	19%
No Metaphor	83%	14%	84%	13%

4.3. Discussion

The results of this study show that when the prompt to generate an interpretation for a metaphor is removed, the forgetting effect remains as a result of novel metaphor processing, but is no longer seen for familiar metaphors. This finding suggests that requiring participants to explicitly type in an interpretation of a familiar metaphor interferes with access to the initially

learned associates. The logic is as follows: the processing times for familiar metaphors were fairly similar for both Experiments 2 and 3. This suggests that participants are able to access the full metaphoric meaning without much effort in resolving competition from the literal associate. However, when participants were required to type in an interpretation of the metaphor, this explicit explanation of any already stable metaphoric representation may have created a strong source of interference that blocked initially learned associates, thereby impairing recall at final test. When this interpretation component was removed (in the reading-only condition used in this experiment) the forgetting effect for familiar metaphors disappeared. However, the forgetting effect was still obtained for novel metaphors suggesting that effortful resolution of their meaning relies on inhibitory processing.

5. Experiment 4

The next two experiments, Experiments 4 and 5, attempted to extend the findings of forgetting of literal associates as a result of processing metaphors seen in Experiments 2 and 3 by using “impossible” metaphors (e.g., “Jealousy is a barn”) for which subjects are unlikely to successfully come to a viable resolution *within a short period of time*. Experiment 4 involved only reading metaphors, while Experiment 5 involved explicitly interpreting metaphors. Additionally, both Experiments 4 and 5 address a possible confound in exposure time from previous studies by imposing a short, fixed time window of 5 s of exposure to the metaphor sentences. In Experiments 2 and 3, participants spent longer on novel than familiar metaphors. It is possible that forgetting effects could have been caused by differences in exposure to the stimuli. Thus, Experiments 4 and 5 kept the time of exposure constant.

The inclusion of impossible metaphors in these studies was intended to provide a strong test of the hypothesis that forgetting is the result of competition during the comprehension process. If reduced recall at final test is a result of inhibitory mechanisms that are utilized to suppress competition arising from irrelevant literal associates during comprehension attempts, then forgetting should still occur even when subjects fail to successfully comprehend the metaphor. This would be consistent with prior work showing that retrieval success is not necessary for retrieval-induced forgetting (Storm & Nesotojko, 2010) and problem-solving-induced forgetting (Storm et al., 2011). For example, Storm et al (2011) had participants attempt to solve RAT problems that had no viable solution after initially studying a dominant “misleading” associate of each of the words that composed these impossible RAT problems (e.g., *cat-board-sleep*, answer word: *WALK* vs. *cat-yellow-manners: NO ANSWER*). Despite the lack of solution success, a forgetting effect was still observed for associates appearing in RAT

problems relative to words that did not appear in RAT problems, and this effect was especially strong when participants spent a longer time attempting to solve the problems. Although subjects did often offer incorrect solutions, the number of solutions did not correlate with the amount of problem-solving-induced forgetting. This suggests that this forgetting effect is not simply due to the generated “solution” word interfering with access to the previous associate, but rather due to the problem-solving attempt itself.

In the context of metaphor processing, a similar effect is expected such that attempting to comprehend “impossible” metaphors for which the vehicle does not offer any obvious features relevant to the topic should produce robust forgetting of initially learned associates. If metaphor comprehension requires subjects to expend effort attempting to override inappropriate features of the metaphor so as to effectively align the vehicle and topic concepts, then attempting to find a plausible meaning for implausible metaphor pairings should require greater effort, and consequently, require more inhibition, even if subjects fail to actually reach a resolution.

For Experiment 4, a main effect of metaphor processing is expected with more forgetting occurring for items appearing in metaphors than not appearing in metaphors. There should also be an interaction of metaphor processing and metaphor novelty as in Experiment 3. This is because the reading-only instruction in this experiment removes any explicit interpretation that can act as a source of interference, thereby providing a closer measure of inhibitory-based forgetting as a result of normal reading comprehension. If forgetting is due to inhibition *during* attempts to resolve the meaning of metaphors and this inhibition is tied to comprehension effort, then processing both novel and impossible metaphors should result in significant forgetting while processing familiar metaphors should result in little forgetting, compared with the no-processing conditions. Additionally, impossible metaphors may result in more forgetting than for novel

metaphors: if metaphor comprehension requires subjects to expend effort attempting to override inappropriate features of the metaphor, then attempting to find a plausible meaning for implausible metaphor pairings should require greater effort, and consequently, processing impossible metaphors should produce more forgetting than processing either novel or familiar metaphors.

5.1. Method

5.1.2. Participants

The initial set of participants consisted of 92 participants from the University of Illinois at Chicago subject pool. To ensure that all participants achieved an equally high level of cue-response strengthening, an a priori criterion was set of 90% correct in initial recall. As a result, 52 participants were excluded from the analysis for failing to meet the 90% initial recall threshold. This left 40 participants. Participants provided agreement to participate and were given course credit for participation.

5.1.3. Design

Experiment 4 used a 2 x 3 repeated-measures design (metaphor processing x metaphor novelty). As in prior experiments, participants only processed half of the words in metaphors during the study. Of these metaphors, one third were familiar, one third were novel, and one third were impossible. The familiar and novel metaphor materials were the same as those used in Experiments 2 and 3.

5.1.4. Materials

For both Experiments 4 and 5, 20 new impossible metaphor sentences were created. Metaphor vehicles were chosen so that they were unlikely to have an associated metaphorical category for the target, nor salient properties that were readily applicable to the topic. Two

examples of such impossible metaphors include: *That boy's indecision is a rooster* and *The fisherman was a mushroom*. In each of these cases, it is difficult to identify features or relational properties of the vehicle words that are highly relevant for the topic word. For example, some features of roosters might include *loud* and *cocky*. However, these do not readily apply to *indecision*.

The final set of 20 impossible metaphors (included in Appendix C) was determined from a larger set of 33 candidates by an initial norming study ($N = 12$). In this initial norming study, participants viewed the 33 candidate impossible metaphors along with the 40 possible metaphors from Experiment 2 (20 familiar; 20 novel) in a random order for interpretation via E-Prime and were allowed up to 5 s to think of an interpretation (indicated via button press). The interpretation times were recorded by the computer. If participants did not come up with an interpretation within the 5 s deadline, they advanced to the next metaphor.

The 20 metaphors from the initial norming study for which the fewest number of participants generated a viable response were selected for use in a second norming study. In the second norming study ($N = 15$) participants were shown these 20 impossible metaphors along with the 40 metaphors (20 familiar; 20 novel) from Experiment 2. The procedure was similar to that of the initial norming study, except that if participants did think of an interpretation, they were also asked to judge how good they thought their interpretation was on a 1 – 5 scale (1 = not good at all, 5 = very good). Additionally, interpretations were coded by two independent coders for whether the participant typed something (number of complete responses), and whether they related the two concepts to each other (number of viable responses). For example, for the metaphor “That science is museum of a muffin” the response “it has lots of displays” was not considered a viable response because displays are not relevant for muffins. Reliability between

the two coders was high (Krippendorff's Alpha > .85). This was done to test whether the three kinds of metaphors to be used in Experiment 4 differed as intended with the familiar, novel and impossible metaphors representing a continuum of resolution difficulty. As seen in Appendix D, the three metaphor types differed as expected. Interpretation times increased from familiar to novel to impossible $F(2, 14) = 73.82, p < .01, \eta_p^2 = .84$, number of complete responses decreased $F(2, 14) = 66.07, p < .01, \eta_p^2 = .83$, number of viable responses decreased $F(2, 14) = 146.60, p < .01, \eta_p^2 = .91$, and judgments of interpretation quality decreased $F(2, 14) = 127.00, p < .01, \eta_p^2 = .90$. Impossible metaphors never resulted in a viable interpretation from more than two participants. All contrasts were significant ($p < .01$) across both subject and item-level analyses.

Literal associates were chosen for the impossible metaphors such that there was no overlap with any potential figurative meaning. The full set of stimuli for Experiment 4 consists of 60 cue-response word pairs, in which the cue word is the metaphor vehicle of the sentence, and the target response is a strong literal associate of the vehicle. The assessment of base-rate recall for the target responses followed the same procedure as in Experiment 2 except that participants ($N = 14$) had 5 minutes for both the study and initial recall phases to account for the increased number of items. Using these base rates, the impossible stimuli were split into two lists of 10 items. The new base rates for recall still matched for the lists of novel and familiar metaphors as used in Experiment 2. Each of the 6 sets of 10 items was also matched on written frequency (Kucera-Francis) number of letters, and number of syllables. Additionally, the cue words were matched on the number of living things.

5.1.5. Procedure

The procedure and scoring of the final recall test were similar to that of Experiment 3. However, participants were allowed 5 minutes for both the initial study and recall phases, to

account for the increased list size of 60 items. Additionally, for the metaphor processing task, the exposure time was fixed at 5 s during which participants read the metaphor on the screen. This fixed time helped to control for differences in exposure seen in the previous experiments.

5.2. Results

Mean initial recall was 96%. Initial recall scores were entered into a repeated measures ANOVA crossing metaphor processing (metaphor vs. no metaphor) and metaphor novelty (familiar vs. novel vs. impossible), which produced no significant main effects of metaphor processing, novelty and no two-way interaction (All F s < 1).

Final recall rates are shown in Table 4. An ANOVA revealed no significant main effect of metaphor processing $F(1, 39) = 2.18, p = .15, \eta_p^2 = .05, F(1, 57) = 22.80, p < .01, \eta_p^2 = .29$, no main effect novelty $F(2, 39) = 1.64, p = .20, \eta_p^2 = .04, F(2, 57) = 1.50, p = .23, \eta_p^2 = .05$, and no significant interaction $F < 1$.

Table IV.

Final recall for the metaphor and no-metaphor conditions for familiar, novel and impossible metaphors in Experiment 4

Metaphor condition	Familiar		Novel		Impossible	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
90% Criterion						
Metaphor	91%	16%	87%	23%	89%	20%
No-Metaphor	92%	17%	89%	17%	91%	16%
80% Criterion						
Metaphor	86%	18%	81%	20%	83%	19%
No-Metaphor	89%	12%	86%	12%	88%	13%

The overall low rates of forgetting meant that over half the sample was excluded from these analyses. To increase power, a less stringent criterion of 80% initial recall was able to

recapture participants, increasing the sample to 52. This resulted in a main effect of metaphor processing $F(1, 52) = 6.43, p < .05, \eta_p^2 = .11$, with lower recall in the metaphor processing condition than the no metaphor processing condition. However, the effect of familiarity was not significant $F(2, 52) = 2.08, p = .13, \eta_p^2 = .04$, nor was the interaction ($F < 1$). Contrasts between the metaphor processing and no metaphor processing conditions were carried out separately for each level of familiarity. As shown in the bottom panel of Table 4, for familiar metaphors, final recall was not significantly lower for words appearing in metaphors, than not $F(1, 51) = 1.64, p = .20, \eta_p^2 = .03$. However, recall was lower for words in the novel metaphor processing condition compared with the no-metaphor condition $F(1, 51) = 4.93, p < .05, \eta_p^2 = .09$, and lower for words in the impossible metaphor processing condition compared with the no-metaphor condition $F(1, 51) = 4.13, p < .05, \eta_p^2 = .08$. Thus, under conditions in which participants read the metaphors without providing an explicit interpretation, forgetting was observed for novel and impossible metaphors, but not familiar metaphors.

5.1.3. Discussion

This experiment attempted to extend the previous findings of metaphor-related forgetting during the reading of novel metaphors to “impossible metaphors” for which subjects were very unlikely to arrive at viable resolutions. This allowed for a test of whether this forgetting effect results from inhibitory mechanisms that are tied specifically to comprehension effort, in the absence of any interpretation that is produced from this effort.

Using an initial recall threshold of 90%, this experiment did not replicate the previous experiments, as the effect of metaphor processing on recall did not approach significance, nor was there an interaction with metaphor novelty. However, further exploration of the data did provide some evidence that the familiarity of metaphors affected forgetting. Lowering the initial

recall threshold to 80% resulted in significant forgetting effects for reading novel and impossible metaphors, but *not* familiar metaphors. This is in line with the findings of Experiment 3 in which reading-only instructions produced forgetting for novel metaphors but not familiar metaphors, suggesting that the processing mechanisms needed to access the meaning of less familiar metaphors may involve the inhibition of literal information, while more directly-accessed familiar metaphors may not require such a mechanism. Moreover, this effect was observed for “impossible” metaphors, which the norming study demonstrated are unlikely to result in any meaningful resolution. This finding suggests that forgetting can be partly tied to the effort needed during comprehension, and not just to post-access interference.

However, these results should be taken with caution due to the low rates of forgetting observed in this experiment, especially for impossible metaphors, compared to Experiment 3. One important difference between the studies is the control over exposure time across conditions in Experiment 4 that was not present in the previous experiments where participants took longer to read novel than familiar metaphors, indicating more involved processing. In Experiment 4, exposure time was fixed such that an equal amount of time was spent on familiar, novel and impossible metaphors. While participants in Experiment 3 were able to spend more time reading and comprehending the sentences due to the self-pacing of the reading task, in Experiment 4 the fixed time may have not provided as much of a processing opportunity for the more challenging metaphors. Consequently, this reduced processing opportunity may have diminished the amount of inhibition, resulting in relatively preserved recall for the more difficult novel metaphors, as well as impossible metaphors (which are necessarily novel). Thus, while Experiment 4 replicated the forgetting patterns seen for familiar vs. novel metaphors in Experiment 3, along with

demonstrating a forgetting effect for impossible metaphors, this latter forgetting effect was not more sizeable than those seen in the novel conditions.

6. Experiment 5

Experiment 5 used familiar, novel, and impossible metaphors under instructions to explicitly interpret them as in Experiment 2. The predictions for Experiment 5 (interpret) contrast somewhat with those of Experiment 4 (reading-only). While the main effect of metaphor processing condition should follow that of Experiment 4, an interaction of novelty and metaphor processing is not expected. This is because generating an explicit interpretation may not only involve inhibiting literal information during processing, but it may act as a source of interference at final recall. Familiar metaphors in the interpret condition may still produce significant forgetting due to the highly salient generated interpretation blocking the initially learned word pair. Thus, this experiment serves as an attempt to replicate the findings of Experiment 2.

Additionally, given the hypothesis that impossible metaphors should result in the most forgetting due to their greater difficulty, understanding more of how such metaphors are processed would be informative. Thus, the content of the interpretations may provide additional information on how the impossible metaphors are being processed.

6.1. Method

6.1.1. Participants

The initial set of participants consisted of 96 participants from the University of Illinois at Chicago subject pool. Fifty-six participants were excluded from the analysis for failing to meet the 90% initial recall threshold. This left 40 participants. Participants provided agreement to participate and be given course credit for participation.

6.1.2. Design

The design followed that of Experiment 4

6.1.3. Materials

The materials were the same as those of Experiment 4

6.1.4. Procedure

The procedure was similar to that of Experiment 4; however, following the 5 s exposure to the metaphor, it was then removed from the screen while participants completed a prompt to type in an interpretation within a 10 s deadline. This kept the metaphor exposure time (5 s) similar to Experiment 4.

6.2. Results

Mean initial recall was 96%. Initial recall scores were entered into a repeated measures ANOVA crossing metaphor processing (metaphor vs. no metaphor) and metaphor novelty (familiar vs. novel vs. impossible), which produced no significant main effects of metaphor processing $F < 1$ or novelty $F(2, 39) = 1.74, p = .18, \eta_p^2 = .04$ and no two-way interaction $F(2, 39) = 1.51, p = .23, \eta_p^2 = .04$.

The metaphor interpretations allowed for a manipulation check of metaphor novelty in both Experiments 4 and 5. The frequency with which participants were able to generate viable interpretations of the impossible metaphors was examined. The coding for the number of viable responses followed the same procedure as the norming study. The ANOVA examining the rate of viable interpretations yielded a significant effect of metaphor novelty $F(2, 39) = 502.16, p < .01, \eta_p^2 = .93, F(2, 57) = 240.04, p < .01, \eta_p^2 = .89$. Participants generated viable interpretations for impossible metaphors 10% of the time. For familiar metaphors, this rate was 91%, and for novel metaphors it was 68%. All contrasts were highly significant ($p < .01$). Because of the low rate of interpretation for impossible metaphors, the primary analyses proceeded without separating viable and nonviable responses.

Final recall rates are shown in Table 5. An ANOVA revealed a main effect of metaphor processing $F(1, 39) = 23.28, p < .01, \eta_p^2 = .37, F(1, 57) = 22.80, p < .01, \eta_p^2 = .29$ with lower recall occurring in the metaphor conditions than the no-metaphor conditions.. Additionally there was a main effect novelty $F(2, 39) = 3.50, p < .05, \eta_p^2 = .08, F(2, 57) = 1.50, p = .23, \eta_p^2 = .05$. Recall of response words associated with novel metaphors was lower than that of familiar metaphors $F(1, 39) = 5.18, p < .01, \eta_p^2 = .12$. However, recall of response words associated with novel metaphors was also lower than it was for impossible metaphors $F(1, 39) = 4.78, p < .05, \eta_p^2 = .11$, and, no recall differences were observed between impossible and familiar metaphors ($F < 1$). There was no interaction of metaphor processing and novelty $F < 1$.

Table V.

Final recall for the metaphor and no-metaphor conditions for familiar, novel and impossible metaphors in Experiment 5

Metaphor condition	Familiar		Novel		Impossible	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
90% Criterion						
Metaphor	86%	16%	80%	23%	85%	20%
No-Metaphor	91%	17%	89%	17%	91%	16%
80% Criterion						
Metaphor	82%	14%	75%	19%	80%	17%
No-Metaphor	88%	14%	84%	15%	87%	13%

As in Experiment 4, a second set of analyses were run on including participants whose initial recall was at least 80% which resulted in a sample of 52 participants. This resulted in a main effect of metaphor processing $F(1, 52) = 30.54, p < .01, \eta_p^2 = .38$, with lower recall in the metaphor processing condition than the no metaphor processing condition, and a main effect of familiarity $F(2, 52) = 7.32, p < .01, \eta_p^2 = .04$. The interaction was not significant ($F < 1$). As in Experiment 4, contrasts between the metaphor processing and no metaphor processing conditions

were carried out separately for each level of familiarity. As shown in the bottom panel of Table 5, for familiar metaphors, final recall was lower for words appearing in metaphors than not, $F(1, 51) = 7.82, p < .01, \eta_p^2 = .13$. Recall was also lower for words in the novel metaphor processing condition compared with the no-metaphor condition, $F(1, 51) = 15.53, p < .01, \eta_p^2 = .23$, and lower for words in the impossible metaphor processing condition compared with the no-metaphor condition $F(1, 51) = 8.23, p < .01, \eta_p^2 = .14$. Thus, it appears that forgetting occurred across all types of metaphors.

To explore the pattern of forgetting for participants outside of this initial recall range, final recall scores were also computed for participants whose initial recall was 70%-89%, and less than 70% for Experiments 4 and 5. This allows for an assessment of whether the use of the 90% threshold reduced statistical power, or if it reflects a potential selection bias (i.e., people with at least a 90% threshold have higher cognitive ability overall). These scores are shown in Appendix E. It appears that the forgetting effect was quite large for participants in the 70-89% band despite the reduced sample size (e.g., $N = 24$ for the read-only condition). This further suggests that participants with high initial recall (i.e., >90%) are less prone to forgetting effects.

Finally, a follow-up analysis explored the content of the interpretations that were offered. Participants explicitly used the literal associate more often in their interpretations of impossible metaphors (2.7%) than familiar metaphors (0.8%) $F(1, 51) = 4.89, p < .05, \eta_p^2 = .05$, and novel metaphors (1.5%), although the latter contrast was not significant $F(1, 51) = 1.66, p = .20, \eta_p^2 = .03$. This analysis suggests that perhaps the processing of apparently meaningless uses of the previously studied cue words (in the impossible metaphor conditions) actually made participants focus *more* on the literal associate.

6.3. Discussion

In Experiment 5, under instructions to not only read but also provide an interpretation of the metaphors, a clear forgetting effect was apparent as in previous experiments. While descriptively it appears that the forgetting effect was largest for novel metaphors, this effect occurred across all novelty conditions, including familiar metaphors. Because reading alone did not produce reliable forgetting associated with familiar metaphors in previous experiments, this supports the idea that explicitly providing the metaphoric meaning for a familiar metaphor can interfere with final recall of previously learned associates. On the other hand, the results for the impossible items were less consistent with predictions. Being forced to generate an interpretation for impossible metaphors did not lead to more forgetting than for novel. However, there was some indication that when faced with bizarre expressions readers were forced to think more about literal associates in their search for meaning.

7. General Discussion

Across the five experiments, it was generally observed that processing metaphoric sentences resulted in reduced recall of previously learned literal associates of the metaphor vehicles. This forgetting effect appeared to have two different sources. On one hand, when required to explicitly interpret metaphors rather than simply read them, then forgetting was seen for all metaphor types. On the other hand, when asked to simply read metaphors, forgetting appeared to be strongest for more novel metaphors.

The following pieces of evidence from the five experiments are consistent with this interpretation. First, forgetting was observed not only when participants were required to interpret the metaphors, but even when instructed to simply read the metaphors without a requirement to explain their meaning. Because instructing participants to interpret the metaphors requires not only reading the metaphors, but also explicitly generating their meaning, it is more difficult to conclude whether forgetting can be explained by inhibition, as opposed to post-access interference arising from the interpretation. However, the occurrence of forgetting under reading-only instructions helps to rule out the latter explanation because of the lack of such an interpretation in this condition. Forgetting also tended to be more robust under the interpretation compared to the reading instructions. This suggests that forgetting in the former might reflect both inhibition *and* post-comprehension interference. Moreover, the general tendency for more forgetting for novel metaphors than familiar metaphors is consistent with an inhibitory account. If the forgetting were purely due to interference from the metaphoric meaning, one would not expect metaphor novelty to differentiate this forgetting effect. Yet, one issue with concluding the use of inhibitory mechanisms during the reading of metaphors is that their covert resolution may still act as a source of interference at final recall. The use of impossible metaphors, which are

unlikely to result in a resolution, was intended to address this issue in Experiments 4 and 5.

Critically, significant forgetting was also observed for impossible metaphors. Unfortunately, the rate of forgetting was lower in these studies. In Experiments 2 and 3, forgetting due to metaphor use was around 10%, while it was only 5% in 4 and 5. Although the metaphor-related forgetting effect appeared to be less robust in these experiments, the overall pattern was still consistent with previous experiments.

There are a number of possible explanations for why the forgetting effect was less robust in Experiments 4 and 5. It may be that including impossible metaphors changed the way participants went about the metaphor processing task. As shown in the follow-up analysis examining the content of metaphor interpretations in Experiment 5, participants actually focused more on the literal associates of the impossible metaphors, which was not intended by design. Participants were given no instruction regarding the relationship between the initial study phase and the metaphor interpretation phase. Perhaps in the absence of such instruction, participants were more likely to wonder whether the previous response words may somehow serve as hints as to the metaphoric meaning. Future experiments could provide a warning that the interpretation of the metaphoric phrases could never be arrived at using the previously learned responses. Such a warning was provided in the Storm, et al, (2011) study regarding RAT solutions words (including impossible RAT problems).

It is also possible that the increased proportion of difficult metaphors (impossible and novel) actually caused participants to disengage from the task and reduce their processing effort (due to fatigue, frustration, confusion, etc.), which is counter to this manipulation's intention. When exposed to impossible metaphors, participants may have simply shrugged them off as meaningless. This may help explain the lower rates of forgetting observed in Experiment 4.

Because of the abundance of difficult metaphors and the lack of a requirement to actually interpret them, participants may have only processed the sentences in a very passive way, with minimal effort toward making sense of them. This would eliminate the need to overcome the previous literal associates, resulting in relatively preserved recall. Perhaps adjusting the proportion of difficult metaphors could address this issue. For example, the use of only the familiar and impossible conditions within a single experiment may help to keep participants engaged.

Another more general concern is with the high rate of participant exclusion due to low initial recall. This may have created an inadvertent selection bias toward people with higher retention ability, which may have reduced the chances of finding forgetting effects. Returning to shorter lists representing only two conditions instead of three (and only 40 items instead of 60) should also help with this issue. Alternatively, future work could set up cue-response strengthening during the initial learning phase so that more people to reach 100% initial recall (e.g., increase the letter-stem length). This would ensure that the literal associates are activated in memory similarly across participants with a wide range of cognitive ability.

With regards to prior work on the processing of metaphoric language, these findings provide additional evidence for the inhibition of literal meaning as part of metaphor comprehension (Gernsbacher et al., 2001; Glucksberg et al, 2001). However, in contrast to these previous studies, the current findings indicate that such inhibitory mechanisms are mainly of importance for more novel metaphoric expressions, for which the reader must construct the figurative meaning. Additionally, there was some evidence of forgetting resulting from processing “impossible” metaphors. Because participants are unlikely to meaningfully reach an interpretation for these metaphoric expressions, this more strongly places the locus of any

inhibition within the comprehension attempt itself. Finally, these results cannot address the extent of such inhibition. While the occurrence of forgetting of previously-learned associates suggests that their episodic trace is the target of inhibition, these experiments cannot determine if additional information in long-term memory is also inhibited as a result of processing metaphors.

This pattern of findings fits well with the established structure-mapping (Gentner, 1983) and career of metaphor theories of metaphor processing (Bowdle & Gentner, 2005). In this framework, metaphors are viewed as statements of relational similarity, wherein higher-order relational information is emphasized, and low-level attribute information is discarded. This selective processing may involve inhibiting irrelevant attributes associated with the metaphor vehicle during the initial mapping process. Moreover, this theory proposes that familiar metaphor vehicles whose meaning has become conventionalized may not require as extensive a mapping process as novel metaphors, because these vehicles simply point to a stored metaphoric category, such that that the topic can be placed directly within that category. This is consistent with the current finding that novel metaphors tended to elicit greater forgetting than familiar metaphors. During novel metaphor processing, the metaphoric category has to be constructed, and this creates a greater need for inhibition of information not relevant to the mapping. Future work should seek to address possible methodological issues associated with using impossible metaphors as this condition still has promise to help to clarify the relationship between processing effort, comprehension, and forgetting in the context of figurative language processing.

8. References

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9. APPENDICES

Appendix A

Materials used in Experiment 1

Sentence	Word pair	Base-rate recall	List
Her husband is a gem	GEM-stone	86%	A
The twelve speed bicycle was a rocket	ROCKET-fuel	86%	A
My uncle's surgeon is a butcher	BUTCHER-meat	86%	A
The lawyer for the defense is a shark	SHARK-swim	86%	A
My history teacher is an encyclopedia	ENCYCLOPEDIA-page	100%	A
My brother says that soothing music is medicine	MEDICINE-doctor	100%	A
His kindergarten class is a zoo	ZOO-cage	100%	A
That pregnant woman is a duck	DUCK-feather	100%	A
In the winter, my studio is a refrigerator	REFRIGERATOR-appliance	100%	A
My grandmother is a peach	PEACH-tree	100%	A
My boyfriend's arms are steel	STEEL-iron	100%	A
Her final exam in geography was a bear	BEAR-mammal	100%	A
His late afternoon hunger is a lion	LION-mane	100%	A
My sister says that happiness is gold	GOLD-yellow	100%	A
That woman at the payroll desk is a crab	CRAB-sea	86%	A
That man plowing the field is a horse	HORSE-hay	100%	A
Confetti at weddings is a fireworks display	FIREWORKS-ignite	100%	A
My mother says that birds are airplanes	AIRPLANE-engine	100%	A
When she is upset, her voice is a siren	SIREN-truck	86%	A
The planet earth is a ball	BALL-toy	100%	A
The senator is a fossil	FOSSIL-dig	100%	B
The tiny mountain lake is a mirror	MIRROR-break	100%	B
The tiny mosquito was a vampire	VAMPIRE-black	100%	B
Her unflinching gaze is ice	ICE-slip	86%	B
The Great Plains are a board	BOARD-wood	100%	B
That criminal's fingerprint is a portrait	PORTRAIT-gallery	86%	B
My daughter's smile is sunshine	SUNSHINE-burn	86%	B
That baby monkey is a vine	VINE-plant	86%	B
My young cousin is a shrimp	SHRIMP-lobster	86%	B
Her mother is a mule	MULE-donkey	86%	B
The boy in the corner of the room is a mouse	MOUSE-rodent	86%	B
My cat's fur is silk	SILK-worm	100%	B
The lightning that struck down the old oak tree was a knife	KNIFE-butter	100%	B
The cheering crowd was thunder	THUNDER-storm	100%	B
Jalapeño peppers are fire	FIRE-oxygen	100%	B
That fashion model is a rail	RAIL-metal	100%	B
His old car is a boat	BOAT-water	100%	B
That seventh-grader's brain is a computer	COMPUTER-machine	100%	B
When waiting for someone, time is a snail	SNAIL-shell	100%	B
That baby's cheeks are roses	ROSE-thorn	100%	B

Appendix B

Materials used in Experiments 2 and 3

Metaphor	List	Condition	Familiarity	Word Pair	Base-rate recall
My uncle's surgeon is a butcher	A	Familiar	5.14	BUTCHER : meat	1
My grandmother is a peach	A	Familiar	5.71	PEACH : tree	1
That baby's cheeks are roses	A	Familiar	6.00	ROSE : thorn	1
His kindergarten class is a zoo	A	Familiar	6.71	ZOO : cage	1
My history teacher is an encyclopedia	A	Familiar	7.00	ENCYCLOPEDIA : page	1
The senator is a fossil	A	Familiar	5.00	FOSSIL : dig	0.875
In the winter, my studio is a refrigerator	A	Familiar	5.57	REFRIGERATOR : appliance	1
That twelve speed bicycle is a rocket	A	Familiar	5.14	ROCKET : fuel	1
Jalapeño peppers are fire	A	Familiar	6.43	FIRE : oxygen	0.625
When she is upset, her voice is a siren	A	Familiar	5.43	SIREN : truck	1
The news media is an octopus	A	Novel	1.71	OCTOPUS : ink	1
My mother says that envy is rust	A	Novel	3.00	RUST : red	1
Their lifelong friendship was wine	A	Novel	3.71	WINE : glass	1
That lightweight boxer is a wasp	A	Novel	2.71	WASP : nest	0.875
The teacher's passion was a battery	A	Novel	2.43	BATTERY : car	0.75
That pregnant woman is a duck	A	Novel	2.00	DUCK : feather	1
That groupie for the band is a satellite	A	Novel	2.00	SATELLITE : moon	0.875
Some dreams are rivers	A	Novel	2.71	RIVER : bank	1
My professor says that science is a glacier	A	Novel	2.43	GLACIER : arctic	1
The forest on the summer day was a harmonica	A	Novel	1.71	HARMONICA : guitar	1
Her husband is a gem	B	Familiar	6.86	GEM : stone	1
My sister says that happiness is gold	B	Familiar	5.43	GOLD : yellow	1
The cheering crowd was thunder	B	Familiar	5.57	THUNDER : storm	1
My young cousin is a shrimp	B	Familiar	5.14	SHRIMP : lobster	1
My boyfriend's arms are steel	B	Familiar	6.43	STEEL : iron	1
My brother says that soothing music is medicine	B	Familiar	6.14	MEDICINE : doctor	1
The lawyer for the defense is a shark	B	Familiar	6.43	SHARK : swim	0.875
My daughter's smile is sunshine	B	Familiar	6.14	SUNSHINE : burn	0.875
My cat's fur is silk	B	Familiar	6.29	SILK : worm	0.75
Her unflinching gaze is ice	B	Familiar	5.14	ICE : slip	0.875
The artist said that imagination is a cave	B	Novel	2.43	CAVE : man	1
That daily newspaper is a telescope	B	Novel	1.71	TELESCOPE : lens	1
The billboards along the highway were warts	B	Novel	1.43	WART : skin	1
My mother said that discipline is fertilizer	B	Novel	2.43	FERTILIZER : odor	0.75
That philanthropist is a fountain	B	Novel	2.57	FOUNTAIN : park	0.875
The goalie tending the net was a spider	B	Novel	2.57	SPIDER : venom	1
For the writer, creativity was a toaster	B	Novel	1.14	TOASTER : bread	0.875
That baby monkey is a vine	B	Novel	1.29	VINE : plant	1
My gossiping office mate is a radio	B	Novel	2.43	RADIO : antenna	0.875
My friend says strong communities are soil	B	Novel	2.14	SOIL : grass	1

Appendix C

Materials used in Experiments 4 and 5

Metaphor	List	Condition	Word Pair	Base-rate recall
My uncle's surgeon is a butcher	A	Familiar	BUTCHER : meat	0.93
My grandmother is a peach	A	Familiar	PEACH : tree	0.93
That baby's cheeks are roses	A	Familiar	ROSE : thorn	0.93
His kindergarten class is a zoo	A	Familiar	ZOO : cage	0.93
My history teacher is an encyclopedia	A	Familiar	ENCYCLOPEDIA : page	0.86
The senator is a fossil	A	Familiar	FOSSIL : dig	0.86
In the winter, my studio is a refrigerator	A	Familiar	REFRIGERATOR : appliance	0.86
That twelve speed bicycle is a rocket	A	Familiar	ROCKET : fuel	0.79
Jalapeño peppers are fire	A	Familiar	FIRE : oxygen	0.64
When she is upset, her voice is a siren	A	Familiar	SIREN : truck	0.57
The news media is an octopus	A	Novel	OCTOPUS : ink	0.93
My mother says that envy is rust	A	Novel	RUST : red	0.93
Their lifelong friendship was wine	A	Novel	WINE : glass	0.93
That lightweight boxer is a wasp	A	Novel	WASP : nest	0.86
The teacher's passion was a battery	A	Novel	BATTERY : car	0.79
That pregnant woman is a duck	A	Novel	DUCK : feather	0.79
That groupie for the band is a satellite	A	Novel	SATELLITE : moon	0.79
Some dreams are rivers	A	Novel	RIVER : bank	0.71
My professor says that science is a glacier	A	Novel	GLACIER : arctic	0.64
The forest on the summer day was a harmonica	A	Novel	HARMONICA : guitar	0.64
My friend says jealousy is a barn	A	Impossible	BARN : hay	0.71
The chirping canary was a desk	A	Impossible	DESK : paper	0.86
Homelessness is a towel	A	Impossible	TOWEL : dry	1.00
That sermon was a toe	A	Impossible	TOE : finger	0.93
That widow is a canoe	A	Impossible	CANOE : oar	0.86
My brother's memory is a moustache	A	Impossible	MOUSTACHE : shave	0.86
The small farm was a sled	A	Impossible	SLED : hill	0.86
That breakfast was a sidewalk	A	Impossible	SIDEWALK : cement	0.79
That science museum is a muffin	A	Impossible	MUFFIN : oven	0.71
That dancer is a helmet	A	Impossible	HELMET : soldier	0.57
Her husband is a gem	B	Familiar	GEM : stone	1.00
My sister says that happiness is gold	B	Familiar	GOLD : yellow	1.00
The cheering crowd was thunder	B	Familiar	THUNDER : storm	1.00
My young cousin is a shrimp	B	Familiar	SHRIMP : lobster	0.93
My boyfriend's arms are steel	B	Familiar	STEEL : iron	0.93
My brother says that soothing music is medicine	B	Familiar	MEDICINE : doctor	0.86
The lawyer for the defense is a shark	B	Familiar	SHARK : swim	0.79
My daughter's smile is sunshine	B	Familiar	SUNSHINE : burn	0.71

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My cat's fur is silk	B	Familiar	SILK : worm	0.64
Her unflinching gaze is ice	B	Familiar	ICE : slip	0.57
The artist said that imagination is a cave	B	Novel	CAVE : man	0.93
That daily newspaper is a telescope	B	Novel	TELESCOPE : lens	0.93
The billboards along the highway were warts	B	Novel	WART : skin	0.93
My mother said that discipline is fertilizer	B	Novel	FERTILIZER : odor	0.86
That philanthropist is a fountain	B	Novel	FOUNTAIN park	0.79
The goalie tending the net was a spider	B	Novel	SPIDER : venom	0.79
For the writer, creativity was a toaster	B	Novel	TOASTER bread	0.79
That baby monkey is a vine	B	Novel	VINE : plant	0.79
My gossiping office mate is a radio	B	Novel	RADIO : antenna	0.71
My friend says strong communities are soil	B	Novel	SOIL : grass	0.50
The ambulance was a skirt	B	Impossible	SKIRT : blouse	1.00
The fisherman was a mushroom	B	Impossible	MUSHROOM : pizza	0.86
My new office is rice	B	Impossible	RICE : bowl	0.86
That boy's indecision is a rooster	B	Impossible	ROOSTER : chicken	0.86
The woman's impulse was a rug	B	Impossible	RUG : wool	0.79
My regular mechanic is a bath	B	Impossible	BATH : soap	0.71
My sister's coach is a patio	B	Impossible	PATIO : lawn	0.57
The gnats in the air were a frame	B	Impossible	FRAME : gallery	0.50
Beaches can be flagpoles	B	Impossible	FLAGPOLE : school	0.93
Some people think justice is a banana	B	Impossible	BANANA : split	0.93

Appendix D

Table VI.

Mean interpretation times, mean number of complete responses, mean number of viable responses, and mean quality rating for familiar, novel and impossible metaphors from the pilot study for Experiments 4 and 5

Metaphor novelty	Interpretation time (s)	# Complete interpretations	# Viable interpretations	Quality rating
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Familiar	2.85 (.73)	16.27 (2.91)	16.20 (3.00)	3.53 (.57)
Novel	3.94 (.91)	9.93 (6.31)	8.33 (5.65)	2.14 (.27)
Impossible	4.35 (.90)	5.07 (5.79)	1.33 (1.88)	1.27 (.76)

Appendix E

Table VII.

Final recall for the metaphor and no-metaphor conditions for familiar, novel and impossible metaphors in Experiment 4 for participants whose initial recall ranged 70-89%, and 70% or less

Metaphor condition	Familiar		Novel		Impossible	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
70-89% Criterion						
Metaphor*	66%	22%	58%	25%	64%	19%
No-Metaphor	72%	17%	69%	17%	74%	12%
<70% Criterion						
Metaphor	48%	19%	38%	16%	47%	17%
No-Metaphor	54%	15%	43%	15%	54%	18%

* = main effect of metaphor condition $F(1, 23) = 6.88, p < .05, \eta_p^2 = .23$

Table VIII.

Final recall for the metaphor and no-metaphor conditions for familiar, novel and impossible metaphors in Experiment 5 for participants whose initial recall ranged 70-89%, and 70% or less

Metaphor condition	Familiar		Novel		Impossible	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
70-89% Criterion						
Metaphor*	64%	16%	56%	16%	63%	15%
No-Metaphor	73%	13%	62%	16%	71%	12%
<70% Criterion						
Metaphor	54%	19%	47%	16%	51%	19%
No-Metaphor	54%	14%	50%	20%	51%	16%

* = main effect of metaphor condition $F(1, 30) = 11.00, p < .01, \eta_p^2 = .27$

10. HUMAN SUBJECTS COMMITTEE PROTOCOL APPROVAL

This research was approved by the University of Illinois Human Subjects Institutional Review Board under protocol 2010–1018.

11. CURRICULUM VITAE

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George, T., & Wiley, J. (2015). The more the merrier: Diversity of items leads to more creative *alternate uses*. Manuscript in preparation. [Data collection completed, final coding needed].

George, T., & Wiley, J. (2015). Forgetting the literal: The role of inhibition in metaphor comprehension. Revised manuscript submitted to *Journal of Experimental Psychology: Learning, Memory, & Cognition*

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CONFERENCE PRESENTATIONS

George, T., & Wiley, J. (2015, April). *Fixation, flexibility, and forgetting during alternate-uses tasks*. Poster presented at the Annual Meeting of the Psychonomic Society. Chicago, IL.

George, T., & Wiley, J. (2015, April). *The more the merrier: Diversity of items leads to more creative alternate uses*. Poster presented at the Annual Meeting of the Midwestern Psychological Association. Chicago, IL.

George, T., & Wiley, J. (2014, November). *Forgetting the literal: The role of inhibition in metaphor comprehension*. Poster presented at the Annual Meeting of the Psychonomic Society. Long Beach, CA.

George, T., Koppel, R.H., & Wiley, J. (2014, August). *Forgetting the literal: Reduced memory for metaphor-irrelevant information following metaphor comprehension*. Poster presented at the Annual Meeting of the Society for Text & Discourse. Chicago, IL.

George, T., & Haarmann, H.J. (2014, May). *Left hemisphere sensitivity to detection of weak associates*. Poster presented at the Annual Meeting of the Midwestern Psychological Association. Chicago, IL.

O'Rourke, P. George, T., Smaliy, A., Grunewald, K., Dien, J., & Haarmann, H. (2012, March). *Verbal creativity and Alpha: A brain wave entrainment study*. Poster presented at the Annual Meeting of the Cognitive Neuroscience Society. Chicago, IL.

Berens, M., Blok, S., Smaliy, S., George, T., Cook, J., & Haarmann, H. (2011, November). *Validation of a workplace-relevant divergent thinking task*. Poster presented at the Annual Meeting of the Psychonomic Society. Seattle, WA.

Haarmann, H., George, T., & Smaliy, A. *Surprising left hemisphere advantage for detection of novel metaphors*. (2011, May). Poster presented at the Annual Meeting of the Association for Psychological Science. Washington, DC.

Haarmann, H., George, T., Dien, J., Chrabaszcz, J., Smaliy, A., Freynik, S., & Novick, J. (2010, April). *Creative cognition benefits from incubation with neurofeedback*. Poster presented at the Annual Meeting of the Cognitive Neuroscience Society, Montreal, QC, Canada.

Haarmann, H., George, T., Smaliy, A., Grunewald, K., & Novick, J. (2009, March). *Alpha neurofeedback training and its implications for studies of cognitive creativity*. Poster presented at the Annual Meeting of the Cognitive Neuroscience Society. San Francisco, CA.

RESEARCH PROJECTS AND EXPERIENCE

University of Illinois at Chicago, Department of Psychology, Chicago, IL

Inhibition and Metaphor Comprehension (Fall 2013 - present)

Conducted three studies examining whether metaphor interpretation involves inhibition of metaphor-irrelevant literal information using a variant of the retrieval-induced forgetting paradigm. The third study served as my Masters' Thesis (defended August 2015).

Divergent Thinking and Executive Control (Fall 2013 – present)

Advisor: Jennifer Wiley, Ph.D.

Examining the task conditions which benefit divergent thinking on the alternate uses task, and whether working memory capacity is beneficial to creative idea generation.

University of Maryland, Center for Advanced Study of Language (CASL), College Park, MD

Divergent Thinking in Language Analysis (June 2008 - August 2013)

Senior Research Assistant

Supervisor: Henk J. Haarmann, Ph.D.

Researched neural and behavioral underpinnings of divergent thinking ability in order to develop methods for improving this ability. Designed and implemented behavioral and EEG studies. Recruited and tested participants. Organized and analyzed data. Assisted with writing technical reports.

American University, Department of Psychology, Washington, DC

Priming of Metaphorical Meaning (August 2007 - May 2008)

Human Memory & Cognition Laboratory

Advisor: Zehra Peynircioglu, Ph.D.

Conducted research on figurative language processing in a lexical decision paradigm testing whether access to metaphor vehicle words is strengthened following metaphor-relevant sentences.

TEACHING EXPERIENCE

University of Illinois at Chicago, Department of Psychology, Chicago, IL

Teaching Assistant, PSCH 242, Introduction to Research in Psychology, Spring 2015, Fall 2015

Teaching Assistant, PSCH 352, Cognition and Memory, Spring 2015 (Guest lecture: Language – word level processing)

Teaching Assistant, PSCH 262, Behavioral Neuroscience, Spring 2014 (Guest lectures: Sensory systems: audition, gustation, olfaction; Language & lateralization)

Teaching Assistant, PSCH 100, Introduction to Psychology, Fall 2013 and Fall 2014

American University, Department of Psychology, Washington, DC

Teaching Assistant, PSYC 200, Behavior Principles, Fall 2005

MENTORING EXPERIENCE

<i>Assistant</i>	<i>Term</i>	<i>Course Level</i>	<i>Project</i>
Himani Kumar	Fall 2015	PSCH 396	Creative Consequences
Wai Yung	Spring 2015	PSCH 396	Alternate Uses
Paula Kilpatrick	Fall 2014	PSCH 396	Alternate Uses
Monica Makar	Summer 2014	PSCH 396	Alternate Uses

AD HOC REVIEWING EXPERIENCE

The Journal of Problem Solving

PROFESSIONAL SOCIETIES

Midwestern Psychological Association Graduate Student Member

APA Division 10 Graduate Student Affiliate

ADDITIONAL SKILLS & EXPERIENCE

SPSS, R, E-Prime, EGI's NetStation EEG software