INTRODUCTION

Divergent thinking (DT) is the ability to generate diverse solutions to a problem. This type of problem solving helps analysts to engage in alternate analysis, that is, the ability to consider multiple hypotheses (Haarmann, Platt, Donavos, Fox, & Bowles, 2007). DT is cognitive skill that can be trained (for a review see Haarmann, O’Rourke, & Ragusa, 2013), including in analysts (Haarmann, George, Berens, Grunewald, & Freynik, 2012). Since DT ability is beneficial for analysis and can be trained, it would be of much interest to know whether engaging the same skill benefits language learning, in view of its importance for language analysts. Indeed CASL’s sponsor requested a pilot study to address this question.

Creative elaboration

One may speculate that DT promotes language learning for a variety of reasons (Haarmann et al., 2013). For example, a hypothesis that is central in the present pilot study is that words are better learned when during study each word is embedded in a broader network of meaning associations. This occurs through elaboration of its context where context refers to how a word is used given its meaning (i.e., creative elaboration hypothesis)(Haarmann et al., 2013). For example, considering using a fork to comb one’s hair represents creative elaboration in that it creates new meaning associations as that is an unconventional use (i.e. context) for a fork. Diversity of meaning associations has been proposed as a factor underlying cognitive creativity (Martindale, 1995; Mednick, 1968), which is of key importance for good DT. Creative elaboration may benefit language learning, particularly acquisition of second language vocabulary, for a number of reasons such as (a) access to a greater number of retrieval cues, (b) more distinct and thus easier to retrieve memory representations, (c) longer memory encoding time (i.e., due to having to go beyond the more dominant immediate associations), and (d) deeper, that is,
semantic (i.e., meaning-based) encoding instead of shallow form-based encoding. The positive impact of each of these factors on memory retrieval has been validated in other research outside the domain of cognitive creativity (encoding depth: Craik & Tulving, 1975; encoding time: Davelaar, Goshen-Gottstein, Ashkenazi, Haarmann, & Usher, 2005; distinctiveness: Howard & Kahana, 1999).

Yet another reason that creative elaboration may benefit language learning is related to semantic diversity, which is an index of cognitive creativity (used in its automated scoring: Haarmann et al., 2011) and which may facilitate learning through greater exposure to, or generation of, variable contexts for a given L2 word during study. Evidence that exposure to context variation promotes word learning comes from a study in which definitions of new words were inferred and learned better from variable than constant sentence contexts (Bolger, Balass, Landen, & Perfetti, 2008). Such an effect is consistent with neurocomputational models that pose a role of semantic memory (i.e., general memory) in extracting invariant information from traces of context-specific events in episodic memory (i.e., event memory) (McClelland, McNaughton, & O'Reilly, 1995; Stark, Stark, & Gordon, 2005; Winocur, Moscovitch, & Sekeres, 2007). Simulation results from these models suggest that invariance extraction (extraction of a word’s core meaning) occurs more rapidly or robustly with greater context variation during learning (e.g., processing the meaning of a word across sentences that are more different from each other).

However, the creative elaboration hypothesis, has not yet been tested. More generally, evidence that divergent thinking promotes language learning is limited (Haarmann et al., 2013). The available studies on this topic tend to be correlational and thus permit no causal inferences. Several studies reported a positive correlation between verbal divergent thinking and language learning (Albert & Kormos, 2011; Otto, 1998; Pishghadam, Khodadady, & Zabihi, 2011). Such a correlation may have been obtained because verbal divergent thinking causes better language learning. Alternatively however, the same correlation may be due to a third shared factor which has a positive effect on divergent thinking and language learning. For example, a person with good word processing skills may be a good verbal divergent thinker and language learner (Haarmann et al., 2013). Moreover, only a few correlation studies have been conducted and not all of them support the hypothesis of a positive association between divergent thinking and language learning (Hajilou, Yazdani, & Shokrpour, 2012). Finally, one may reason a priori that, while good divergent thinking may benefit language learning, it may also interfere with it. For example, the broader meaning representations of good divergent thinkers might help them to encode words and their meaning more deeply in memory, but it may also make their understanding of the meaning of words less precise (Haarmann et al., 2013). In view of a lack of studies testing whether better DT causes better language learning, we explored whether language learning may benefit from engagement of DT during the learning process. To do this, we conducted a pilot study that provided a first test of the above-mentioned creative elaboration hypothesis.

A crucial (but not sufficient) ingredient of the rationale for the creative elaboration hypothesis is the idea that elaborating upon a word during study with meaning associations beyond the word’s core meaning promotes its memory encoding and thus memory retrieval (i.e., elaboration hypothesis). The research that is relevant for this hypothesis involves word learning studies in which the participant is given a new word and its meaning, asked to study it, and elaborate upon it with meaning associations related to its core meaning, for example in the form of a sentence or story (Bobrow & Bower, 1969; Graf, 1990; Hulstijn, 1998; Hulstijn & Laufer, 2001; Pichette, De Serres, & LaFontaine, 2012). Word study with less elaboration, less active elaboration (e.g., reading instead of generating a sentence), or no elaboration serves as the control condition in this type of research. When a person engages in
elaboration during study, one may reason that memory stores a representation of the new word, a representation of its meaning, and its generated meaning associations. These generated meaning associations may provide additional retrieval cues that aid the recall of the meaning of the new word when the learner is asked to indicate what the new word means during a subsequent memory test.

Several studies reported evidence for the elaboration hypothesis in the form of better word recall after elaborative study compared to a control condition with less (active) or no elaboration. An early study on this topic used a paired-associate learning task, in which learners are asked to study pairs of two unrelated words so that they can later recall one of the two words in a pair when cued with the other word (Bobrow & Bower, 1969). Learners were better at this task when they generated a sentence incorporating the two words than when they merely read such a sentence (Bobrow & Bower, 1969). This effect was also obtained in another study using paired-associate learning (Graf, 1990), particularly when sentences were meaningful but not when they were semantically anomalous, suggesting that it is not the mere act of generating a sentence but rather the associated semantic integration that enhances word learning. Other studies reporting evidence for the elaboration hypothesis reported the sentence generation effect in the context of L2 vocabulary learning. In two studies Hulstijn and colleagues, provided learners with a list of L2-L1 (2nd - 1st language) word pairs and asked them to process the pairs in the context of a passage, for which participants either (a) generated all sentences, (b) read all sentences, or (c) filled in blanks with the missing words (Hulstijn, 1998; Hulstijn & Laufer, 2001). In both studies, the condition with the most elaboration (i.e., sentence generation) led to better retention of the L2 vocabulary items. Pichette, De Serres and LaFontaine (Pichette et al., 2012) also provided learners with a list of L2 words and their meaning in an L2 vocabulary learning study. In their study, learners were asked to either generate or read a sentence for each word during the study phase of the experiment. Acquisition of the L2 vocabulary was better in the sentence generation than sentence reading condition, at immediate recall for concrete and abstract words and at delayed recall for concrete but not abstract words. The latter findings provides some evidence for persistence of the sentence generation effect. A study by Folse on L2 vocabulary acquisition included a sentence generation during study but was not designed to draw firm conclusions regarding its impact on learning (Folse, 2006). The results of this study showed that performance was better in a condition requiring three fill-in-the-blank items per word, compared to a condition requiring only one fill-in-the-blank item per word and compared to the sentence generation condition. Performance was best in the first condition (i.e, three fill-in-the-blank items), possibly reflecting a positive impact of number of word retrievals or time on task during study. Since the comparision with the sentence generation condition did not control for this factor, the results of this study do not warrant firm conclusions about the impact of sentence generation on word learning.

The consistent finding of a facilitative effect of sentence generation on word learning provides good evidence for the elaboration hypothesis and it sets the stage for a test of the more specific creative elaboration hypothesis. As discussed above, the creative elaboration hypothesis states that word learning benefits more from creative than non-creative elaboration. To test this hypothesis, we conducted a pilot experiment.

**Approach and rationale:** Participants studied a list of written pseudo-L2 words (i.e., nonword letter strings that are pronounceable in English) and their meanings a total of three times. All word meanings referred to concrete objects and were communicated to the learner via an image of the object. Immediately after studying such a word - picture combination for a few seconds, participants generated a sentence in English that incorporated the new word, before going on to the next word-picture pair on the list. Crucially for the test of the creative elaboration hypothesis, this elaboration with a self-
generated sentence could be either creative (i.e., creative elaboration condition) or uncreative (uncreative elaboration condition). In the creative elaboration condition, participants were instructed to generate a sentence as creatively as possible by forming a sentence with an uncommon use context for the studied word. By contrast, in the uncreative elaboration condition participants were instructed to generate a sentence with a conventional common use context for the studied word. In both conditions, participants generated three different sentences for each word across the three list presentations.

As in prior studies on the elaboration hypothesis, cued recall during a testing phase after the study phase of the experiment served as an outcome measure. Another outcome measure was semantic judgment. This task required judging whether or not the learned word was related in meaning to another word that had not been presented in the experiment. Inclusion of this task increased chances of detecting relevant effects and enabled assessment of whether participants acquired knowledge about the meaning of the words beyond lower-level, wordform-based associations. These two outcome measures were obtained at immediate recall immediately after the study phase of the experiment and, a few days later, at delayed recall to examine the short-term persistence of any creative elaboration effect. Better performance in the creative than uncreative elaboration condition would indicate evidence for the creative elaboration hypothesis. The instruction to be creative in the creative elaboration condition may be more successful - and thus more likely to impact word learning - in more creative individuals.

To assess this possibility, the pilot study included an alternate uses test, which is a frequently used DT test (Coren, 1995; Haarmann et al., 2013).

The explorative nature of the pilot study needs to be emphasized for two major reasons. First, this study is a first test of the creative sentence elaboration hypothesis and uses one of several feasible implementations of creative elaboration. Second, one can think a priori of factors that may produce better performance in creative elaboration condition but also of factors that produce an effect in the opposite direction, as discussed above.

**Retrieval practice**

Given the potential benefit of creative elaboration and to compare its effect size to that of another study method for improving word learning (i.e., retrieval practice), we designed the pilot study to provide a test of both effects and their interaction (e.g., greater improvement of word learning when both methods are combined compared to either study method alone).

Retrieval practice involves attempting to recall studied information from memory during learning and before a final memory test. Retrieval practice has been studied often in the context of paired-associate learning in which pairs of unrelated words or L1-L2 words are presented for memorization (Karpicke & Blunt, 2011; Karpicke & Roediger, 2008; Pyc & Rawson, 2011; Roediger & Karpicke, 2006; Szpunar, McDermott, & Roediger, 2008; Zaromb & Roediger, 2010). Experiments on this topic compare word learning with and without retrieval practice. In each case, learners are exposed at least once to all word pairs to allow them to develop initial associations between each pair’s two words (i.e., study practice). In a study-only control condition, learners continue with study practice across one or more list presentations (i.e., presentation of all word pairs). In the retrieval practice condition, on each trial, learners are given the first word of a pair and attempt to recall the second word for an equivalent number of list presentations (i.e., retrieval-practice), with or without error feedback. A frequent finding is that retrieval practice produces better word learning (i.e., recall on final test) when compared to study practice (Karpicke & Blunt, 2011; Karpicke & Roediger, 2008; Pyc & Rawson, 2011; Roediger & Karpicke, 2006; Szpunar et al., 2008; Zaromb & Roediger, 2010). This effect, which is known as the testing effect, has been observed during a final test after the word learning phase in delayed recall (but not in immediate) recall, indicating its positive impact on long-term retention. Delayed recall intervals have varied from half an hour to several days (Halamish & © 2011 University of Maryland. All rights reserved. January 2014 4
The testing effect has been observed in paired-associate learning for pairs of unrelated words (Mulligan, 2002; Siegel, Allendorfer, Lindsell, Vannest, & Szafarski, 2012; Slamecka & Graf, 1978; Vannest et al., 2012) and for L1-L2 words (Basi, Thomas, & Wang, 1997; McNamara & Healy, 1995; Melcher & Kowler, 2001; O’Neill, Roy, & Tremblay, 1993). The benefits of retrieval practice are larger when learning is spaced instead of massed (i.e., practicing fewer other items until the next repetition of the same item) and when error feedback is provided, but these benefits are often still obtained when such feedback is absent (Roediger & Butler, 2010). The testing effect has been obtained not only for word pairs in cued recall in adult learners but for a variety of memory tasks (cued recall, free recall, multiple choice), materials (word pairs, face-name pairs, texts, and maps), populations (children and adults), and settings (laboratory experiment and classroom) (for a review see Karpicke & Blunt, 2011).

Various hypotheses have been proposed to account for the benefits of retrieval practice on long-term retention (i.e., the testing effect): the retrieval effort hypothesis (Larsen, Butler, & Roediger, 2008), the elaborative retrieval hypothesis (Carpenter, 2009), the strategy shifting hypothesis (Bahrick & Hall, 2005; Pyc & Rawson, 2010, 2011), and the pro-active interference hypothesis (Szpunar et al., 2008). The causal mechanisms these hypotheses postulate are not mutually exclusive. They all emphasize the importance of establishing effective associations in long-term memory and assume a role of executive control. Executive control is the direction of attention to enable goal-driven behavior by initiating, maintaining, updating, and redirecting information processing and by reducing the negative impact of internal and external distractions and competing knowledge.

According to the first hypothesis of the testing effect, the retrieval effort hypothesis, retrieval during retrieval practice is more effortful than retrieval during re-study practice. This more effortful retrieval promotes the establishment of stronger memory traces (Larsen et al., 2008). The elaborative retrieval hypothesis (Carpenter, 2009) states that retrieval practice encourages the learner to elaborate the link between the cue (e.g., L1 word) and response (e.g. L2 word) with associations, which can then be used as additional memory cues to support retrieval of the response. By contrast, such associative elaboration is not necessary and therefore not encouraged when the cue and response are simultaneously provided to the subject for restudy during practice. In several word-pair association studies, retrieval practice was structured so that elaboration during such practice was guaranteed. These studies obtained evidence of a retrieval practice effect, especially if the elaboration promoted deep, meaning-based processing instead of lower-level, form-based phonological or orthographic processing, both for unrelated pairs of words (Mulligan, 2002; Siegel et al., 2012; Slamecka & Graf, 1978; Vannest et al., 2012) and for L1-L2 words (Basi et al., 1997; McNamara & Healy, 1995; Melcher & Kowler, 2001; O’Neill et al., 1993). The study by McNamara and Healy (1995) used non-words, which were pronounceable in English as L2 words, a procedure adopted in this pilot study.

The strategy shift hypothesis (Bahrick & Hall, 2005; Pyc & Rawson, 2010, 2011) postulates that retrieval practice makes learners aware of retrieval failures and therefore provides them with opportunities to change to a more effective strategy for associating a cue with a response (Pyc & Rawson, 2010, 2011). A particular version of the strategy shifting hypothesis, the mediator shift hypothesis, states that retrieval practice enables a learner to shift to the use of more effective key words for bridging the association between the cue and response (Pyc & Rawson, 2010, 2011). According to the fourth and final major hypothesis of the testing effect, the pro-active interference hypothesis (Szpunar et al., 2008) retrieval practice reduces pro-active interference, that is, the negative impact that an earlier presented item (e.g., the word chair) has on the recall of a later presented similar item (e.g.,
The pilot study was not designed to distinguish among these various hypotheses of the testing effect, but we will return to one of them in the discussion section.

**Approach and rationale:** To test the effect of retrieval practice and its interaction with creative sentence elaboration, half of the participants practiced the pairs with retrieval practice (i.e., given the L2 word of a pair, type in its corresponding L1 word) and the other half without retrieval practice (i.e., study-only practice, involving reading the L2 word and associating it with a simultaneously displayed picture of its meaning). The retrieval and study practice condition were equated for total practice time per word per learning trial and content feedback. Recall from above that each participant, practiced the L2-L1 word pairs with uncreative and creative elaboration.

**Preliminary work to detail the approach**

Several important details of the approach documented in the methods section below were arrived at after testing several aspects of it with small groups of participants including the number of words (10 versus 20 words), the number of sentences and thus list presentations (3 to 5 sentences/list presentations), and the degree of constraint imposed on the form of the sentences in the elaboration task (fill-in-the-blank versus free sentence formulation), and the direction of the cued recall from L2 to L1 or vice versa. We arrived at 10 words in each of the 4 cells of the design, 3 sentences per word, free sentence formulation, and recall with L2 as the cue and L1 as the target. Free sentence formulation was chosen to be able to maximally engage participants’ creativity in the creative sentence elaboration condition and avoid time pressure from interfering with it. Whereas a fill-in-the-blank format (e.g., generate an action for the empty verb slot of a sentence) would have probably afforded better control over the time on task in the two sentence-elaboration conditions, our joint subjective impression was that it stifled the process of most interest, creative elaboration, too much. The time to complete each sentence was recorded in order to enable a post-experimental check of whether the two elaboration conditions were matched in terms of this aspect of performance. Ten words instead of more words (i.e. 15 or 20 words) were chosen to enable administration of the word learning task in a single session and limit a negative impact of fatigue built-up on creative and other aspects of performance. Recall of L2 words given L1 words instead of vice versa was adopted to avoid floor effects (i.e. task too difficult to detect effects), since recall in the opposite direction is more difficult and since the effects of interest if obtained would be most likely to occur in delayed recall (i.e., after a few days), where overall recall is lower than in immediate recall.

Following Karpicke and Roediger (2008), all participants completed an arithmetic, distractor task after each list presentation (i.e., one cycle of studying all word pairs) in order to empty out the word contents of working memory and promote recall from long-term memory, where retrieval practice effects are believed to occur. We also tried out different versions of this distractor task prior to the major pilot study reported here, varying its duration (30 and 60 seconds) and difficulty (arithmetic problems solving problem with or without the aid of paper and pencil) and selected a task involving 30s of solving multicolumn addition and subtraction with the aid of paper and pencil.
METHOD

Participants

A total of 68 neurologically normal, right-handed\(^2\) individuals were tested. All participants rated their reading, listening, speaking, and writing skills in American English as good. Four participants were excluded from the analysis for failing to complete the delayed recall and relatedness judgment tasks on the appropriate day. Two individuals were excluded for generating an inappropriate number of sentences in the word learning task. Finally, 5 individuals were excluded for failing to pass the creative-uncreative manipulation check discussed in the results below. The analysis, therefore, included 57 participants over the age of 18 with normal or corrected-to-normal vision. (Note, one additional participant is excluded from relatedness judgment analyses due to missing data on that task only.) All participants were University of Maryland students who were compensated for their participation.

Design

The design of the word learning task was 2x2x2 mixed-factor design, crossing the factors elaboration (creative, uncreative), practice (retrieval+study, study-only), and test phase (immediate, delayed). Elaboration and test phase were manipulated within subjects, while practice was manipulated between subjects. Two factors were counterbalanced across participants, both impacting the study phase of the word learning task: the assignment of two matched word lists to elaboration condition (list1-creative, list2-uncreative versus list2-creative, list1-uncreative) and the order in which they performed the elaboration condition (creative-uncreative, uncreative-creative). Thus, the presentation of trials in the elaboration condition was blocked by condition. The dependent variables were cued recall and semantic relatedness judgment, assessed immediately after word study in the first session and again after a 3 days’ delay in a second session without word study. Performance on an alternate uses test was assessed at the end of the second and final session to serve as a potential covariate and/or pseudo-experimental grouping factor. A post-experimental questionnaire was administered at the end of the first session to assess what strategies participants used to study the words.

Materials

Materials were developed for four tasks, word learning, cued recall, relatedness judgment, and alternate uses test.

**Word learning task.** Twenty L2-L1-picture triples were created for the word learning task (see Appendix A). The L2 words were pseudo-words, that is, pronounceable non-words (i.e, mimicking words in an artificial 2\(^\text{nd}\) language), obtained from the MCWord Orthographic Wordform Database ([www.neuro.mcw.edu/mcword/](http://www.neuro.mcw.edu/mcword/)) or made up by the experimenters. The L2 words were one-or two-syllables long, between five to seven letters in length, had a wordform frequency of zero, and no

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\(^2\) The vast majority of people (i.e., approximately 95% of all people) are right handed. Individuals with left and mixed handedness were not included in this study because their brain organization - and thus possibly also their creative thinking and language mechanisms- are different from right handers, introducing a source of noise in the data that makes it more difficult to test the effects of interest. Also, examining the effect of handedness would have required a much larger participant sample.
orthographic neighbors. Each L2 word was paired with an English L1 word and picture depicting its meaning. The L1 words were concrete nouns that referred to objects and were 1 to 3 syllables in length and only two L1 words were 3 syllables in length. The pictures were obtained from open internet sources of clip art. The 20 L2-L1-picture triples were divided into 2 lists, List A and List B. The assignment of these lists to the creative and non-creative condition was counterbalanced across participants, so that each triple occurred in both conditions but was encountered by a participant only once. The L2 words on these lists were were matched on length (M = 5.8 characters), letter distribution, average constrained bigram frequency (t(19) = .49, p = .70, two-tailed), and number of wordforms that share the same constrained bigrams (t(19) = .33, p = .99, two-tailed). The word learning task also included a distractor task. Its materials consisted of 5 lists of 16 arithmetic problems each, requiring addition and subtraction of 3-digit numbers, constructed so that almost all of them require borrowing or carrying.

Cued recall task. The L2 words of the L2-L1-picture triples of the word learning task served as the cues for the cued recall test and the corresponding L1 words represented the correct response.

Relatedness judgment task. For each of the 20 studied L2 words from the word learning task, a related L2-L1 word pair (e.g., gorben-forest) and unrelated L2-L1 word pair (e.g., gorben-tree) were created, resulting in a list of 20 related and 20 unrelated L2-L1 word pairs (see Appendix B). The second, L1 words in these pairs were all concrete, 1-2 syllable nouns that did not occur elsewhere in the experiment. The relation between the L2-L1 pair was defined in terms of the relation between the English translation equivalent of the L2 word (e.g., tree for gorben) and the second, L1 word in the pair (e.g., tree-forest is related, while tree-fridge is unrelated). Related words were either near synonyms (e.g., chair-seat) or had a part-whole relationship (e.g., razor-blade); their average similarity was 0.38 as measured by latent semantic analysis (Landauer, Foltz, & Laham, 1998) with a standard deviation of 0.10, whereas unrelated words had an average similarity of 0.09 and a standard deviation of 0.08. In addition to being associatively related, the related words had to be semantically related, as judged by two of the researchers (e.g., bike and bell are often associated but not semantically related, whereas bike and pedal are both often associated and semantically related). Unrelated word pairs were created from related ones by re-scrambling the cue words (i.e., first words) across the related pairs. Likewise, a second set of 10 related and 10 unrelated pairs was created for an L1-L1 relatedness judgment task with English words that had not been studied and that were matched for lexical properties with the L1 words in the work learning task (i.e. word frequency, number of letters and syllables, and concreteness (see Appendix B).

Alternate uses test. Four concrete nouns, referring to objects (e.g., stapler) and not appearing anywhere else in the experiment, were selected for this task. One noun, basket, served as a practice item and the remaining three nouns served as the actual test items (i.e., crutch, stapler, spoon). Each noun was paired with a black and white picture of the object it referred to. Participants were instructed to write as many different unusual or creative uses for an item as they could think of in a text box on a computer display. They were given 3 minutes per item. Fluency of divergent thinking, defined as the total number of responses, served as the score on this task. This index of cognitive creativity can also be considered to yield a rough estimate of the originality of divergent thinking (Harbison & Haarmann, 2013).
Procedures

The experiment was administered across two sessions. The first one lasted about 2 hours and 15 minutes, while the second one lasted about 45 minutes. Participants were tested in groups of up to 15 individuals and each was seated in front of a laptop. All tasks were presented on laptop computers using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) and detached Apple keyboards. In the first session, participants performed the word learning task, and immediately following it their performance in that task was assessed with cued recall and relatedness judgment. In the second session, they performed the cued recall and semantic relatedness judgment task again (i.e., delayed recall), followed by an alternate uses test. The details of the procedures for each of these tasks were as follows.

Word learning. The word learning task consisted of a familiarization phase followed by a study phase involving paired-associate learning of the L2-L1 pairs, where L2 is the new word and L1 is its English translation equivalent, communicated in the form of a picture (e.g., L1 = gorben and L2 = picture-of-a-tree, i.e., gorben means tree). Pictures were used to focus the participant on the meaning of the L2 word. The word learning task lasted about one hour.

During the familiarization phase, participants were familiarized with the pictures that were used to communicate the meaning of the L2 words (e.g., picture of tree). On each trial, they were shown a different picture and asked to type in the corresponding L1 word (e.g., when shown a picture of a tree, they had to type in word tree). They were given feedback after each response, either seeing Correct! or the message, We would prefer that you think of this item as [common-American-English-word]. After all pictures had been presented, any pictures which were incorrectly labeled were re-presented and this procedure was repeated until participants typed in the correct name for each picture.

During the study phase, the presentation of words was blocked by elaboration condition and the assignment of words to elaboration condition was counterbalanced across subjects, such that half of the participants received 10 words in the creative condition and 10 other words in the uncreative condition, while the assignment of words to condition was the opposite for the remaining participants. In each elaboration condition, participants were presented with a list of 10 words with one study trial per word. The list of 10 words was presented a total of 3 times (i.e., list presentation 1 to 5), so that each word was practiced 5 times. Items were presented in the same order on each list presentation. A distractor task that involved solving addition and subtraction problems was performed for one minute after each list presentation to empty out the contents of working memory in order to promote recall from long-term memory. Performance on the distractor task was self-paced and as a result participants completed different number of problems in the allotted time. The stimulus presentation and response collection for the distractor task was computer controlled, but subjects were given paper and pencil to aid their calculations. The events on a study trial in the study-only condition (i.e., no retrieval practice) were as follows. The L2 word appeared (e.g, gorben) together with the picture depicting its meaning (e.g., picture of tree) for four seconds and participants were asked to study the meaning of the L2 word. Following this, subject were asked to use the L2 word in an otherwise English sentence (i.e, elaboration). Participants were instructed as follows: “before writing each sentence, form a clear picture in your mind of the situation you are describing. Make sure that it describes a memorable situation which will help you remember the meaning of the new word.” They were then instructed to generate sentences “that describe very common scenarios that fit the conventional meaning of the new word” (e.g., The boy climbed the gorbin in his backyard) in the uncreative elaboration condition and “that describe very uncommon out-of-the ordinary situations” in the creative elaboration condition (e.g. The boy polished the gorbin on the moon, with gorbin meaning tree). Prior to the start of the word learning task,
participants were given examples of creative and uncreative sentences for each of three words that were not used in the actual test. The operationalization of the creativity of a sentence in terms of uncommonness was the same as the operationalization of originality, an important aspect of creativity, for responses on the Torrance Test for Creative Thinking (Torrance, 2008). Participants had unlimited time to generate and type in a sentence, before the next study trial started. When participants elaborated on a word with a sentence, they were shown all the sentences they had generated for that particular word on any previous list presentations and instructed to generate a different sentence. The events on a study trial in the retrieval-practice condition were as follows. The L2 word appeared by itself and participants were instructed to type in the L2 word (e.g., given gorben, they had to type in tree) within three seconds (i.e., cued recall). Regardless of whether the answer was correct or incorrect, they were then shown the L2 word with corresponding picture for 1 second to provide feedback and study. Following this, they performed the elaboration task as in the study-only condition. Immediately, prior to the start of a particular elaboration condition, participants received three practice trials for that condition with each of two words not used in the actual word learning task. Each typed response and the time to type it in was recorded, measured from the onset of the sentence prompt to the onset of the first and last key stroke corresponding to the first letter of the first word and the final letter of the last word of the sentence, respectively.

Cued recall. For each of the studied words, the cued recall task assessed whether, when given the L2 word, the participant could recall the corresponding L1 word (e.g., Gorben? Answer: Tree). On each trial, participants were shown an L2 word and were instructed to type in the L1 word. The response deadline was ten seconds. There was no response feedback. Accuracy and response time were recorded. An response was considered correct if it matched the L1 word and incorrect otherwise. Response time was defined as the time between the onset of the L2 word and the onset of the key press for the first letter of the L1 word. The cued recall task was presented at immediate recall and delayed recall with the same items appearing in the same trial order.

Relatedness judgment. This task consisted of two block of trials. The first block assessed relatedness judgments for non-studied L1-L1 word pairs, while the second block assessed relatedness judgments for all studied L2-L1 word pairs (e.g., fiteg – horn Related; fiteg – salad Unrelated, with fiteg meaning trumpet). The L2 word always occurred before the L1 word as in the example. The procedure was the same for both trial blocks. On each trial, participants were shown a word pair and had to judge as accurately and quickly as possible with a yes/no button press whether its two words were related in meaning or not. The response deadline was four seconds. Accuracy (correct, incorrect) and response time were recorded. No response feedback was provided. Half of the pairs within a block (i.e, 20 pairs) were related and remaining half were unrelated. The order of related and unrelated trials was pseudo-randomized with the restriction that no more than 4 related or unrelated pairs appeared in a row. The assignment of buttons (1, 2) to relatedness (related, unrelated) was counterbalanced across participants and same for both blocks. The first block was preceded by 10 practice trials with non-studied L1-L1 pairs, including five related pairs and five unrelated ones. Accuracy feedback was provided on practice but not actual test items. The relatedness judgment task was presented at immediate recall and delayed recall, using the same materials, and with the blocks and items within blocks appearing in the same order.

Alternate uses test. On each of three test trials, participants were presented with one object noun and corresponding picture (e.g., the word telephone and a picture of a telephone). They were instructed to type words or phrases indicating as many different unusual or creative uses for the item as they could think of. A word-picture item remained in view for a response period of three minutes. The actual test
was preceded by a practice trial. Performance on this test was scored in terms of fluency, flexibility, and originality (Torrance, 2008).

RESULTS

Manipulation Check. To check whether the creative versus uncreative elaboration instructions were followed by participants while completing the word learning task, 3 separate coders evaluated each of the two sets of sentences that participants generated. Coders made a binary decision as to whether each set resulted from instructions to generate creative sentences.

This coding found that the majority of participants were following the creative versus uncreative elaboration instructions. Of the 124 sentence sets reviewed, the coders disagreed on only 6 sets (4.84%). Moreover, for 1 set, coders unanimously agreed that the participant was generating uncreative sentences when he or she should have been generating creative sentences. Based on these disagreements, 5 individuals were excluded from analysis for failing to unambiguously meet the manipulation check.

Cued Recall Accuracy. A 2 (Practice Condition: Retrieval+Study v Study-only) by 2 (Elaboration Condition: Uncreative v Creative)) by 2 (Test Phase: Immediate v Delayed) mixed-factor ANOVA was conducted predicting cued recall accuracy.

Practice Condition was not found to impact recall accuracy, $F(1, 55) = .65, p = .42, \eta^2_p = .01$, with recall being similar in both the Retrieval+Study and Study-only conditions. No effect was seen for the Elaboration manipulation, $F(1, 55) = .25, p = .62, \eta^2_p = .004$. Further, there was no significant interaction between Practice and Elaboration, $F(1, 55) = .20, p = .66, \eta^2_p = .004$.

Test Phase was a significant predictor of recall accuracy, $F(1, 55) = 26.65, p < .001, \eta^2_p = .33$, with Immediate recall being better than Delayed recall. However, Test Phase did not significantly interact with either Practice Condition, $F(1, 55) = .69, p = .41, \eta^2_p = .01$, or Elaboration Condition, $F(1, 55) = .53, p = .47, \eta^2_p = .01$, nor was the 3-way interaction significant, $F(1, 55) = .39, p = .53, \eta^2_p = .01$.

![Figure 1](image_url)

*Figure 1. Proportion of correct responses on cued recall task. Panel A shows participants in the Retrieval+Study condition while Panel B shows participants in the Study-only condition. Error bars represent one standard error.*
Relatedness Judgment Accuracy. A 2 (Practice Condition: Retrieval+Study v Study-only) by 2 (Elaboration Condition: Uncreative v Creative) by 2 (Test Phase: Immediate v Delayed) mixed-factor ANOVA was conducted predicting relatedness judgment accuracy. One additional participant was excluded from the relatedness analyses due to missing data on that task for the Delayed Test Phase.

Practice Condition was not found to impact relatedness judgment accuracy, $F(1, 54) = 1.58, p = .21$, $\eta_p^2 = .03$. A significant effect was identified for Elaboration Condition, $F(1, 54) = 8.97, p = .004$, $\eta_p^2 = .14$, such that relatedness-judgments for words learned in the Creative condition ($M = .71, SD = .14$) were less accurate than words learned in the Uncreative condition ($M = .75, SD = .13$). Elaboration Condition did not significantly interact with Practice Condition, $F(1, 54) = .20, p = .66, \eta_p^2 = .004$.

Test Phase was not a significant predictor of relatedness judgment accuracy, $F(1, 54) = .93, p = .34$, $\eta_p^2 = .02$. Test Phase also did not significantly interact with Practice Condition, $F(1, 54) = 2.02, p = .16, \eta_p^2 = .04$. The interaction between Test Phase and Elaboration Condition was marginal, $F(1, 54) = 3.49, p = .07, \eta_p^2 = .06$. Follow-up paired-samples t-tests indicated that the effect of Elaboration Condition on relatedness rating accuracy was significant for Immediate judgments, $t(55) = -3.47, p = .001$, and not significant for Delayed judgments, $t(55) = -1.26, p = .21$.

Finally, the 3-way interaction between Practice Condition, Elaboration Condition, and Test Phase was not significant, $F(1, 54) = 1.43, p = .24, \eta_p^2 = .03$.

![Bar chart A](image1.png)  
![Bar chart B](image2.png)

Figure 2. Proportion of correct responses on relatedness judgment task. Panel A shows participants in the Retrieval+Study condition while Panel B shows participants in the Study-only condition. Error bars represent one standard error.

Relatedness Judgment Reaction Time. A 2 (Practice Condition: Retrieval+Study v Study-only) by 2 (Elaboration Condition: Uncreative v Creative) by 2 (Test Phase: Immediate v Delayed) mixed effects ANOVA was conducted predicting reaction times (RTs) to accurate relatedness judgments. Reaction times for correct responses only were used in this analysis.

Practice Condition was not found to impact relatedness reaction times, $F(1, 54) = .54, p = .47, \eta_p^2 = .01$. Elaboration Condition was also not significant, $F(1, 54) = 8.97, p = .004$, $\eta_p^2 = .14$, and did not significantly interact with Practice Condition, $F(1, 54) = .20, p = .66, \eta_p^2 = .004$. 

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Test Phase was a significant predictor of reaction time, $F(1, 54) = 32.69, p < .001, \eta_p^2 = .38$, with slower RTs during the Immediate than during the Delayed judgments. Additionally, Test Phase interacted with Elaboration Condition, $F(1, 54) = 6.68, p = .01, \eta_p^2 = .11$. Paired-samples t-tests were used to follow up this interaction. For the Immediate judgments, RTs for words learned with a Creative instruction were higher than those learned with the Uncreative instruction, $t(55) = 2.47, p = .02$. For Delayed judgments, there was no significant differences between RTs for words presented with the Creative or Uncreative elaboration instructions, $t(55) = -1.01, p = .32$.

Test Phase did not significantly interact with Practice Condition, $F(1, 54) = .07, p = .80, \eta_p^2 = .001$, and the 3-way interaction between Practice Condition, Elaboration Condition, and Test Phase was also not significant, $F(1, 54) = .01, p = .92, \eta_p^2 < .001$.

**DISCUSSION**

The major goal of this pilot study was to test – for the first time - the creative elaboration hypothesis of word learning. According to this hypothesis individuals retain the association between a newly learned word and its meaning better when they generate additional associations (i.e., elaboration) that are creative instead of uncreative or conventional. This study instantiated elaboration by asking learners to generate a sentence that incorporated the new word. There was no evidence for the creative elaboration hypotheses under this particular instantiation. Cued recall of the L1 word given the new, L2 word was the same in the creative and uncreative elaboration condition and this null effect was obtained in both the immediate and delayed recall condition.

Moreover, immediately after the study phase of the experiment, the semantic relatedness judgment data revealed an effect in the opposite direction with more accurate and faster judgment in the uncreative than creative sentence elaboration condition. This advantage of uncreative over creative elaboration in semantic-relatedness judgment may reflect an associative semantic priming effect that is stronger in the uncreative than creative elaboration condition because it relies on strong associations that existed before the experiment. The benefit of uncreative elaboration on accuracy of relatedness judgment may have been no longer present after a few days delay because the associative semantic priming may have merely increased activation levels in short-term-memory without a lasting impact on traces in long-term memory.
Such an effect may have opposed and masked any advantage of creative over uncreative elaboration in cued recall. As mentioned in the introduction, given other opposing factors that may be at work (e.g., greater distinctiveness in the creative elaboration condition but also less precision of the semantic representations in the uncreative elaboration condition) these findings are not necessarily surprising. Indeed, the goal of this pilot study was to explore the creative elaboration hypothesis in full knowledge of the possibility that the combined effect of opposing factors might be to yield no effect, an advantage of creative elaboration, or one of uncreative elaboration.

Nevertheless, we would like to offer suggestions for follow-up research aimed at further exploring the creative elaboration hypothesis by considering why this hypothesis was not supported given the particular approach adopted in the present study. There are several potential reasons for this. First, there may not have been sufficient creative sentence elaboration practice. Participants received only three practice trials and no feedback during the experiment as to how successful they were at generating sentences in a creative manner. This consideration suggests the possibility that a benefit of creative elaboration may be demonstrated after offering more creative elaboration practice with feedback in a future study. Second, participants may have not fully engaged their cognitive creative potential and adopted an uncreative strategy to implement the instruction to generate creative, uncommon sentences. One such strategy involves first generating a sentence with a conventional meaning by using another word than the target word (e.g., “the cook put carrots in the pot” and then substituting with the target word (e.g., “the cook put the gorben in the pot”, with gorben meaning tree). The responses of several participants indeed suggest that they may have adopted such a strategy.

A more effective way of engaging the creative potential of participants may be to instruct them to generate a creative story with the L2 word that consists of several integrated sentences, after considerable practice in creative story writing. To the extent that participants engage their creative potential in the creative elaboration condition, one would expect to find a positive association between a measure of the creativity of their performance in that condition and an index of cognitive creativity such as performance on a divergent thinking task. Our data did not reveal a modulating influence of divergent thinking, as indexed by fluency on the alternate uses task, on performance in the creative compared to uncreative elaboration condition. We checked this by splitting participants into low-creative (22 or fewer uses generated; \( N = 33 \)) or high-creative (23 or more uses generated; \( N = 30 \)) groups based on a median split of AUT fluency. Rerunning all of the above-reported analyses did not reveal any significant effects or interactions associated with this high-low split. The lack of such a modulating influence could mean that participants’ creative potential was not fully engaged. However, the null effect does not permit distinguishing this particular interpretation from other possibilities, including that there is no effect of creative elaboration on word learning.

A second goal of this pilot study was to test the retrieval practice hypothesis for two major reasons including (1) to compare the size of a previously reported method for improving word learning (i.e., retrieval practice) to the new method of creative elaboration and (2) to investigate whether the two methods have practically relevant interactive effects such that retrieval practice enhances the effects of creative elaboration. Unfortunately, no effect of retrieval practice was obtained. Although effects of retrieval practice on word learning have been documented in several studies, it is possible that such effects are not as robust as assumed and depend on subject strategies or other yet to be determined factors. For example, several years ago a CASL researcher who was not involved in the present study and tested the retrieval practice effect in the context of a doctoral program failed to find evidence of it. Such replication failures often do not make it into the academic research literature, contributing to
overestimation of the robustness of effects (i.e., “file-drawer effect”) and lack of understanding of the conditions under which they are obtained and not obtained.

In the present pilot study, the retrieval practice manipulation did not have the expected effect (i.e., better delayed recall in the retrieval-practice than study-only practice condition). However, this manipulation did have an unexpected effect: participants in retrieval practice condition spent significantly less time (sec) on the sentence generation tasks ($M = 2522.92$, $SD = 717.51$) than did participants in the study-only condition ($M = 2124.32$, $SD = 399.43$), $t(46.29) = 2.62$, $p = .01$. Given the approach in this study, one can only speculate about the interpretation of the finding. Perhaps participants who engage in retrieval practice, have a greater confidence in their knowledge of the words during the study phase and therefore are less motivated to invest time in the sentence-elaboration component of the word-learning task. As a result, such participants would receive more benefit from retrieval practice and less benefit from creative elaboration compared to participants in the study-only practice condition, a tradeoff that may have masked a benefit of retrieval practice.

This possibility suggests that it may be important to consider the question under what conditions an effect of retrieval practice will be obtained. Two conditions to consider are the number of words that need to be learned and the absence/presence of a sentence elaboration activity that is independent of retrieval practice. The number of words was relatively small in this study (i.e., 20 words) compared to studies that did obtain the retrieval effect (e.g., 40 words in Roediger & Karpicke, 2008). Moreover, a sentence elaboration activity was present in this study but not in those previous studies. When the number of words is smaller, repeated practice of the same item is spaced closer together which makes recall less effortful and possibly rely to a greater extent on decaying information in short-term memory in addition to recall from long-term memory. Likewise, engagement in sentence elaboration immediately after associating the L2-L1 pair by itself may also contribute to making recall less effortful because this activity may make the short-term and long-term memory representations of the practiced words more accessible. As a result, due to the reduced effort in word recall, no effect of retrieval practice may be obtained. While post-hoc, this interpretation is consistent with the retrieval effort hypothesis of retrieval practice (Larsen et al., 2008), which states that benefits of retrieval practice occur because the underlying traces in long-term memory are strengthened during retrieval and this requires cognitive effort. Another possibility is that effects of retrieval practice would emerge when the recall task at the final test is different from the one used during the learning phase and made more difficult, for example by replacing cued recall with free recall (Halamish & Bjork, 2011).

These considerations could be taken into account in future studies that adopt an alternative approach for testing the separate and combined effects of creative elaboration and retrieval practice. In the present study, sentence elaboration occurred in both the retrieval practice and study-only practice condition and after the L2-picture pair had been processed alone for a few seconds with or without retrieval practice. An alternative approach would be to incorporate the sentence elaboration activity only in the retrieval practice condition and to engage in it only after an incorrect retrieval attempt. The advantage of this approach would be twofold. First, the overall amount of sentence elaboration per word would be reduced, offering more opportunity to benefit from effortful retrieval. Second, sentence elaboration would be engaged more selectively when it is needed to strengthen the associations between the L2 word and its meaning, that is, after a retrieval failure, consistent with the rationale of the strategy-shift hypothesis of retrieval practice discussed in the introduction. Within that more selective approach of utilizing sentence elaboration to strengthen associations when needed, one could then address the question of whether strengthening associations between the L2 word and its meaning after retrieval failure is more effective when it involves creative instead of uncreative elaboration.
Given the purported benefit of cognitive effort during retrieval practice and given that creative generation after error feedback could proceed with and without effort, it would be advisable to also obtain a separate measure of cognitive effort.

A clear effect in this study was the reduction in cued recall performance in delayed recall compared to immediate recall. This is not a noteworthy effect as it is typically obtained in memory research (Davelaar et al., 2005). However, the reason to mention it here is that this effect occurred at levels of recall in both immediate and delayed recall that were in between ceiling and floor performance. Any effects of creative elaboration and retrieval practice if they had been obtained would have been superimposed on top of performance in between these two extremes. The implication of this observation is that it is therefore unlikely that the lack of these effects in our study is due to floor or ceiling performance either in the immediate or delayed condition.

CONCLUSION

The pilot study provided no evidence that deepening the association between a new word and its meaning through creative sentence elaboration improves word learning, as indicated by immediate or delayed recall and relatedness judgment. Follow-up research aimed at testing whether there is a benefit of creative over uncreative elaboration should adopt the following recommendations: provide more creative generation practice with performance feedback; ask participants to elaborate creatively with an integrated story rather than an isolated sentence; integrate the creative elaboration activity selectively after retrieval failure in a retrieval practice condition; monitor what levels of cognitive effort benefit creative elaboration; and be aware of psycholinguistic factors that may oppose the finding of a creative elaboration effect. Finally, while this study focused on a test of the creative elaboration hypothesis on word learning, there are other ways in which enhanced creativity may benefit language learning and proficiency. For example, brainstorming prior to essay composition improves ideational fluency during foreign language use (for review see Haarmann et al., 2013), which in turn may improve foreign language proficiency.
ACKNOWLEDGEMENTS

This material is based upon work supported, in whole or in part, with funding from the United States Government. Any opinions, findings and conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the University of Maryland, College Park and/or any agency or entity of the United States Government. Nothing in this report is intended to be and shall not be treated or construed as an endorsement or recommendation by the University of Maryland, United States Government, or the authors of the product, process, or service that is the subject of this report. No one may use any information contained or based on this report in advertisements or promotional materials related to any company product, process, or service or in support of other commercial purposes. This report is not Releasable to the Defense Technical Information Center per DoD Directive 3200.12. The Contracting Officer’s Representative for this project is John Walker, Government Technical Director at CASL, (301) 226-8912, jwalker@casl.umd.edu.

APPENDIX A: WORD LEARNING MATERIALS

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APPENDIX B: RELATEDNESS JUDGMENT MATERIAL

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