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**AN INVESTIGATION OF THE EFFECTS OF RETRIEVING AND BEING  
RE-EXPOSED TO OLD IDEAS ON THE GENERATION OF NEW IDEAS**

A dissertation submitted in partial satisfaction  
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGY

by

**Annie Stanfield Ditta**

March 2019

The Dissertation of Annie S. Ditta  
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Lori Kletzer  
Vice Provost and Dean of Graduate Studies

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## Table of Contents

<b>List of Figures</b>	<b>vi</b>
<b>Abstract</b>	<b>vii</b>
<b>Acknowledgements</b>	<b>ix</b>
<b>CHAPTER I: Introduction</b>	<b>1</b>
<b>CHAPTER II: Testing Boundary Conditions on Potential Retrieval-Induced Fixation Effects in a Divergent Thinking Task</b>	<b>7</b>
Comparing the Effect of Retrieval versus Restudy on Idea Generation	7
Comparing the Effect of Being Re-exposed to One's Own versus Someone Else's Ideas on Idea Generation	9
<b>CHAPTER III: The Present Studies</b>	<b>13</b>
Experiment 1a	14
Method	15
Participants	15
Design	16
Materials	16
Procedure	16
Results & discussion	18
Initial ideas retrieved	19
Total output (repetitions included)	19
Repetitions	20
Fluency of new ideas (repetitions removed)	21

Divergence	21
Creativity	24
Experiment 1b	25
Method	26
Participants, design, & materials	26
Procedure	26
Results & discussion	26
Initial ideas retrieved	26
Total output (repetitions included)	27
Repetitions	27
Fluency of new ideas (repetitions removed)	28
Divergence	30
Creativity	30
Experiment 2	31
Method	32
Participants	32
Design	33
Materials	33
Procedure	34
Results & discussion	35
Initial ideas retrieved	35
Total output (repetitions included)	36

Repetitions	36
Fluency of new ideas (repetitions removed)	38
Divergence	40
Creativity	41
<b>CHAPTER IV: General Discussion</b>	<b>44</b>
Concluding Comments	49
<b>References</b>	<b>50</b>

## **List of Figures**

<b>Figure 1.</b> Fluency, divergence, and creativity ratings in Experiment 1a	23
<b>Figure 2.</b> Fluency, divergence, and creativity ratings in Experiment 1b	29
<b>Figure 3.</b> Fluency and divergence ratings in Experiment 2	39
<b>Figure 4.</b> Creativity ratings in Experiment 2	42

## **Abstract**

### **An Investigation of the Effects of Retrieving and being Re-Exposed to Old Ideas on the Generation of New Ideas**

Annie S. Ditta

People are inherently creative in that they produce ideas to solve problems often in their everyday lives. Work on idea production has investigated the role of viewing examples on people's ability to think of new ideas, to mixed results. Some work has found that people experience fixation when they are exposed to examples that are meant to help them think more creatively (demonstrating a negative effect on the ability to think of new ideas), while other work has shown that being shown examples can be helpful for producing more creative ideas (demonstrating a positive effect). However, no work to date has examined the effect of 1) different sources of examples (i.e., self- vs. other-generated), and 2) the manner in which one interacts with these examples on creative thinking (i.e., retrieving, restudying, or doing nothing with those ideas). To examine these effects, the set of experiments in this dissertation utilized a modified version of the Alternative Uses Task to investigate the effects of example type and interaction method on the ability to generate new ideas. In these experiments, participants were asked to generate their own examples or study someone else's examples in two phases, where the ideas from the initial phase served as examples for the second phase. Before thinking of additional ideas, participants were asked to interact with the example ideas in different ways (i.e., retrieve from memory, restudy, or do nothing with them). Results from these experiments



demonstrate that recalling and restudying a diverse set of initial examples—whether one’s own or someone else’s—may not induce measurable differential effects in the Alternative Uses Task. The results from these experiments add to the growing literature on idea generation ability after exposure to examples in a number of important ways.

## Acknowledgements

A section like this is difficult for me to write, as I'm not usually an outwardly-expressive person with my emotions. But for something as important as the dissertation, I'll make this happen.

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## **CHAPTER I**

### **Introduction**

People are constantly required to think of new ways to solve problems in their everyday lives. For example, someone may need to think of new combinations of words to express their thoughts out loud or in writing. Someone else may have dropped a remote control to an inaccessible place behind their couch and may need to devise an innovative way to retrieve it. Though these problems may not require “creative” solutions in the most common use of the term, such ideas may be novel and creative to the person producing them. Work on everyday creativity has shown that the ways in which people navigate their world require creative thinking (e.g., Cropley, 1997, 2016; Ivcevic & Mayer, 2009; Nicholls, 1972; Richards, 2007; Richards, Kinney, Bennet, & Merzel, 1988), and scholars who study creativity through the lens of creative cognition argue that the cognitive system is built in order to allow people to produce solutions to problems that they encounter in their everyday lives (Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995; Ward, Smith, & Finke, 1999).

Despite the fact that people are constantly required to think creatively, actively trying to think of new ideas can be difficult, and people often generate many suboptimal ideas before arriving at an idea that works as a solution. Such a process of generating many ideas in an attempt to address a single problem is known as divergent thinking (Guilford, 1957; compared to convergent thinking, which requires

people to unite many disparate ideas into a single solution; e.g., Bowden & Jung-Beeman, 2003; Mednick, 1962; Mednick & Mednick, 1971).

Divergent thinking is typically measured through the Alternative Uses Task (AUT; Guilford, 1957), which requires people to think of as many alternate uses for a common household object as possible (e.g., a spoon). To be successful on this task, people must overcome the tendency to repeat solutions that have already been generated before (i.e., canonical uses for the object; e.g., *eating soup*) or solutions that are not useful to the context (e.g., *reading it*, which cannot be done with a spoon). To meet these requirements for generating creative and appropriate solutions, people draw on information they already know and combine that prior knowledge in new ways to yield new ideas (Madore, Jing, & Schacter, 2016; Ward, 1994; Ward, Patterson, Sifonis, Dodds, & Saunders, 2002). Indeed, proponents of the creative cognition approach argue that the ability to remember information is a key component in people's ability to generate new ideas (e.g., Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995; Ward, Smith, & Finke, 1999).

While relying on prior knowledge can help people think of new ideas, it can also serve to block production of new ideas as well. Such an experience is known as *mental fixation*, which is defined as the tendency to perseverate on old ideas, prior knowledge, and/or previous problem-solving attempts, despite the fact that they are known to be unhelpful and that they ultimately limit creative output (Smith, 2003). Fixation is particularly detrimental to problem solving and idea generation because it can manifest in a number of different ways. People can become fixated on their

initial problem-solving attempts, or pre-existing knowledge that they have about a task that is unhelpful for solving the problem—especially when they are experts about a topic, but that expertise is not useful in that specific context (e.g., Wiley, 1998). Interestingly, fixation not only occurs for solutions to problems, but can occur for the problem-solving method itself. Work on *Einstellung* has shown that people can become fixated on old methods of solving a problem, even when such solutions no longer work, and when better solutions become available (Luchins & Luchins, 1959). Ormerod, MacGregor, and Chronicle (2002) have also found that participants can be fixated on incorrect problem-solving methods, especially when they initially seem to be making progress toward the goal.

In the context of divergent thinking (particularly in the AUT), people can become fixated on the canonical use for the objects and fail to think of other uses—a finding known as functional fixedness (e.g., Duncker & Lees, 1945; Maier, 1931). Other work on divergent thinking has shown a negative effect of being shown examples; that is, people become fixated on the examples, which then constrains their subsequent idea generation. For example, a classic study asked undergraduate students to draw alien creatures that they had never encountered before after looking at a set of three examples. Critically, these examples all contained shared core features (i.e., four legs, a tail, and antennae). Participants ended up incorporating those features after looking at the examples, even when they were explicitly told not to (Smith, Ward, & Schumacher, 1993). Subsequent work has replicated this fixating effect of examples in a number of ways; for example, with engineering design

students being tasked to create a spill-proof coffee cup (Jansson & Smith, 1991; see also, Cardoso & Badke-Schaub, 2011; Chrysikou & Weisberg, 2005; George, Wiley, Koppel, & Storm, 2017; Kohn & Smith, 2011; Landau & Leynes, 2004; Marsh, Landau, & Hicks, 1996). Together, these studies suggest that there are circumstances under which exposure to example ideas and/or prior knowledge can have negative effects on idea generation (though there is work that supports the idea that exposure to the examples can benefit idea generation as well; e.g., Agogué, et al., 2014; Dugosh & Paulus, 2005; Dugosh, Paulus, Roland, & Yang, 2000; Fink, et al., 2012; Fink, Schwab, & Papousek, 2011; George, Wiley, Koppel, & Storm, 2017; Nijstad, Stroebe, Lodewijx, 2002; Perttula & Sipilä, 2007; Sio, Kotovsky, & Cagan, 2015; Shin, Cotter, Christensen, & Silvia, 2018).

Given that 1) the goal of divergent thinking is to generate as many different ideas as possible, and 2) people may experience fixation while attempting divergent thinking tasks, it is important to understand the factors surrounding the presentation of examples (whether they are intended to be helpful or harmful to problem solving) that contribute to fixation and limit people's ability to think of new ideas. Of particular interest to this dissertation are the studies that have presented examples before a subsequent problem-solving attempt (e.g., Smith & Blankenship, 1991; Beda & Smith, 2018). In these studies, participants suffered from fixation at the time of problem solving, indicating that retrieval of the examples from memory was acting to hinder their problem-solving ability (in contrast to studies that present example information simultaneously at the timing of solving; Smith & Blankenship, 1989).

In a recent study, Beda and Smith (2018) specifically investigated the idea that retrieval of information from memory can have a negative effect on problem solving ability (while the prior studies only suggested this idea). This series of studies utilized a measure of convergent thinking, the Remote Associates Task (RAT), which requires participants to find a word that relates to a set of three seemingly unrelated words (e.g., COTTAGE, SWISS, CAKE; solution: CHEESE). Before completing these problems, participants were exposed to paired words that were related to each of the problem words, but were not the solution (i.e., blockers; e.g., COTTAGE-hut, SWISS-chocolate, CAKE-icing), which make the RAT problems more difficult to solve<sup>1</sup>. It was predicted that when these paired associates were made easier to recall at the time of problem solving, performance would be impaired relative to when the associates were more difficult to remember. One of the ways in which ease of recall was manipulated was through context reinstatement, which is when the context in which the blockers were learned are reactivated at the time of problem solving (Smith, 1979; 2013). To do this, the paired associates were encoded on photo backgrounds, and these photo backgrounds were either displayed or not displayed at the time of problem solving. When the context was reinstated at the time of problem solving (making the blockers easier to retrieve), participants solved fewer RAT problems than when the context was not reinstated (and retrieval was

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<sup>1</sup> Though this information was presented with the intention of fixating participants (i.e., as a blocker of problem-solving), such information can also be considered “examples” in that they are suboptimal solutions to the problem in that they only match with one word, instead of all three.



more difficult).

The findings described above suggest that retrieval of example ideas can hinder subsequent problem solving, and one mechanism through which this occurs is via context reinstatement. However, this study was conducted using a convergent thinking paradigm; to date, no studies have examined whether retrieval of example ideas can cause a fixation effect in a divergent thinking paradigm. While there is good reason to think that the mechanisms would be the same in both types of creative thinking, it is important to directly test these ideas. It is especially important to understand the mechanisms that affect idea generation in divergent thinking paradigms because when people have the goal of trying to think of many ideas, example ideas may be presented with the intention of aiding the generation of those new thoughts (rather than with the intention of blocking ideas/solutions; Beda & Smith, 2018). It is therefore important to understand whether such retrieval of example ideas in a divergent thinking task—which is more in line with how people try to think creatively in the real world, compared to a convergent thinking task—also causes fixation and impairs idea generation.

## **CHAPTER II**

### **Testing Boundary Conditions on Potential Retrieval-Induced Fixation Effects in a Divergent Thinking Task**

#### **Comparing the Effect of Retrieval versus Restudy on Idea Generation**

Though one goal of this dissertation is to investigate retrieval as a possible mechanism of fixation in a divergent thinking task, this work aims to extend prior work in two important ways. First, prior work suggests that retrieval is a mechanism that affects subsequent problem-solving/idea-generation ability. However, there are other methods of re-exposure to old ideas that have not been compared to the effect of retrieval that may also serve to reinstate fixating contexts. Specifically, being re-exposed to old ideas through restudying (instead of retrieving) may or may not have a similar fixating effect on idea generation. However, there is a wealth of studies that suggest retrieval of information from memory alters that information in ways that merely restudying the information does not (e.g., Anderson, Bjork, & Bjork, 2000; Roediger & Karpicke, 2006; Rowland, 2014; Sara, 2000).

Work investigating the special nature of retrieval as compared to restudy comes from work on the testing effect, which is the finding that people are more likely to recall information if they are tested on that information initially, compared to restudying the information for the same amount of time (Nungester & Duchastel, 1982; Rowland, 2014). Of particular interest in studies of the testing effect is the finding that the effects of retrieval are strongest with a delayed final test; indeed, some research shows that restudy can be more beneficial than testing (i.e., retrieval)

on an immediate test (Roediger & Karpicke, 2006). Such an effect observed at a delay is argued to occur because retrieval integrates the retrieved information with information that is already in long-term memory, thus relating it to prior knowledge and making subsequent retrieval easier than it would have been if it were not retrieved prior.

Retrieval has also been argued to be a special process that alters the accessibility of information in memory similar to the way in which sleep acts to consolidate memory (Antony, Ferreira, Norman, & Wimber, 2017). Antony, et al. (2017) claim that retrieval can act as a “fast consolidation” process that makes the retrieved information more recallable at long delays than information that is merely re-encountered or re-studied. Specifically, they argue that retrieval reactivates information in memory that is not only the target information itself, but other, related memories are well. This coactivation of related information with the target information serves to strengthen the target information’s recallability in memory, particularly when external cues to the memory may not be accessible (i.e., at longer time delays). Proponents of this theory would claim that retrieval goes above and beyond merely reactivating the context in which earlier information occurred—it fundamentally changes the retrieved information such that it becomes strengthened in memory.

Other work on the special nature of retrieval comes from research on retrieval-induced forgetting (RIF), which is the finding that recalling some information in memory causes the forgetting of other, related information (Anderson, Bjork, &

Bjork, 1994). Such forgetting effects are argued to be retrieval-specific; that is, simply being re-exposed to information is not enough to cause the non-re-exposed information to be forgotten (Anderson, Bjork, & Bjork, 2000). RIF effects are sometimes argued to be the result of inhibitory processes that act upon the non-retrieved information that competes for access with target information (Murayama, Miyatsu, Buchli, & Storm, 2014; Storm & Levy, 2012) and make non-retrieved information less recallable at the time of final test. Thus, retrieval can limit the accessibility of other information in memory while simultaneously strengthening the retrieved information.

Taken together, this body of work provides the basis for the idea that retrieving information can modify that information in ways that may have detectable effects on someone's ability to think of new ideas above and beyond restudying that information. While re-exposure through either retrieval or restudy may act to reinstate a context in which old (and potentially fixating) example ideas were encountered, retrieval may reinstate the context more strongly. Additionally, retrieval of old ideas may inhibit alternate search spaces and integrate fixation-inducing information in ways that restudy does not, thus revealing a stronger fixating effect on subsequent idea generation.

### **Comparing the Effect of Being Re-exposed to One's Own versus Someone Else's Ideas on Idea Generation**

In all of the studies of mental fixation described thus far, ideas, blockers, and examples have been presented to the participants with the intention of having some

effect (usually fixating) on their subsequent idea-generation and/or problem-solving ability. While it is true that people are often presented with examples to help their idea generation in the real world, this is not the only way in which people may encounter examples. In fact, people may rely on their own, older ideas as examples—particularly when they try to think of new ideas in multiple sessions. For example, a person trying to think of a spill-proof coffee cup may think of some ideas in one session, decide to take a break, and then return to the problem to try to think of more ideas. At their return, they may try to retrieve their initial ideas from memory (i.e., retrieval) or look them over on a sheet of paper (if they were written down; i.e., restudy) with the intention of using them as examples of ideas to improve on or avoid. While the research discussed thus far has clearly demonstrated that information presented to someone can cause fixation and hinder problem solving and idea generation, there have been no studies to date that examine the potential fixating effect of being re-exposed to (through retrieval or restudy) one's own, compared to someone else's, ideas. Based on prior work in the memory field, there is good reason to think that people generate ideas in ways that may be affected differently by re-exposure to their own versus someone else's ideas.

Though there is not much work that has examined how one's own ideas may or may not impede idea generation to-date, work on error generation in the context of tip-of-the-tongue states (TOT; the experience of knowing a word but being unable to produce it) provides some insight into the role retrieval may play in idea generation. In a study by Kornell and Metcalfe (2006), participants generated (i.e., retrieved from

memory) incorrect words in response to prompts that put them in TOT states, but such error production did not block access to the correct answers, compared to when they did not produce such errors. This finding contrasts with those of Smith and Blankenship (1991), who found that experimenter-provided blockers did indeed cause fixation and thus, less resolution of TOT states compared to when such blockers were not provided. These results point to the idea that self-retrieved, compared to externally-presented, information may have differential effects on the ability to think of new ideas. Because self-generated information is produced through the use of one's own memory structures, such information may serve as a mediator to access other helpful information stored in memory in ways that externally-presented information does not (Metcalfe, 2017).

While retrieval of one's own ideas has not been found to be detrimental to performance on a task with a single solution (i.e., the sought-after word in TOT states), it is not known how retrieval of one's ideas might influence their ability to think of ideas that are new and different from those earlier ideas (i.e., open-ended idea generation). There are good reasons to think that such findings may not generalize to tasks that require diverging from old ideas. In divergent thinking tasks, retrieving one's own ideas may actually facilitate new idea generation because the retrieval takes advantage of a person's idiosyncratic idea generation strategies in ways that retrieving someone else's ideas do not. Indeed, retrieving someone else's ideas may serve to hinder idea generation in a manner similar to collaborative inhibition in memory recall because someone else's output distracts from one's own

unique cognitive processing strategies (e.g., Wright & Klumpp, 2004). Given that there are reasons to suspect that re-exposure to one's own, versus someone else's, ideas may have differential effects on subsequent idea generation, the second extension goal of this dissertation was to investigate these potential differential effects.

## CHAPTER III

### The Present Studies

The three experiments conducted in this dissertation sought to answer the three theoretical questions outlined above: 1) whether retrieval of old ideas causes fixation in a divergent thinking task, 2) whether any observable effects are retrieval-specific, and 3) whether there is a difference between being re-exposed (through retrieval or restudy) to one's own, compared to someone else's, ideas. To investigate these questions, a modified version of the AUT was utilized in which participants were asked to either generate their own ideas in two separate phases (Experiment 1a), or to study examples from someone else and then generate their own ideas (Experiment 1b). Ideas from the first phase served as example ideas that were later 1) recalled from memory, 2) restudied, or 3) not interacted with at all (i.e., baseline) immediately before the second idea-generation phase in which participants were prompted to generate as many ideas as possible. It was predicted that re-exposure—whether through restudy or retrieval—to one's own initial ideas might not lead to observable fixation effects (Experiment 1a, based on the findings of Kornell & Metcalfe, 2006). However, it was predicted that re-exposure to someone else's ideas would result in observable fixation effects (perhaps through contextual reinstatement; Beda & Smith, 2018). Additionally, it was predicted that re-exposure through retrieval would result in the largest fixation effects, compared to re-exposure through restudy (Experiment 1b; e.g., Anderson, Bjork, & Bjork, 2000; Roediger & Karpicke, 2006; Rowland, 2014; Sara, 2000). Finally, Experiment 2 sought to maximize the



conditions under which retrieval would be expected to have an observable effect (different from an effect of restudy) on idea generation through 1) increasing the number of times old ideas were retrieved, and 2) inserting a delay between the re-exposure and second idea generation phase.

### **Experiment 1a**

The goals of Experiment 1a were twofold: 1) to determine whether re-exposure to one's own initial ideas affects the ability to generate new ideas, and 2) to test whether such effects are retrieval-specific. To these ends, participants completed an initial round of the AUT in which they were asked to generate four alternative uses for two common household objects within a short timeframe. They then completed a distractor task for 20 minutes before being re-exposed to their uses in one of three ways: 1) retrieving the uses, 2) restudying the uses, or 3) not being re-exposed to the uses at all (i.e., continuing with a different filler task; baseline). Finally, they were given a second short timeframe to generate as many new uses as possible for those same objects. Uses were then scored on three different characteristics: fluency, divergence from original ideas (i.e., the inverse of fixation), and creativity. It was predicted that re-exposure—regardless of whether it occurred through retrieval or restudy—to one's own ideas would not impair people's ability to produce new ideas that diverge from their own original ideas, or to produce many new ideas (i.e., they would not experience fixation), compared to when they are not re-exposed to their initial ideas. This is because idea generation based off of one's own thought process would not be negatively impacted by re-presenting the same ideas they already

produced through their personal cognitive strategies (Kornell & Metcalfe, 2006; Metcalfe, 2017). Creativity was measured as an additional variable of interest, but no specific predictions were made with regard to the creativity of the additional ideas relative to the initial ideas based on re-exposure.

### **Method.**

**Participants.** A power analysis based on a two-phase sampling procedure in which data from the first 15 participants were used to calculate final sample size determined that our experiment needed approximately 138 participants to detect a small effect size (Cohen's  $d = .3$ ) for the divergence measurement (the most critical comparison) with  $\alpha = .05$  and  $1 - \beta = .80$ . A total of 161 participants were recruited from the UCSC participant pool in a two-phase sampling procedure, where data from the first 15 participants were used in a power analysis (power set to 80%) to determine final sample size. The final sample size was 138, with data from 22 participants removed for one of two reasons: 1) failure to understand the instructions (i.e., the generated ideas were synonyms for or descriptions of, rather than uses for, the object; 18 participants), or 2) failure to generate four initial uses for an object (four participants). Participants in the final sample were between the ages of 18 and 32 ( $M_{age} = 20.28$ ,  $SD_{age} = 2.05$ ). No other demographic information about participants were collected. Informed consent was obtained as required by the Institutional Review Board, and participants were compensated partial credit in a psychology course for their participation.

**Design.** Experiment 1a utilized a three-level (idea re-exposure: retrieval vs. restudy vs. baseline), between-subjects design. A between-subjects design was used in order to avoid potential order effects that may have occurred as a result of experiencing the retrieval condition before the baseline or restudy conditions, as it is plausible that if participants were instructed to retrieve their ideas on their first trial, they may have tried to covertly retrieve their ideas on subsequent trials when they were not supposed to be doing so, which would confound the results of the experiment.

**Materials.** Materials for this study were adapted from the AUT, in which participants are asked to think of uses for common household objects. In Experiment 1a, participants were asked to think of uses for 1) a newspaper, and 2) a bucket (presented in a counterbalanced order), by writing them down on a lined sheet of paper. These objects were chosen specifically for this study because they have been used in prior studies in our lab utilizing the AUT and were shown to be the objects that participants were able to produce the most uses for (Ditta & Storm, 2017; Storm & Patel, 2014), and because they are both very different from each other in terms of shape and canonical use (i.e., generating uses for one object should not influence the manner in which ideas for the second object are generated).

**Procedure.** After obtaining informed consent, participants were told that the researchers are interested in understanding their ability to think. They were then familiarized with the AUT and given up to three minutes per object (presented one at a time) to generate four “alternative” uses for that object. The 3-minute timeframe

was chosen based on several studies in the literature utilizing similar time constraints and to ensure that participants had enough time to think of four uses (e.g., Baird, Smallwood, Mrazek, Kam, Franklin, & Schooler, 2012; Benedek, Mühlmann, Jauk, & Neubauer, 2014; Gilhooly, Fioratou, Anthony, & Wynn, 2007). The word “alternative” was explained to be any use that is different from the traditional or canonical use of the object (e.g., getting information, carrying water), and was chosen for this experiment to eliminate any demand characteristics that may arise when individuals are told to “be creative” (Harrington, 1975). After the 6-minute initial generation phase (3 minutes each for two objects), participants were told that they had finished that portion of the experiment, and that they would now be asked to recall their childhood home in as much detail as possible. They were instructed to take 5 minutes to either draw the floor plan of the house (and label the drawing), or to write down a description of the layout of the house (Jonker, Seli, & MacLeod, 2013; Sahakyan & Kelley, 2002). This imagination task was used to distance participants from their original ideas by creating an internal context shift (i.e., have participants think about something other than common uses for objects). After completing the imagination task, participants played Bubble Shooter (an online game that involves shooting a colored ball at matching colored balls to remove them from the screen) for 15 minutes as a filler task. This Bubble Shooter acted as a delay between the initial idea generation and the retrieval of the initial ideas, since retrieving immediately after generating ideas would have acted more as a rehearsal event, rather than a recall event.

After the 5-minute imagination task and 15-minute Bubble Shooter session (for a total delay of 20 minutes), participants were asked to interact with their original ideas in one of three ways: 1) to recall the ideas they generated by writing them down on a lined sheet of paper (e.g., “You will now be asked to recall the four uses you generated for [newspaper/bucket] earlier in the experiment”), 2) to restudy their ideas (e.g., “You will now be shown the four uses you generated for [newspaper/bucket] earlier in the experiment”), or 3) to not interact with their ideas at all (i.e., baseline; e.g., “You will now have 1 minute to work on a word search,” where the word search was unrelated to any other part of the experiment they had completed). Participants were given 1 minute to interact with their ideas, so that time was controlled across all three conditions. Finally, all participants were told that they would have a second chance to generate as many uses as possible for the same object. Participants were given 3 minutes for this additional generation phase, and no specific instructions were given regarding whether they were allowed to repeat the initial four uses during this phase. If participants asked, the experimenter repeated the instructions until the participant agreed to proceed, so the tendency to repeat ideas was not influenced by the experimenter in any way. After the three minutes, participants completed the same two steps again (i.e., retrieval/restudy/baseline plus additional generation for 3 minutes) for the second object. They were then thanked, debriefed, dismissed from the experiment, and awarded credit for participation.

***Results & discussion.*** Uses from the second idea generation phase were scored on a number of characteristics (divergence, creativity, and fluency, described

below), while uses from the first idea generation phase were scored for creativity only (since everyone was required to generate four uses, and these were the starting ideas against which divergence was measured). Because the main question of interest with regard to fixation was whether participants would be able to generate ideas in the second phase that are new and different (i.e., divergent) from the four they initially produced (or studied, in subsequent experiments), repetitions of any ideas from the initial idea generation session during the second session were excluded from all ratings and analyses for the measures of interest. Repetitions were identified by one of the raters, with ambiguities resolved by a second opinion.

**Initial ideas retrieved.** On average, participants in the retrieval condition successfully recalled 3.84 ( $SE = .04$ ) of their four initial ideas. Ten participants failed to recall one idea across both of their items (for a total of seven recalled ideas out of a possible eight), and two participants failed to recall one idea for each item. This high rate of recall is unsurprising given the fact that these were ideas participants generated themselves. When presented with the task, participants would likely write down what came to mind first and so when they are asked to recall their ideas, they are highly likely to come to mind again with little difficulty.

**Total output (repetitions included).** During the additional generation phase, participants generated 10.23 ( $SE = .48$ ), 8.62 ( $SE = .44$ ), and 10.87 ( $SE = .50$ ) ideas in the retrieval, restudy, and baseline conditions, respectively—a significant difference,  $F(2,135) = 5.98, p = .003, MSE = 10.34, \eta_p^2 = .08$ . Three Bonferroni-corrected pairwise comparisons revealed there to be a significant difference between restudy

and baseline,  $t(90) = 3.38, p = .001, d = .70$ , and between retrieval and restudy,  $t(90) = 2.45, p = .015, d = .51$ , but a nonsignificant difference between baseline and retrieval,  $t(90) = .93, p = .36, d = .19$ . Though this difference is significant, this effect was not predicted. This difference is driven by the difference in participants' likelihood of including repetitions of their initial four ideas, as detailed in the section below.

**Repetitions.** During the additional generation phase, participants generated 1.72 ( $SE = .25$ ), 0.97 ( $SE = .23$ ), and 2.28 ( $SE = .24$ ) repetitions in the retrieval, restudy, and baseline conditions, respectively—a significant difference,  $F(2,135) = 7.59, p = .001, MSE = 2.64, \eta_p^2 = .10$ . Three Bonferroni-corrected pairwise comparisons revealed there to be a significant difference between restudy and baseline,  $t(90) = 3.98, p < .001, d = .83$ , but a nonsignificant difference between retrieval and restudy,  $t(90) = 2.21, p = .03, d = .46$ , as well as baseline and retrieval,  $t(90) = 1.64, p = .11, d = .34$ . Though this difference is significant, this effect was not predicted, as described in the section above. It is difficult to interpret what such a significant difference in the rate of repetitions might mean, but it is possible that re-exposure via restudy changes the way in which people are likely to reproduce their original ideas later on. While this is a possibility, it is also possible that participants were merely reacting to demand characteristics of the task (i.e., thinking they were not “allowed” to repeat their initial ideas in the restudy condition, but not the retrieval and baseline conditions; based on participants asking whether repetitions were allowed in general before the second idea generation phase). Because re-exposure

was manipulated between-subjects, it is possible that participants in each condition reacted differently (on average) to the instructions for idea generation in the second phase, thus driving this difference in rate of repetitions.

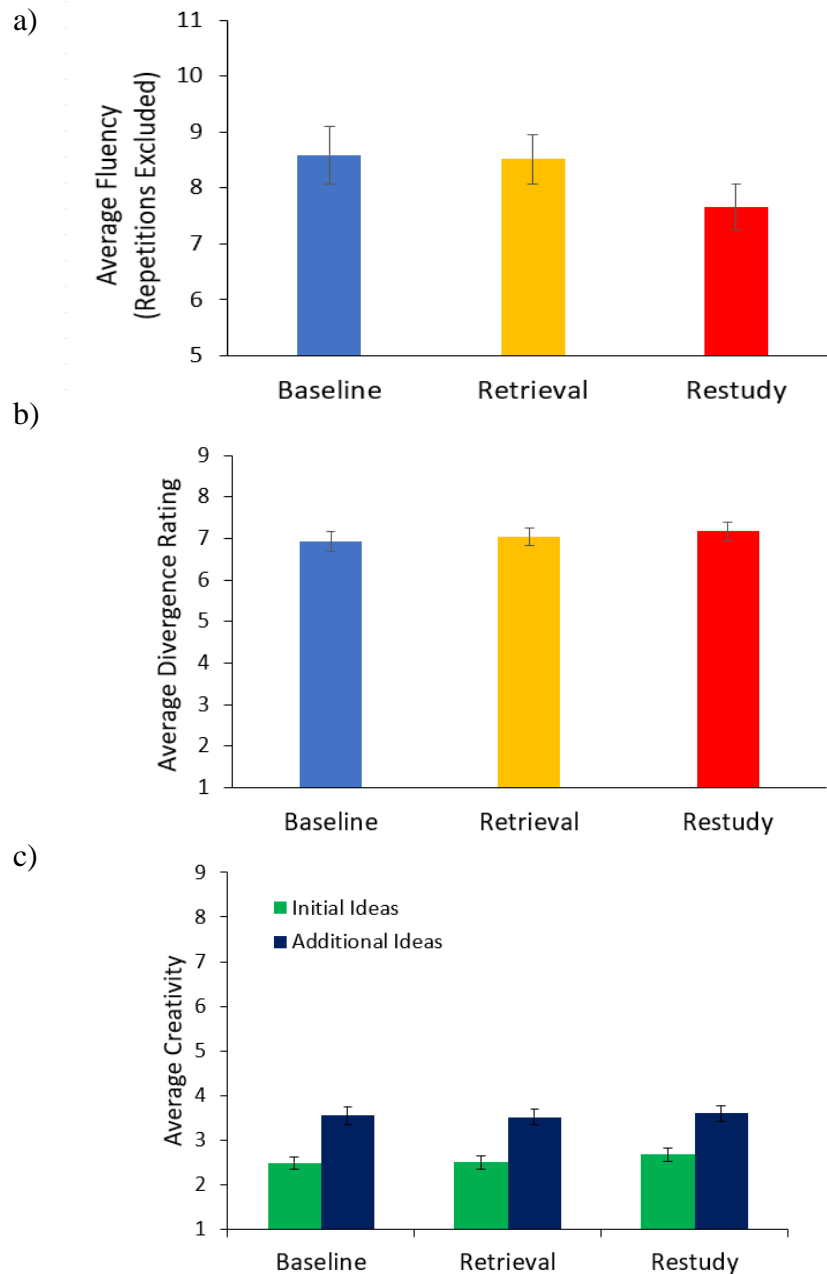
**Fluency of new ideas (repetitions removed).** Fluency was defined as the total number of new ideas generated in the second phase, with any repetitions of the initial four ideas excluded. During the additional generation phase, participants generated 8.51 ( $SE = 0.45$ ), 7.65 ( $SE = 0.42$ ) and 8.59 ( $SE = 0.51$ ) uses in the retrieval, restudy, and baseline conditions, respectively (see Figure 1). A one-way ANOVA on the re-exposure conditions (retrieval vs. restudy vs. baseline) determined this to be a nonsignificant difference,  $F(2,135) = 1.28$ ,  $p = .28$ ,  $MSE = 9.71$ ,  $\eta_p^2 = .02$ . These results suggest that there was no detectable difference in the number of novel ideas participants were able to produce as a function of being re-exposed (or not) to their old ideas.

**Divergence.** Divergence (i.e., the degree to which later ideas are different from earlier ideas; the inverse of fixation) was scored by asking a team of three independent raters to determine whether each use in the second generation phase has a meaning that is different from each of the four uses generated in the initial phase (adapted from similarity ratings used in Storm & Patel, 2014). The raters were instructed to consider whether the additional use had 1) a different overall purpose from the initial use, and/or 2) utilized a different part of the object compared to the initial use, with higher divergence ratings being assigned if both criteria were met. Divergence ratings for each of the additional uses were then averaged together and



across both objects in order to obtain a single divergence value for each participant. To obtain interrater reliability, all three raters were asked to rate the same set of 12 participants, and their results were compared. Reliability for divergence was high ( $\alpha = .80$ ), so the rest of the participants' data were randomized and evenly distributed across the three raters.

On average, divergence ratings across the re-exposure conditions were 7.04 ( $SE = .21$ ), 7.17, ( $SE = .22$ ), and 6.92 ( $SE = .24$ ) for retrieval, restudy, and baseline, respectively (See Figure 1). A one-way ANOVA revealed no significant effect of re-exposure on divergence,  $F(2,135) = .35$ ,  $p = .71$ ,  $MSE = 2.01$ ,  $\eta_p^2 = .01$ , indicating that participants did not exhibit differing levels of fixation as a function of re-exposure to their old ideas. This finding is in line with what was predicted, as there was no observable difference in the amount of fixation observed across re-exposure conditions. These results were likely observed due to the fact that as one's own ideas would come to mind regardless of the method of being re-exposed to them and thus would not be expected to cause fixation above and beyond participants' baseline levels of fixation. These findings are, however, in line with those of Metcalfe (2017) and Kornell and Metcalfe (2006), who found that retrieval of self-generated (incorrect) solutions to a problem was not detrimental to finding the correct solution. Thus, it is possible that re-exposure to one's own ideas does not cause observable fixation in a divergent thinking task.



*Figure 1.* Average fluency (number of new ideas generated, with repetitions removed) across the re-exposure conditions (a). Average divergence (difference of new ideas from original ideas, with repetitions removed) across the re-exposure conditions (b). Average creativity (compared to all uses generated in the entire experiment for that particular item) across the re-exposure conditions in the first and second idea generation sessions in Experiment 1a (c). Error bars reflect 1 standard error of the mean (SEM).

**Creativity.** Creativity was scored by instructing the same team of three independent raters to rate each use on a 1-9 scale (1 being very uncreative, and 9 being highly creative) by comparing these uses to how the object is used in everyday life, and to all the other uses in the sample for that object (Ditta & Storm, 2017; Storm & Patel, 2014). All uses were placed into the same spreadsheet and alphabetized, so that similar uses would receive similar creativity ratings. Again, reliability was good (particularly for creativity ratings;  $\alpha = .75$ ) so the same even distribution across the three raters was employed. Creativity ratings were provided both for the initial set of four ideas and all additional ideas.

Creativity ratings for the initial four ideas were 2.49 ( $SE = .15$ ), 2.67 ( $SE = .15$ ), and 2.48 ( $SE = .14$ ) for the retrieval, restudy, and baseline conditions, respectively, while creativity ratings for the additional ideas were 3.51 ( $SE = .17$ ), 3.59 ( $SE = .18$ ), and 3.54 ( $SE = .20$ ), respectively, indicating overall low levels of creativity across all ideas (See Figure 1). A 2 (idea generation session, within-subjects: initial vs. additional) x 3 (re-exposure, between subjects: retrieval vs. re-exposure vs. baseline) mixed ANOVA revealed a significant main effect of idea generation session, with creativity ratings being higher in the additional session ( $M = 3.55$ ,  $SE = .10$ ) than in the initial session ( $M = 2.55$ ,  $SE = .09$ ),  $F(1,135) = 145.88$ ,  $p < .001$ ,  $MSE = .47$ ,  $\eta_p^2 = .52$ . The ANOVA failed to find a main effect of re-exposure condition,  $F(2,135) = .24$ ,  $p = .79$ ,  $MSE = 2.06$ ,  $\eta_p^2 < .01$ , or the interaction,  $F(2,135) = .24$ ,  $p = .78$ ,  $MSE = .47$ ,  $\eta_p^2 < .01$ . These results are not surprising given other creativity research that typically finds that more creative ideas emerge later in the

thinking process (Beaty & Silvia, 2012; Christensen, Guilford, & Wilson, 1957; Parnes, 1961; Ward, 1969). These findings contribute to the replication of this robust effect in the literature.

### **Experiment 1b**

Given the (expected) null fixation findings in Experiment 1a, Experiment 1b sought to determine whether exposure to someone else's ideas causes fixation in a divergent-thinking task. It was predicted that re-exposure to someone else's ideas, compared to their own (Experiment 1a) would impair people's ability to diverge from those example ideas, compared to when they are not re-exposed to someone's ideas (i.e., they would experience fixation). Such fixation effects as a result of being shown someone else's ideas would replicate fixation effects demonstrated in the literature that emerge when people are presented with examples (e.g., Smith & Jansson, 1991; Smith, Ward, & Schumacher, 1993). It was additionally predicted that retrieval, compared with restudy, would impair people's ability to diverge from those example ideas (divergence) and produce more novel ideas (fluency) above and beyond that of the restudy condition, since retrieval would not only reinstate the original context that the ideas were studied in (Beda & Smith, 2018), but would also serve to alter the structure of the initial studied ideas in memory such that they are more difficult to deviate from (e.g., Sara, 2000). Again, creativity information was collected as an additional variable of interest.

## **Method.**

***Participants, design, & materials.*** Again, a final sample size of 138 participants was recruited from the UCSC participant pool based on the power analysis described in Experiment 1a ( $M_{age} = 20.01$ ,  $SD = 1.76$ ). The data from 12 additional participants were removed for various reasons including: failure to understand the experiment, failure to pay attention during the experiment, and failing to complete the experiment. The materials and experimental design (i.e., the three between-subjects re-exposure to initial ideas conditions) were the same as those used in Experiment 1a.

***Procedure.*** The procedure of Experiment 1b was identical to that of Experiment 1a, with one exception. During the initial idea phase, participants did not generate their own ideas; instead, they were shown the four initial ideas that the corresponding participant in Experiment 1a had generated. This yoked design was used to control for potential item effects of being shown examples selected by the researchers (e.g., the four most common or most creative, etc.). Participants were given 30 seconds per object to look over these four uses. The rest of the experimental procedure was the same as Experiment 1a.

***Results & discussion.*** Uses from the second idea generation phase were scored as described in Experiment 1a.

***Initial ideas retrieved.*** On average, participants in the retrieval condition successfully recalled 2.97 ( $SE = .12$ ) of the four studied initial ideas. This lower level of recall compared to that found in Experiment 1a is not surprising, given that

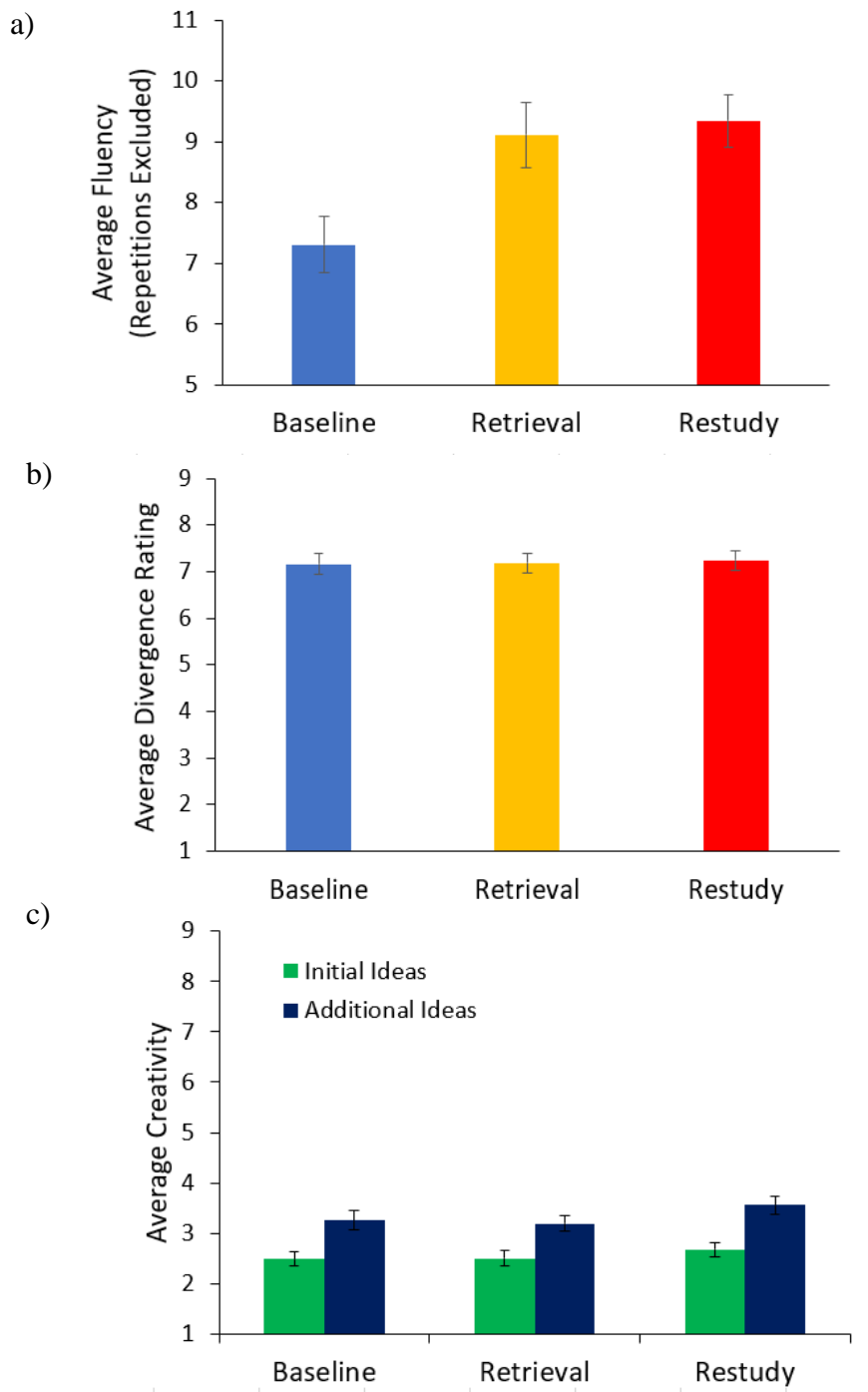
participants were being asked to recall information that they had only studied (for 30 seconds), compared to that which they had produced.

**Total output (repetitions included).** During the additional generation phase, participants generated 9.75 ( $SE = .57$ ), 10.30 ( $SE = .45$ ), and 9.51 ( $SE = .47$ ) ideas in the retrieval, restudy, and baseline conditions, respectively—a nonsignificant difference,  $F(2,135) = .67$ ,  $p = .52$ ,  $MSE = 11.43$ ,  $\eta_p^2 = .01$ . These results do not mirror those found in Experiment 1a, potentially indicating that total output is affected differently by re-exposure to one's own, versus someone else's, ideas. However, since a fixation effect on total output including repetitions was not the main focus of interest of this dissertation, such effects will require further investigation in additional studies.

**Repetitions.** During the additional generation phase, participants generated 0.64 ( $SE = .16$ ), 0.96 ( $SE = .24$ ), and 2.21 ( $SE = .21$ ) repetitions in the retrieval, restudy, and baseline conditions, respectively—a significant difference,  $F(2,135) = 16.21$ ,  $p < .001$ ,  $MSE = 1.95$ ,  $\eta_p^2 = .19$ . Three Bonferroni-corrected pairwise comparisons revealed there to be a significant difference between retrieval and baseline,  $t(90) = 5.89$ ,  $p < .001$ ,  $d = 1.23$ , as well as between restudy and baseline,  $t(90) = 3.94$ ,  $p < .001$ ,  $d = .82$ , but a nonsignificant difference between retrieval and restudy,  $t(90) = 1.10$ ,  $p = .28$ ,  $d = .23$ . These results are similar to those found in Experiment 1a (though the comparison between retrieval and baseline was significant here), providing more evidence that re-exposure to old ideas, compared to no re-exposure, may change the way in which people generate new ideas later on. Such

findings indicate that re-exposure may induce fixation such that people are more likely to reproduce someone else's old ideas when they encounter them again. However, as in Experiment 1a, these results are tentative given that such a difference in repetition was not predicted, and that such a difference could be the result of demand characteristics of the task (described in the "Repetitions" section of Experiment 1a). As such, the results presented here should be interpreted with caution.

**Fluency of new ideas (repetitions removed).** During the additional generation phase, participants generated 9.11 ( $SE = 0.54$ ), 9.35 ( $SE = 0.43$ ) and 7.30 ( $SE = 0.46$ ) uses in the retrieval, restudy, and baseline conditions, respectively (See Figure 2). A one-way ANOVA on the re-exposure conditions (retrieval vs. restudy vs. baseline) determined this to be a significant difference,  $F(2,135) = 5.4$ ,  $p = .006$ ,  $MSE = 10.65$ ,  $\eta_p^2 = .07$ . Three Bonferroni-corrected pairwise comparisons revealed there to be a significant difference between retrieval and baseline,  $t(90) = 2.53$ ,  $p = .01$ ,  $d = .53$ , as well as between restudy and baseline,  $t(90) = 3.24$ ,  $p = .002$ ,  $d = .68$ , but a nonsignificant difference between retrieval and restudy,  $t(90) = 0.35$ ,  $p = .73$ ,  $d = .07$ . These results mirror the repetition results, potentially indicating that when people are re-exposed to someone else's ideas, they become fixated on them such that they reproduce those ideas and then prematurely stop generating more ideas, even though they have the ability to do so when not re-exposed to those ideas. Such results are interesting and indicate a potential difference (across experiments) in the effect of being re-exposed to one's own, compared to someone else's, example ideas.



*Figure 2.* Average fluency across the re-exposure conditions (a). Average divergence across the re-exposure conditions (b). Average creativity across the re-exposure conditions in the first and second idea generation sessions in Experiment 1b (c). Error bars represent 1 SEM.



**Divergence.** Divergence ratings across the re-exposure conditions were 7.19 ( $SE = .21$ ), 7.24, ( $SE = .22$ ), and 7.16 ( $SE = .22$ ) for retrieval, restudy, and baseline, respectively (See Figure 2). As in Experiment 1a, a one-way ANOVA revealed no significant effect of re-exposure on divergence,  $F(2,135) = .04$ ,  $p = .96$ ,  $MSE = 1.85$ ,  $\eta_p^2 = .001$ , indicating that participants did not exhibit differing levels of fixation as a function of re-exposure to someone else's ideas. This finding goes against what was predicted and is especially surprising given the finding that fixation effects emerge as a result of retrieval practice of presented information (i.e., ideas being imposed on/provided to a person; e.g., Beda & Smith, 2018). Perhaps there is something different about the manner in which retrieval affects idea generation in convergent versus divergent thinking tasks, as Beda and Smith's findings were with the Remote Associates Task (a convergent measure of creativity).

**Creativity.** Creativity ratings for the initial four ideas were the same as in Experiment 1a, since they were the same ideas, with each set of four yoked to a participant in Experiment 1b. Creativity ratings for the additional ideas were 3.19 ( $SE = .16$ ), 3.56 ( $SE = .18$ ), and 3.26 ( $SE = .19$ ), respectively, indicating overall low levels of creativity across all ideas (See Figure 2). A 2 (idea generation session, "within"-subjects: initial vs. additional) x 3 (re-exposure, between subjects: retrieval vs. re-exposure vs. baseline) mixed ANOVA revealed a significant main effect of idea generation session, with creativity ratings being higher in the additional session ( $M = 3.34$ ,  $SE = .10$ ) than in the initial session ( $M = 2.55$ ,  $SE = .09$ ),  $F(1,135) = 37.80$ ,  $p < .001$ ,  $MSE = 1.13$ ,  $\eta_p^2 = .23$ . The ANOVA failed to find a main effect of

re-exposure condition,  $F(2,135) = 1.56, p = .21, MSE = 1.35, \eta_p^2 = .02$ , or the interaction,  $F(2,135) = .18, p = .83, MSE = 1.13, \eta_p^2 = .003$ . These results are again not surprising, as they replicate those found in Experiment 1a.

## **Experiment 2**

Surprisingly, no differences in the ability to generate divergent ideas emerged as a result of any type of re-exposure (including no re-exposure) to either one's own or someone else's ideas in Experiments 1a and 1b (though there was a significant effect on the ability to generate many novel ideas; fluency). However, it is possible that the conditions under which the effects of retrieval are expected to emerge were not manipulated strongly enough in the previous two experiments. For example, effects of retrieval are increased with increased retrieval practice; that is, the more times information is retrieved, the more recallable that information becomes, even spontaneously (e.g., Beda & Smith, 2018; Jacoby & Dallas, 1981). Additionally, effects of retrieval are sometimes not observed immediately; indeed, work on the testing effect suggests that the effects of retrieval relative to restudy emerge after a delay (e.g., Bjork, 1988; McDaniel & Fisher, 1991; McDaniel, Kowitz, & Dunay, 1989; Roediger & Karpicke, 2006). Finally, it is possible that the nature of the ideas shown to participants in Experiment 1b were not significantly different from the ideas that people would produce naturally—this is especially likely given that in the AUT, the most common ideas tends to be produced first (e.g., Gilhooly, Fiatorou, Anthony & Wynn, 2007). Thus, participants may have been exposed to examples that were too similar to what their own ideas would have been, thus minimizing the chance of

detecting a fixating effect on idea generation based on being exposed to examples that are not their own.

Given the above considerations, the purpose of Experiment 2 was to more strongly manipulate the conditions under which re-exposure through retrieval of someone else's ideas would be expected to have an effect on subsequent idea generation. Four changes were made to the design to address these issues: 1) the re-exposure manipulations were repeated multiple times instead of a single time, 2) a delay of one week was inserted between the re-exposure manipulation and final idea generation, and 3) extremely creative, statistically rare ideas from a prior study were presented to participants as example ideas, and 4) the effect of idea type and re-exposure were examined within the context of a single experiment utilizing a mixed-participants design, thus increasing power to detect effects if they exist. It was predicted that under these conditions, fixation effects as a result of re-exposure to someone else's ideas through retrieval would emerge. Additionally, it was predicted that re-exposure to someone else's ideas through restudy would have a fixating effect, though not to the same degree as retrieval, since restudy could reasonably be expected to reinstate the fixating context of the initial ideas (Beda & Smith, 2018). Finally, it was predicted that no differential effects of re-exposure would be observed when participants were shown their own ideas.

### **Method.**

*Participants.* A power analysis determined that our experiment needed approximately 64 participants to detect a small effect size (Cohen's  $d = .3$ ) for the

interaction between re-exposure and idea type for the divergence measurement (the most critical comparison) with  $\alpha = .05$  and  $1 - \beta = .80$ . A total of 72 participants ( $M_{age} = 19.69$ ,  $SD = 2.42$ ) were recruited from the UCSC participant pool in order to properly counterbalance across the conditions of the experiment. All participants were compensated partial course credit for their participation.

**Design.** Experiment 2 utilized a 2 (idea type: own vs. other) x 3 (idea re-exposure: retrieval, restudy, baseline) mixed factorial design, with idea type manipulated between participants and idea re-exposure manipulated within participants to increase power.

**Materials.** Materials for this study were the same as those used in Experiment 1a and 1b, though a third object (spoon) was added to this experiment so that each object was in one of the three re-exposure conditions for each participant. This third object was chosen in the same manner as the previous two—it was used in the same previous experiment in the lab that newspaper and bucket were drawn from, and it was the object that participants produced the third-highest number of uses for in that previous experiment.

For the ideas presented to participants in the other-ideas condition, four uses were chosen from Experiments 1a and 1b (newspaper and bucket) and a previous experiment in the lab (spoon) that were deemed highly creative, in order to identify a set of uses that would be unlikely to come to participants' minds naturally. This was done to maximize the likelihood of fixation occurring, in order to be able to detect a difference in fixation based on the re-exposure manipulations. Uses from the prior

data sets were deemed highly creative if they received a creativity rating of 9 (the highest on the scale) and were produced in the entire dataset for that object only once. In the event that more than four uses met these criteria, a set of four were randomly selected from the set.

***Procedure.*** Experiment 2 was conducted in two sessions, separated by a week delay. In the first session, participants were acquainted with the AUT as described in Experiment 1a. They were then asked either to generate (own ideas condition) or study (other ideas condition) four uses per each of the three objects, with the order of the objects held constant (newspaper, bucket, spoon). Participants had 90 seconds to complete this portion of the experiment, though time was extended for the participants in the own-ideas condition ( $n = 9$ ) who failed to produce four uses within the timeframe. Next, participants completed the imagination task and Bubble Shooter filler task as in Experiments 1a and 1b. After the 20-minute filler period, participants experienced all three of the re-exposure manipulations (retrieval, restudy, baseline), with one manipulation per object. For example, a participant in the own-ideas condition may have been asked to retrieve their original ideas for newspaper, to restudy their original ideas for bucket, and to do nothing (i.e., complete an unrelated word search) with their original ideas for spoon. This order of events was repeated three times, with each manipulation lasting 30 seconds—this was done in order to strengthen the manipulation, as done with multiple rounds of retrieval in testing-effect paradigms (e.g., Roediger & Karpicke, 2006). Participants in the other-ideas condition experienced this same set of events, though they were asked to retrieve,

restudy, or do nothing with the ideas they had studied instead of ideas they generated. Order of the re-exposure manipulations was counterbalanced across participants, while order of the objects was held constant. Upon completion of the re-exposure manipulations, participants were thanked for their time and reminded that they should return in one week to complete the experiment.

Participants returned approximately one week later (three participants returned a few days past one week due to scheduling conflicts) to complete session two of the experiment. During this session, participants were given three minutes to think of as many alternative uses as possible for each of the three objects they had seen in session 1. The experimenter did not mention any of the ideas that the participants had produced or studied in session 1. Upon completion of the experiment, participants were thanked, debriefed, and compensated for their participation in the experiment.

**Results & discussion.** Uses from the first and second idea generation phase were scored as described in Experiments 1a and 1b, though the creativity ratings of the ideas that were shown to participants in the other-ideas condition were at ceiling (9) as described in the Method, above.

**Initial ideas retrieved.** On average, participants in the own-ideas retrieval condition successfully recalled 3.57 ( $SE = .10$ ) of their four initial ideas, while participants in the other-ideas condition successfully recalled 3.13 ( $SE = .14$ ). An independent-samples t-test revealed this to be a significant difference,  $t(70) = 2.61$ ,  $p = .01$ ,  $d = .62$ . Given that participants were being asked to recall ideas they

personally generated, compared to ideas presented to them, this significant difference in recall rates is not surprising.

**Total output (repetitions included).** During the additional generation phase, participants in the own-ideas condition generated 9.67 ( $SE = .61$ ), 9.86 ( $SE = .39$ ), and 9.67 ( $SE = .57$ ) ideas in the retrieval, restudy, and baseline conditions, respectively. Participants in the other-ideas condition generated 10.89 ( $SE = .72$ ), 10.44 ( $SE = .66$ ), and 10.14 ( $SE = .73$ ) ideas in the retrieval, restudy, and baseline conditions, respectively. A 2 (idea type: own-ideas vs. other-ideas) x 3 (re-exposure: retrieval, restudy, baseline) mixed ANOVA did not reveal a main effect of idea type,  $F(1,70) = 1.11, p = .30, MSE = 27.99, \eta_p^2 = .02$ , or re-exposure,  $F(2,140) = .37, p = .69, MSE = 7.11, \eta_p^2 = .005$ , and failed to find a significant interaction,  $F(2, 140) = .42, p = .66, MSE = 7.11, \eta_p^2 = .006$ . These results suggest that total output was not differentially affected by different types of re-exposure to either one's own or someone else's ideas.

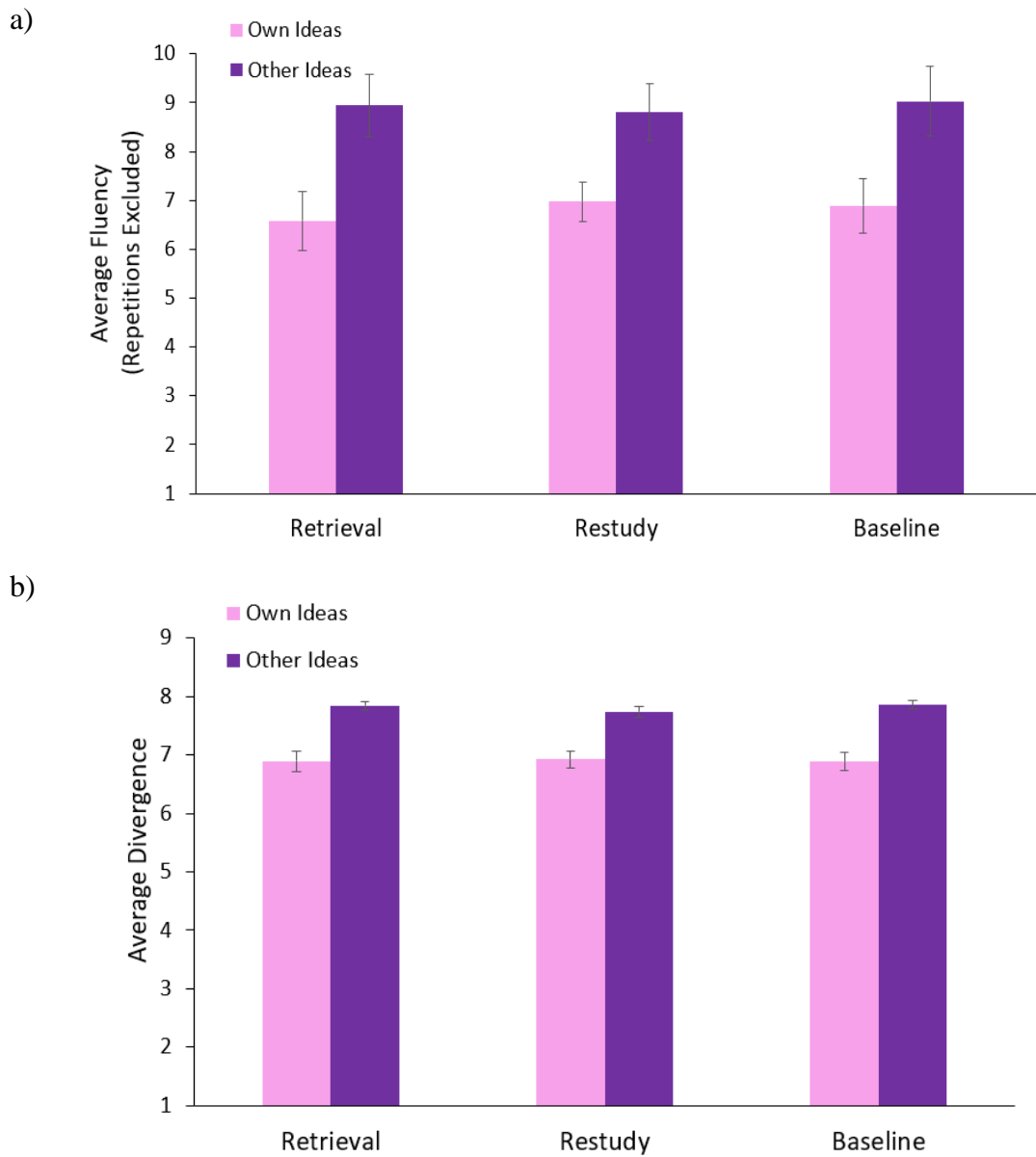
**Repetitions.** During the additional generation phase, participants in the own-ideas condition generated 3.08 ( $SE = .16$ ), 2.89 ( $SE = .16$ ), and 2.78 ( $SE = .21$ ) repetitions in the retrieval, restudy, and baseline conditions, respectively. Participants in the other-ideas condition generated 1.94 ( $SE = .22$ ), 1.64 ( $SE = .23$ ), and 1.11 ( $SE = .19$ ) repetitions in the retrieval, restudy, and baseline conditions, respectively. A 2 (idea type: own-ideas vs. other-ideas) x 3 (re-exposure: retrieval, restudy, baseline) mixed ANOVA revealed a main effect of idea type, with more repetitions produced in the own-ideas condition ( $M = 2.92, SE = .14$ ) compared to the other-ideas condition,

( $M = 1.56, SE = .18$ ),  $F(1,70) = 35.71, p < .001, MSE = 2.76, \eta_p^2 = .34$ , as well as a main effect of re-exposure,  $F(2,140) = 8.66, p < .001, MSE = .68, \eta_p^2 = .11$ .

Bonferroni-corrected pairwise comparisons revealed that the retrieve ( $M = 2.51, SE = .15$ ) and restudy ( $M = 2.26, SE = .16$ ) conditions were significantly different from baseline ( $M = 1.94, SE = .17$ ),  $t(71) = 3.79, p < .001, d = .42$ ;  $t(71) = 2.56, p = .01, d = .23$ , but that the retrieve and restudy conditions were not significantly different from each other,  $t(71) = 1.81, p = .07, d = .19$ . The interaction between re-exposure and idea type failed to reach significance,  $F(2, 140) = 2.06, p = .13, MSE = .68, \eta_p^2 = .03$ . Given the within-participants design of the study, it is more possible to draw conclusions about what the main effect of re-exposure means. Participants who are re-exposed to their ideas, regardless of whether they are their own or someone else's, tend to re-produce those ideas when they are given a second chance to think of new ideas, compared to participants who are not re-exposed to ideas. This can be considered a form of fixation, then, in which re-exposure in any form may lead to an increased likelihood of old ideas coming to mind and being output. The main effect of own versus other ideas in producing repetitions is difficult to draw conclusions about, however, since it is between-subjects, but it could be possible that people are more likely to repeat their own ideas than someone else's ideas—perhaps because they are more memorable, as described in the section above. It is especially promising that these results are similar to those found in Experiments 1a and 1b, as this replication may provide the foundation for future studies of fixation in divergent thinking which has so far been difficult to observe.



**Fluency of new ideas (repetitions removed).** During the additional generation phase, participants in the own-ideas condition generated 6.58 ( $SE = .61$ ), 6.97 ( $SE = .40$ ), and 6.89 ( $SE = .55$ ) ideas in the retrieval, restudy, and baseline conditions, respectively. Participants in the other-ideas condition generated 8.94 ( $SE = .64$ ), 8.81 ( $SE = .57$ ), and 9.03 ( $SE = .71$ ) ideas in the retrieval, restudy, and baseline conditions, respectively (See Figure 3). A 2 (idea type: own-ideas vs. other-ideas) x 3 (re-exposure: retrieval, restudy, baseline) mixed ANOVA revealed a main effect of idea type, with the number of additional ideas generated after being exposed to other ideas ( $M = 8.93$ ,  $SE = .56$ ) being higher than the number of additional ideas generated after being exposed to one's own ideas ( $M = 6.81$ ,  $SE = .35$ ),  $F(1, 70) = 10.14$ ,  $p = .002$ ,  $MSE = 23.73$ ,  $\eta_p^2 = .13$ . However, neither the main effect of re-exposure,  $F(2, 140) = .10$ ,  $p = .90$ ,  $MSE = 6.91$ ,  $\eta_p^2 = .001$ , or the interaction were significant,  $F(2, 140) = .18$ ,  $p = .83$ ,  $MSE = 6.91$ ,  $\eta_p^2 = .003$ . These results complement those described above with regard to repetitions, as participants in the own-ideas condition were more likely to repeat their original ideas, thus reducing their fluency count later on, compared to participants in the other-ideas condition. Participants in the own-ideas condition may have been content to reproduce their original ideas and stop generating, while those in the other-ideas condition could not remember the ideas they had been re-exposed to as well, thus leading them to output more novel ideas. Interestingly, this effect was not significant across re-exposure type (as it was with repetitions), suggesting that different re-exposure types may not



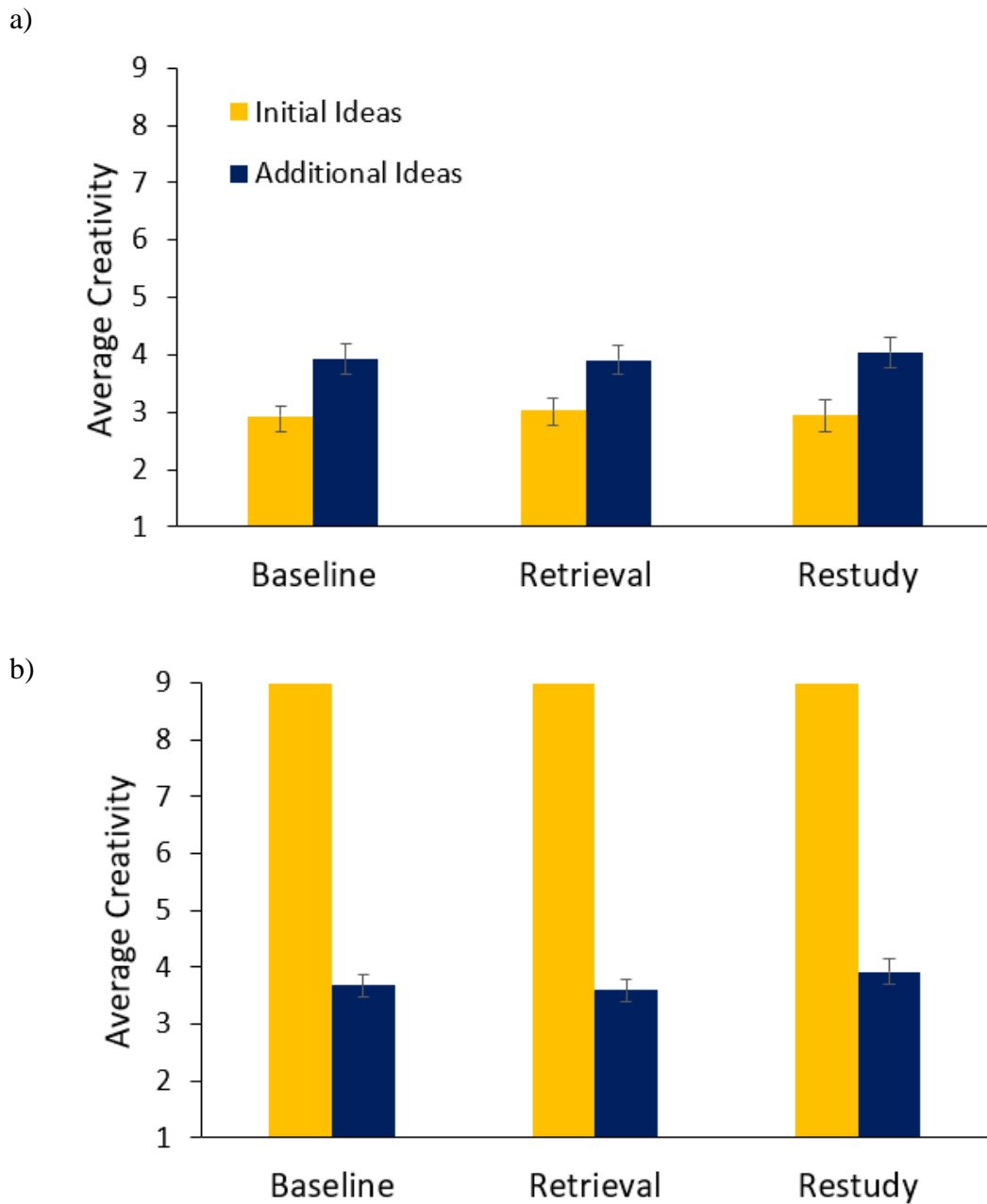
*Figure 3.* Average fluency across the re-exposure conditions (a) and average divergence across the re-exposure conditions (b) as a function of being shown one's own versus someone else's (highly creative) ideas in Experiment 2. Error bars represent 1 SEM.

differentially affect the ability to produce ideas later on. Instead, it may be whether participants are asked to review their own versus someone else's ideas that may affect total idea output. Additionally, the significant fluency effect of both re-exposure conditions, compared to baseline, found in Experiment 1b did not replicate here, further complicating the results. Such results provide fertile ground for future research in fixation in divergent-thinking tasks.

**Divergence.** Divergence ratings across the re-exposure conditions for participants in the own-ideas condition were 6.89 ( $SE = .17$ ), 6.92 ( $SE = .15$ ), and 6.89 ( $SE = .15$ ) in the retrieval, restudy, and baseline conditions, respectively (See Figure 3). Participants in the other-ideas condition had divergence ratings of 7.84 ( $SE = .07$ ), 7.74 ( $SE = .09$ ), and 7.85 ( $SE = .07$ ) in the retrieval, restudy, and baseline conditions, respectively. A 2 (idea type: own-ideas vs. other-ideas) x 3 (re-exposure: retrieval, restudy, baseline) mixed ANOVA revealed a main effect of idea type, with divergence from other ideas ( $M = 7.81$ ,  $SE = .04$ ) being higher than divergence from own ideas ( $M = 6.90$ ,  $SE = .10$ ),  $F(1, 70) = 70.91$ ,  $p < .001$ ,  $MSE = .63$ ,  $\eta_p^2 = .50$ . However, neither the main effect of re-exposure,  $F(2, 140) = .06$ ,  $p = .94$ ,  $MSE = .52$ ,  $\eta_p^2 = .001$ , or the interaction were significant,  $F(2, 140) = .21$ ,  $p = .81$ ,  $MSE = .52$ ,  $\eta_p^2 = .003$ . This set of findings goes against what was predicted in that there was no differential effect of retrieval of old ideas on the subsequent generation of new and divergent ideas. Even more surprising is the counterintuitive finding that people were able to diverge more from ideas presented to them, compared to their own ideas;

however, this is likely due to the nature of the task. Participants were presented with highly creative ideas that very few people in an earlier sample produced. Thus, the more common ideas they produced when given the chance to generate their own ideas seemed very different from the presented set of examples.

**Creativity.** Creativity ratings for the initial four ideas for participants in the own-ideas condition were 2.93 ( $SE = .18$ ), 3.02 ( $SE = .21$ ), and 2.94 ( $SE = .27$ ), for retrieval, restudy, and baseline, respectively. Creativity ratings for the initial four ideas for participants in the other-ideas condition were at ceiling (average rating of 9) due to the way in which they were selected, and the same across conditions since the idea sets for each object were counterbalanced across conditions. Creativity ratings for the additional ideas for participants in the own-ideas condition were 3.92 ( $SE = .26$ ), 3.91 ( $SE = .25$ ), and 4.04 ( $SE = .27$ ), for retrieval, restudy, and baseline, respectively. Creativity ratings for the additional ideas for participants in the other-ideas condition were 3.68 ( $SE = .20$ ), 3.60 ( $SE = .19$ ), and 3.92 ( $SE = .23$ ) for retrieval, restudy, and baseline, respectively (See Figure 4). Given the unique nature in which initial ideas were selected for the other-ideas condition (average rating for the initial ideas was at ceiling), a 2 (idea type, between-subjects: own vs. other) x 3 (re-exposure, within-subjects: retrieval vs. re-exposure vs. baseline) ANCOVA controlling for initial idea rating was conducted. The ANCOVA revealed no main effects of either idea type,  $F(1, 69) = 3.25, p = .08, MSE = 2.40, \eta_p^2 = .05$ , or re-exposure,  $F(2, 138) = 1.41, p = .25, MSE = 2.52, \eta_p^2 = .02$ , and no significant interaction,  $F(2, 138) = 1.39, p = .25, MSE = 1.79, \eta_p^2 = .02$ . Additionally, a 3 (re-



*Figure 4.* Average creativity across the three re-exposure conditions as a function of the first and second (initial vs. additional) idea generation sessions after being re-exposed to one's own ideas (a), or someone else's (highly creative) ideas (b). Legend shown in (a) applies to both graphs. Error bars represent 1 SEM.

exposure: retrieval vs. restudy vs. baseline) x 2 (idea generation session: initial vs. additional) within-subjects ANOVA was run on the own-ideas condition, to determine whether the increased creativity ratings of the additional ideas compared to initial ideas results from Experiments 1a and 1b replicated. Indeed, creativity ratings for ideas in the additional session were higher ( $M = 4.00, SE = .26$ ) than for ideas in the initial session ( $M = 2.96, SE = .22$ ),  $F(1, 35) = 32.79, p < .001, MSE = 1.63, \eta_p^2 = .48$ . There was no main effect of re-exposure condition,  $F(2, 70) = .03, p < .97, MSE = 2.75, \eta_p^2 = .001$ , and the interaction was not significant,  $F(2, 70) = .138, p = .87, MSE = 1.46, \eta_p^2 = .004$ . Finally, a one-way within-subjects ANOVA was conducted on the re-exposure condition (retrieval vs. restudy vs. baseline) for the additional ideas in the other-ideas condition. The effect was not significant,  $F(2, 70) = .85, p = .43, MSE = 1.16, \eta_p^2 = .02$ . Together, these findings replicate those found in Experiments 1a and 1b—people are able to produce more creative ideas in the second session, regardless of the idea type and re-exposure they experienced. These findings additionally replicate the broader literature that has found that creativity of ideas increases as people generate more ideas (e.g., Beaty & Silvia, 2012).

## CHAPTER VII

### General Discussion

This dissertation set out to answer several questions regarding the role of retrieval of initial ideas (i.e., examples) in affecting people's ability to generate ideas in a divergent-thinking task. First, it sought to determine whether retrieval of examples is a mechanism through which people might experience fixation—and thus experience a decrease in their ability to generate novel and divergent ideas (compared to their initial ideas) after such retrieval—in a divergent-thinking task. Second, it sought to determine whether such a fixating effect is retrieval-specific; that is, is retrieval the mechanism that causes fixation, or is it re-exposure to ideas more broadly? Finally, it sought to determine whether there was a differential effect of being re-exposed to one's own, compared to someone else's, example ideas. Together, this dissertation was designed to replicate and extend a well-replicated finding in the literature (i.e., mental fixation), but also investigate theoretically-driven boundary conditions on the effect of retrieval on people's ability to think of new ideas.

Together, all three experiments were unable to find a consistent fixating effect of retrieval of example ideas on subsequent novel and divergent idea-generation ability in a divergent-thinking task. The one exception was in the case of fluency (repetitions removed), in Experiments 1b and 2. In both experiments, significant effects of re-exposure to ideas influenced fluency rates, though in different ways. In Experiment 1b, both retrieval and restudy of someone else's example ideas resulted in

participants generating more novel ideas compared to baseline, but in Experiment 2, being re-exposed to someone else's ideas led to an overall increase in fluency, but no differential effects of re-exposure compared to baseline. Though these effects were significant, the inconsistent pattern of findings across experiments makes interpreting these findings difficult.

In general, the lack of findings stands in contrast with findings on retrieval causing fixation in convergent-thinking tasks (Beda & Smith, 2018) and the fixating effect of examples in divergent-thinking tasks more generally (e.g., Jansson & Smith, 1991; Smith, Ward, & Schumacher, 1993). Such results are surprising, given that experiments investigating the effect of examples on idea generation have revealed some effect of exposure to the examples, whether fixating (e.g., Cardoso & Badke-Schaub, 2011; Chrysikou & Weisberg, 2005; George, Wiley, Koppel, & Storm, 2017; Kohn & Smith, 2011; Landau & Leynes, 2004; Marsh, Landau, & Hicks, 1996) or facilitating (e.g., Agogu e, et al., 2014; Dugosh & Paulus, 2005; Dugosh, Paulus, Roland, & Yang, 2000). Despite the fact that retrieval of examples is thought to reinstate fixating contexts (Beda & Smith, 2018) and impair problem-solving ability in a convergent-thinking task, such results were not found in this series of studies utilizing a divergent-thinking task.

More interestingly, all three experiments were unable to find a differential consistent fixating effect of retrieval, compared to restudy, of old ideas on the ability to generate novel and divergent ideas. These findings, too, stand in contrast to prior literature that 1) demonstrates an effect of retrieval on creative thinking (Beda &



Smith, 2018), and 2) shows that retrieving information from memory makes it more memorable than merely restudying the information (e.g., e.g., Anderson, Bjork, & Bjork, 2000; Roediger & Karpicke, 2006; Rowland, 2014). Even though retrieval has been shown to reinstate fixating context, integrate fixating information in mind such that the retrieved information is more recallable than it would be otherwise, and inhibit alternative search spaces, compared to restudying the same information, such a differential effect on generating novel and divergent ideas was not found here. Perhaps the most surprising finding is that even when conditions under which retrieval of example ideas would be expected to have an effect were maximized through having participants engage in repeated retrieval, showing participants highly unusual example ideas, and having the idea generation phase at a delay from retrieval practice, no such effect on subsequent idea generation was found (Experiment 2).

Finally, all three experiments were unable to find a differential consistent fixating effect of being re-exposed to one's own, compared to someone else's, ideas on subsequent novel and divergent idea generation. Such findings are in line with the currently-proposed idea that one cannot become fixated on self-generated ideas because the ideas that come to mind naturally 1) take advantage of one's idiosyncratic cognitive processing strategies, and 2) are the ideas that would always come to mind naturally and would always cause some level of fixation (compared to ideas that are presented to someone, which may induce fixation above and beyond fixation experienced from one's own ideas; Kornell & Metcalfe, 2006; Metcalfe, 2017). However, these findings are not able to account for the wide body of literature that

argues that externally-presented ideas do cause fixation in idea-generation and problem-solving tasks (e.g., Beda & Smith, 2018; Jansson & Smith, 1991; Smith & Blankenship, 1989; 1991; Smith, Ward, & Schumacher, 1993). Though the experiments described here were not able to detect a differential effect of being re-exposed to one's own, compared to someone else's, ideas, no studies to date have attempted to directly make this comparison between the effect of (re-)exposure to self-generated versus externally-presented ideas, so this dissertation is an important first step toward addressing this theoretical debate about fixation as a result of (re-)exposure to examples.

Taken together, the results from these three experiments failed to find an effect of re-exposure to ideas on the ability to generate new ideas, even when those ideas come from someone else, when they are repeatedly retrieved, and when the idea-generation opportunity is at a delay from the re-exposure—conditions under which a negative, fixating effect of retrieval of example ideas would theoretically be expected to be observed. Such results are surprising because they stand in contrast to similar work on convergent thinking. However, it is worth noting that there may be a hint of a fixating effect that was revealed in these experiments. In all experiments, there was a significant difference in the number of repetitions of initial ideas that participants in the re-exposure conditions produced (though the significant effect was different across experiments). It is possible that re-exposure to ideas may affect people's likelihood to reproduce their original ideas, which can be considered a kind of fixation. However, no predictions were made about repetitions, and the results are

inconsistent across experiments, so it would be premature to make any claims about these findings. The results found here are potentially informative for future experiments in the creative cognition field moving forward.

That said, there may be some alternative explanations for the results observed in the current set of experiments. For example, the lack of an observable effect of re-exposure to example ideas could have been due to the manner in which fixation was measured, as a new measure of fixation was implemented for this set of experiments. Fixation was measured as its inverse—divergence, or the ability to be as different as possible from the previous examples. Given that the measure of fixation (i.e., divergence) used here relies on the comparison between the earlier and later set of ideas, it did not make sense within the structure of the experiment to have a true baseline condition in which participants were never exposed to examples. Thus, it remains possible that being shown examples does fixate people compared to when they do not view any examples at all. The results presented here can only clearly state that there are no observable differences in people's ability to diverge from example ideas as a function of the way in which they are re-exposed to those ideas—whether through retrieval, restudy, or not being re-exposed to them at all.

Additionally, it is possible that the results obtained here are a function of the quality of examples presented to participants. For example, the example ideas were generated by participants with no guidance other than to produce a set of four ideas. The resulting example sets were almost always composed of very different ideas, with little similarity between each example. This is in contrast to how many studies

of fixation have been designed, in which the example sets all share the same core set of features (e.g., all aliens had four legs, antennae, and a tail in the study by Smith, Ward, & Schumacher, 1993). Thus, is it possible for fixation to be observed when the set of example ideas is not homogeneous? Perhaps the (new) method used to measure fixation (i.e., rating divergence) is not sensitive enough to detect fixation, but it is also possible that people do not experience fixation on idea sets that do not share a noticeable theme or set of features. Future work should be aimed at addressing these alternative explanations in order to determine whether retrieval truly does not have an observable fixating effect on people's idea generation ability.

### **Concluding Comments**

Together, the findings from this dissertation failed to provide evidence that retrieval of example ideas—whether one's own, or someone else's—acts as a mechanism that affects people's ability to generate novel and divergent ideas in a divergent-thinking task. Such results are surprising and stand in contrast to a wide body of literature on mental fixation, creative cognition, convergent and divergent thinking, and memory retrieval. Though more work will need to be conducted to determine whether re-exposure to ideas may in some cases have an effect on subsequent idea generation ability in the context of divergent thinking, this dissertation has offered the first investigation into this field. The work presented here paves the way for nuanced future investigations of the role of retrieval in divergent thinking processes.

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