Level of Constraint Influences the Generation Effect for Younger but not Older Adults

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MPM

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CSIM	Conditional Source Identification Measure
FSG	Forward Cue to Target Association Strength

SUMMARY

The generation effect is the memory benefit for information that is self-generated compared to information that is passively perceived from another source. This effect has been reliable in both younger and older adults for item memory (i.e., memory for the "content" of information), but less consistent for context memory, such as source memory (i.e., memory for the source of where information was obtained). Our recent work in younger adults, however, has shown the generation effect can be enhanced when there are fewer experimental constraints placed on what participants can generate. In other words, materials generated under fewer constraints are better remembered than materials generated with more constraints (where participants are limited to generate a single, correct response). This study examined how the level of generation constraint impacts the memory benefits of self-generation in younger and older adults. In this study the item and context memory benefits of a lower-constraint (e.g., free response to cue) and higher-constraint (e.g., solving an anagram) generation task are compared to a read control task. Both younger and older adults showed improved item and context memory for generated materials over read controls, consistent with the standard generation effect. However, when comparing the two generation tasks, the level of generation constraint influenced the memory benefits for younger adults, but older adults showed equivalent memory for both generation tasks. These findings are in line with reality monitoring work that suggests older adults show an impoverished ability to differentiate between the two sources of internally generated information, but can still experience a memory benefit from self-generation.

I. INTRODUCTION

A. **Background**

It is well known that advancing age is accompanied by a decline in memory function (Craik, 2000; Craik & Jennings, 1992; Zacks, Hasher, & Li, 2000). However, some research suggests that not all types of memory decline in the same way. For instance, research has shown that even when younger and older adults show equivalent memory for the general content of information (i.e., item memory), older adults still show memory deficits for contextual details associated with that information (i.e., context memory; Balota, Dolan, & Duchek, 2000; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991; Spencer & Raz, 1995). As an example, an older adult might be able to remember the information that “Exercising is good for your heart,” but they have difficulty remembering whether they heard this information from their doctor, a friend, or a television show. This particular type of context memory known as *source memory,* or discriminating between two or more sources of information, declines with age (Schacter et al., 1991; Spencer & Raz, 1995). However, there is some evidence that certain strategies may be used to combat these memory declines commonly associated with advancing age (Dunlosky & Hertzog, 1998; Hertzog, McGuire, & Lineweaver, 1998).

One particular strategy that has been shown to improve memory in younger and older adults alike is self-generation. Research has shown that information that is self-generated is better remembered than information that is otherwise not generated by the self, which has become known as the generation effect (Jacoby, 1978; Mitchell, Hunt, & Schmitt, 1986; Multhaup & Balota, 1997; Slamecka & Graf, 1978). A large body of work has shown that this effect is robust across a variety of memory tests (i.e., recall, recognition) and generation procedures for both age groups (see Bertsch, Pesta, Wiscott, & McDaniel, 2007, for a review).

Although this work has been useful in better understanding the generation effect, the majority of these studies have used methods that place experimental constraints on what participants can self-generate. That is, participants are constrained to generate a certain “correct” response. As an example, in the typical generation effect paradigm, participants are asked to generate words based on some rule, such as solving an anagram (e.g., open - cosle; Geghman & Multhaup, 2004). Memory for these words is then compared to a control condition in which participants simply read word pairs (e.g., hot – cold). Words presented in the generate condition are often better remembered than words that are read. However, the downside of using a generation task in which participants are constrained (e.g., open – cosle) is that it might limit the memory benefits from self-generation. Indeed, my recent work has shown that a generation task with fewer constraints (in which the participant freely responds to a cue word) often leads to better memory compared to commonly used higher-constraint generation tasks in younger adults (McCurdy, Leach, & Leshikar, 2017). Furthermore, this effect was most robust and consistent for context memory. Therefore, in the present study I directly tested whether a lower-constraint generation task might also improve the generation effect over a higher-constraint task for older adults.

Prior work on the generation effect for younger adults has primarily focused on the *item memory* benefits from self-generation. These effects have been widely reported across a variety of methods and memory tests including both recognition (Graf, 1982; McElroy & Slamecka, 1982; McFarland, Frey, & Rhodes, 1980) and recall (Donaldson & Bass, 1980; Jacoby, 1978). However, more recent work has explored whether the generation effect also extends to other types of memory details, such as *context memory*. Prior work for younger adults in this domain has been mixed, with some providing evidence that self-generation improves context memory over controls (Geghman & Multhaup, 2004; Marsh, 2006; Marsh, Edelman, & Bower, 2001), while others show impairments or no context memory benefits from self-generation compared to controls (Jurica & Shimamura, 1999; Mulligan, 2004, 2011; Riefer, Chien, & Reimer, 2007).

Interestingly, unlike younger adults, similar work in older adults has shown consistent context memory benefits for generated materials over controls (Brown, Jones, & Davis, 1995; Multhaup & Balota, 1997; Rabinowitz, 1989). This contrast between the context memory literature in younger and older adults is surprising given that much of the work comparing younger and older adults has shown that both age groups benefit similarly from self-generation compared to controls (M. M. Johnson, Schmitt, & Pietrukowicz, 1989; Rabinowitz, 1989; Taconnat & Isingrini, 2004; Whiting, 2003). The present study aims to clarify the discrepancy between this idea that younger and older adults benefit similarly from self-generation, and the findings in the two age groups separately that support different conclusions for context memory. If younger and older adults benefit similarly from self-generation, it would be expected that using a lower-constraint task in older adults would lead to enhanced memory benefits compared to a higher-constraint task, given that my prior work showed this outcome in younger adults (McCurdy et al., 2017). However, based on the consistency with which context memory benefits for older adults have been shown in prior work using higher-constraint generation tasks, it is possible that older adults will not be affected by the level of constraint. This outcome would be in line with prior work from the reality monitoring literature (Brown et al., 1995; Hashtroudi, Johnson, & Chrosniak, 1989; M. K. Johnson & Raye, 1981). Reality monitoring is the ability for a person to distinguish between internally generated information and externally perceived information. Prior work on reality monitoring suggests that younger and older adults are both better at distinguishing between generated items compared to read items (Brown et al., 1995; Hashtroudi et al., 1989; M. K. Johnson, Raye, Foley, & Foley, 1981; Rabinowitz, 1989). But compared to younger adults, older adults are worse at distinguishing between two types of internally generated memories (also known as "source monitoring"; Brown et al., 1995; Hashtroudi et al., 1989). These findings are critical to the present experiment because it suggests that older adults may be less impacted by the level of generation constraint if they have difficulty distinguishing between two generation tasks. Therefore, by this logic, it may be that level of constraint influences the context memory benefits for younger adults, but less so for older adults. The present study aims to provide insight on these two ideas.

Surprisingly, few studies have directly compared the benefits of self-generation between younger and older adults. Studies that have made this direct comparison consistently find that although older adults show an overall memory performance deficit relative to young adults, both age groups benefit similarly from self-generation compared to control (M. M. Johnson et al., 1989; Rabinowitz, 1989; Taconnat & Isingrini, 2004; Whiting, 2003). That is, the magnitude of the memory benefit from self-generation over read controls (i.e., the generation effect) is similar in both age groups. Data from a recent meta-analysis supports this claim (Bertsch et al., 2007). These findings suggest that the generation effect is a powerful mnemonic that can improve memory even in an age group that suffers from memory declines. It is interesting to note, however, that much of the prior work looking at the generation effect in older adults have primarily used highly constrained generation tasks, which my prior work in younger adults has shown to limit the memory benefits from self-generation (McCurdy et al., 2017). Therefore, it stands to reason that the memory benefits from self-generation might be similarly limited for older adults as well, providing the possibility that the generation effect could be more effective for older adults when using a lower-constraint generation task. This study examines whether using a lower-constraint generation task increases the memory benefits from self-generation in older adults over a previously used higher-constraint generation task.

B. <u>Specific Aims and Hypotheses</u>

In the present study item and context memory benefits of a lower-constraint generation task were compared to a commonly used higher-constraint (anagram) generation task in both younger and older adults. Additionally, both recognition and cued recall procedures were used. For both age groups and memory types, I expect to find the typical generation effect where both generation tasks lead to greater memory compared to read controls, consistent with prior work (Donaldson & Bass, 1980; Mitchell et al., 1986; Slamecka & Graf, 1978; Taconnat & Isingrini, 2004). However, the primary focus of this study is the influence of constraints on the generation effect. There were two specific aims of this project:

Aim 1: Determine whether the level of generation constraint influences item memory benefits of self-generation, and whether this influence differs by age group.

My prior work in younger adults has shown that in some cases item memory was enhanced for a lower-constraint task (McCurdy et al., 2017). Based on this work, I expect that for younger adults the lower-constraint task will lead to greater item memory compared to the higher-constraint task. Importantly, I aim to extend this work by including an older adult group to determine whether generation constraints influence memory differently for older adults. Given that prior work often shows that younger and older adults benefit similarly from self-generation (M. M. Johnson et al., 1989; Rabinowitz, 1989; Taconnat & Isingrini, 2004), I expect that a lower-constraint generation task will provide greater item memory benefits compared to a higher-constraint task for older adults as well. Additionally, I expect to see this pattern of results for both age groups across both item recognition and item cued recall procedures.

Aim 2: Determine whether the level of generation constraint influences context memory benefits of self-generation, and whether this influence differs by age group.

In my prior work, a lower-constraint generation task also led to greater context memory compared to a higher-constraint generation task for younger adults (McCurdy et al., 2017). Therefore, I expect to find similar results for the younger adult group in this study. For older adults, I also expect to find greater context memory benefits for a lower-constraint task compared to a higher constraint task, since prior work has shown younger and older adults to benefit similarly from generation tasks (M. M. Johnson et al., 1989; Rabinowitz, 1989; Whiting, 2003). However, based on the prior work within the reality monitoring literature (Brown et al., 1995; Hashtroudi et al., 1989; Multhaup & Balota, 1997), if older adults indeed show deficits in distinguishing between two types of internally generated memories, then the level of constraint may have less impact for context memory in older adults compared to younger adults. By this logic, it could be expected that older adults show equivalent context memory for a lower- and higher-constraint generation task.

II. METHOD

A. **Participants**

Twenty-five younger (age: 19.0, SD: 1.1, range: 18-23, 12 females) and 25 older (age: 69.4, SD: 7.6, range: 60-85, 13 females) adults participated in this study. Younger adults were recruited through the University of Illinois at Chicago introductory psychology course subject pool. Older adults were recruited from the greater Chicago community. Participants gave written informed consent in accordance with the University of Illinois at Chicago Institutional Review Board and were compensated with course credit or paid for their participation. Each participant completed a language history questionnaire, and all participants reported being fluent English speakers. Three younger adult participants were removed from all recognition analyses[1], leaving a total N of 22 (age: 19.0, SD = 1.2, range: 18-23, 10 females) for the younger adult recognition analyses.

B. **Stimuli**

A total of 96 unique cue-target word pairs were used, selected from the University of South Florida Free Association Norms (Nelson, McEvoy, & Schreiber, 1998). Word pairs were selected so that both the cue and target were between 4-7 letters. Across participants, each pair was counterbalanced so that it occurred in each encoding task (generate, scramble, read), and as a new item at retrieval.

C. **Procedure**

Participants completed three phases in the experiment: Encoding, recognition, and cued recall. The encoding and recognition phases were presented on a monitor using Eprime presentation software. Prior to the encoding phase participants were trained on shortened

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[1] One participant was removed for 100% false alarm rate; Two participants were removed for scoring > 2 standard deviations below the younger adult mean for item and context memory.

versions of the encoding and recognition phases. Participants were not trained on the cued recall phase as done before (Jacoby, 1978; Watkins & Sechler, 1988). In the encoding phase, participants saw a total of 72 word pairs across three conditions: generate, scramble, and read (24 pairs in each task). In the "generate" task (i.e., lower-constraint generation task), participants were shown a cue word followed by a blank line (e.g., brief – _____) and were instructed to generate a word related to the cue word and then say both words out loud (i.e., the cue and the generated target). The generate task instructions emphasized that the responses were subjective and that there were no correct answers, so that participants were free to generate any word that came to mind. Participant responses during this phase were recorded by the experimenter. In the "scramble" task (i.e., higher-constraint generation task), participants were shown a cue word followed by a scrambled target word (e.g., blaze – feri) and were instructed to unscramble the word and then say both words out loud. If the participant was unable to determine the scrambled word, they were instructed to say "skip" and that trial was later removed. The first letter of the scrambled target word was always in its correct position, as done previously (Geghman & Multhaup, 2004) to reduce the number of skipped trials. Importantly, this scramble task is a commonly used task in prior work that places high constraints on what participants can generate (Foley & Foley, 2007; Foley, Foley, Wilder, & Rusch, 1989; Geghman & Multhaup, 2004). In the "read" task participants were shown a cue and target word (e.g., done – finish) and were instructed to read both words out loud. For all encoding tasks, participants were instructed to say both words out loud to ensure that the participant was processing the cue word in all tasks. Once the participant said both words for that trial, the experimenter advanced the screen and the participant was presented with a new word pair after a 500ms fixation. Encoding trials were presented in six blocks of 12 trials per task, and all trials within a block were the same task condition (generate, scramble, read). The order of the blocks was counterbalanced between participants such that each condition was presented equally as the first task presented, to reduce the likelihood of primacy and recency effects. Before each block, an instruction prompt appeared for 3000ms indicating the next task (e.g., "Get ready to do the generate/scramble/read task.").

Following the encoding phase, participants filled out a 6-question demographics questionnaire while the experimenter uploaded their recorded responses from the generate task into Eprime. This process took about 1 minute in total before the participant began the recognition phase. At recognition, participants were shown all 72 target words (i.e., the words they generated, unscrambled, or read) and 24 new words in a random order, for a total of 96 recognition trials. Each recognition trial consisted of two self-paced recognition judgments: an item memory judgment and a context memory judgment. First, for item memory, a target or new word was presented on the screen, and participants judged whether the word was old, new, or whether they didn't know using their index, middle, and pinky finger, respectively, of their right hand. Second, following a 500ms fixation, participants were shown the same target word and judged whether they encountered that word in the generate, scramble, or read condition, or whether they didn't know, using their index, middle, ring, and pinky finger, respectively, of their right hand. This response served as the context memory judgment. For items that were recognized as "new" in the item memory judgment, participants were instructed to make a "don't know" response for this second decision, as done in previous studies (Leshikar & Duarte, 2012, 2014; Leshikar, Dulas, & Duarte, 2015; Leshikar & Gutchess, 2015). The "don't know" response was included as an option to reduce the likelihood of guessing (Duarte, Henson, & Graham, 2008; Duarte, Henson, Knight, Emery, & Graham, 2010).

Immediately following the recognition test, participants were given a surprise cued recall test. Participants were given a pencil and paper that had a list of all 72 cue words seen during the encoding phase (in a randomized order) followed by a blank line. Participants were instructed to write the word that was paired with that cue word from the experiment. If they were unsure or didn’t know they were instructed to leave the line blank to reduce guessing.

III. RESULTS

Both younger and older adult participants gave responses on 100% of the generate and read trials. Younger adults successfully unscrambled 95.9%, and older adults successfully unscrambled 98.2% of words in the scramble task, which did not significantly differ (p = .19). Trials where participants were unable to unscramble the target word successfully were removed from all analyses. The raw recognition responses for item and context memory are presented in **Table I**. First, a 3 (task: generate, scramble, read) by 2 (age group: younger, older) repeated measures ANOVA was conducted to examine the interaction between younger and older adult memory performance for each memory test (item recognition, context recognition, item cued recall) separately. All follow-up pair-wise comparisons reported in these analyses are Bonferroni-corrected. Because of my *a priori* interest in older adult performance and to offer replication of my prior work in younger adults, I ran analogous ANOVAs for younger and older adults separately as well.

Item recognition scores were corrected for false alarms by taking the number of items correctly judged as “old” for each task minus the number of “new” items incorrectly identified as “old”. Context recognition scores were calculated using the conditional source identification measure (CSIM; Murnane & Bayen, 1996), a procedure that removes the influence of item recognition on source memory performance. Using this measure, context memory scores are represented by the proportion of correctly recognized items (i.e., item hits) that are also correctly identified with their source (i.e., source “hits” / item “hits” of that source). Cued recall scores were calculated as the percent of correctly recalled target words out of all words seen in the encoding phase, and items that were incorrect or left blank were counted as misses.

A. **3 (task) by 2 (age) ANOVAs**

Data from the item recognition analysis comparing younger and older adults are graphed in **Figure 1**. Results showed a significant main effect for task, $F(2, 44) = 64.33$, $p < .001$, $\eta_p 2 =$ .745. Contrary to expectations, follow-up comparisons showed that across younger and older adults, the scramble task ($M = .71$) led to greater memory than both the generate ($M = .64$; $p =$ .008) and read controls ($M = .42$; $p < .001$). The generate task also provided greater item memory compared to the read control task ($p < .001$). Surprisingly, the main effect of age was not significant, $F(1, 45) = 0.75$, $p = .39$, item memory performance was similar in the younger ($M =$ .61) compared to older adults ($M = .57$) across all tasks. No interaction was found between age and task for item memory ($p = .33$).

Data for the context memory analysis are shown in **Figure 2**. This analysis revealed a significant main effect for task, $F(2, 44) = 9.62$, $p < .001$, $\eta_p 2 = .304$, Importantly though, follow-up comparisons showed no difference between the generate ($M = .77$) and scramble tasks $M = .72$; $p = .48$) in contrast to expectations. However, both the generate ($p < .001$) and scramble ($p = .03$) tasks led to higher context memory compared to read controls ($M = .61$) consistent with the typical generation effect. There was also a main effect for age in the context memory analysis, $F(1, 45) = 13.74$, $p = .001$, $\eta_p 2 = .234$, where younger adults outperformed older adults across all tasks. The task by age interaction in this analysis was not significant $F(2, 44) = 2.17$, $p = .13$.

Data for the cued recall analysis are graphed in **Figure 3.** For cued recall there was a main effect for task, $F(2, 43) = 17.67$, $p < .001$, $\eta_p 2 = .451$. Follow-up comparisons again showed no difference between the generate ($M = .92$) and scramble tasks ($M = .90$; $p = .31$), while both the generate ($p < .001$) and scramble ($p < .001$) tasks both led to higher recall compared to read controls (*M* = .80). Interestingly, there was no main effect for age and no interaction for cued recall, suggesting that for cued recall, younger and older adults performed similarly.

B. **Younger Adult One-Way ANOVAs**

Data for these analyses are graphed in **Figure 4.** Results of the item memory ANOVA revealed significant differences between the three tasks, $F(2, 20) = 43.31$, $p < .001$, $\eta_p 2 = .812$. Planned follow-up analyses revealed significant differences between the generate and scramble tasks, $t(21) = -3.05$, $p = .006$, where item memory was greater for the scramble task ($M = .74$) than the generate task ($M = .67$). Compared to the read control task ($M = .42$), both the generate, $t(21) = 7.18$, $p < .001$, and the scramble task, $t(21) = 9.52$, $p < .001$, led to greater item memory performance. These findings are in contrast to our expectations about the level of generation constraint in which lower-constraint generation provides greater memory benefits compared to higher-constraint. However, these results are still consistent with the typical generation effect literature where both generate tasks provided a robust item memory benefit over read controls (Bertsch et al., 2007; Slamecka & Graf, 1978).

The results of the context memory ANOVA for younger adults also revealed significant differences between the three tasks, $F(2, 20) = 14.27$, $p < .001$, $\eta_p 2 = .588$. Planned follow-up analyses revealed that context memory was greater for the generate ($M = .85$) compared to the scramble task ($M = .74$), $t(21) = 3.66$, $p = .001$. Interestingly, context memory was greater for the generate task compared to read controls ($M = .72$), $t(21) = 4.63$, $p < .001$, but there was no significant difference between the scramble and read task, $t(21) = .730$, $p = .47$. This finding is in line with my predictions and prior work in younger adults that shows level of constraint improves the context memory benefits of self-generation (McCurdy et al., 2017).

Results of the cued recall analysis again revealed significant differences between the three tasks, $F(2, 20) = 20.45$, $p < .001$, $\eta_p2 = .672$. Planned follow-up analyses revealed that cued recall performance was marginally greater in the generate task ($M = .96$) compared to the scramble task ($M = .93$), $t(21) = 1.90$, $p = .07$. This is in line with my prior work showing cued recall effects for the lower-constraint compared to higher-constraint task (McCurdy et al., 2017). Interestingly, this pattern is different than the item recognition results suggesting the memory effects generation constraints may differ between recognition and recall procedures. As expected, recall was greater in both the generate and scramble tasks compared to the read control task ($M = .80$), *t*s > 5.12, *p*s < .001, consistent with the typical generation effect.

C. **Older Adult One-Way ANOVAs**

Data from these analyses are graphed in **Figure 5**. Results of the item memory analysis for older adults revealed significant differences between the three tasks, $F(2, 23) = 23.22$, $p < .001$, $\eta_p2 = .669$. Planned follow-up analysis revealed a marginal difference between the generate ($M = .62$) and scramble task ($M = .68$), $t(24) = -1.87$, $p = .07$, where item memory was marginally greater in the scramble compared to the generate task. Further comparisons revealed that both the generate and scramble tasks led to greater item memory compared to read controls ($M = .43$), *t*s > 5.02, *p*s < .001. This finding is similar to the younger adult findings for item memory, where both generate tasks led to greater memory than controls, which is consistent with prior work that suggests younger and older adults benefit similarly from self-generation (Hashtroudi et al., 1989; Rabinowitz, 1989).

For context memory, the analysis again revealed differences between tasks, $F(2, 23) = 5.06$, $p = .02$, $\eta_p2 = .306$. Planned follow-up analyses showed no differences between the generate ($M = .69$) and scramble task ($M = .70$), $t(24) = -0.13$, $p = .90$. However, the generate and scramble tasks both led to greater context memory than read controls (*M* = .51), *t*s > 2.81, *p*s < .01, consistent with a typical generation effect. Unlike item memory, this finding is counter to prior work and our predictions that lower-constraint generation would improve context memory performance in older adults compared to a higher-constraint task.

The cued recall analysis for older adults revealed differences between tasks, $F(2, 22) = 3.84$, $p = .04$, $\eta_p 2 = .259$. Follow-up analyses showed no difference between the generate (*M* = .88) and scramble task (*M* = .87), $t(23) = .688$, $p = .50$, yet both the generate and scramble tasks again led to greater performance than read controls (*M* = .79), *t*s > 2.59, *p*s < .02.

IV. DISCUSSION

This study investigated the effects of generation constraint on item and context memory in younger and older adults. We compared a lower-constraint generation task (where participants responded freely to a cue word) to a commonly used higher-constraint generation task (solving an anagram) and a read control task in both age groups. There were three main findings: First, consistent with the typical generation effect, both age groups showed greater item and context memory for generated materials (lower- and higher-constraint) compared to read controls (with one exception where higher-constraint provided no context memory benefit over controls for younger adults). Second, for younger adults the lower-constraint task led to increased context memory performance compared to a higher-constraint task consistent with our prior work (McCurdy et al., 2017), but for item recognition the opposite pattern occurred (higher-constraint > lower-constraint). Third, across all memory measures for older adults, there was no significant difference between the lower- and higher-constraint generation tasks (with the exception of a marginal difference in item recognition). Overall, these findings suggest that although both age groups benefit from self-generation, the level of constraint seems to influence the generation effect for younger and older adults differently. Further, contrary to prior work (M. M. Johnson et al., 1989; Rabinowitz, 1989; Whiting, 2003), this suggests younger and older adults may not benefit similarly from self-generation when level of constraint is taken into account.

One aim of this investigation was to examine the impact of generation constraints on the item memory benefits of self-generation for younger and older adults. Looking first to the item recognition performance in younger adults, my prior work in this age group has shown that a lower-constraint generation task can provide greater memory benefits over a higher-constraint task, however there were some instances where this additional benefit was not found for item recognition (McCurdy et al., 2017). Interestingly, this study revealed that for younger adults, a higher-constraint generation task led to greater item recognition compared to a lower-constraint task. Although, this finding is not consistent with our prediction, it provides more evidence that the level of constraint may be less impactful on item recognition in younger adults. Specifically, in my prior work we only found an item recognition benefit for lower-constraint over higher-constraint generation in one of three experiments. These findings also concur with prior work that has shown robust, consistent findings for item recognition in studies using higher-constraint generation tasks (Bertsch et al., 2007; Jacoby, 1978; Slamecka & Graf, 1978).

For older adults I also expected greater item recognition for a lower-constraint task compared to a higher-constraint task, however, no reliable difference was found between the lower- and higher-constraint tasks. Given that prior work has shown that older adults typically rely more on internally generated details when making memory judgements (compared to younger adults; Hashtroudi, Johnson, & Chrosniak, 1990; M. K. Johnson & Multhaup, 1992), it may be that all "generation" tasks are effectively the same in older adults, leading to the null differences in performance between the two generation tasks. Furthermore, much of the prior work comparing the generation effect benefits in younger and older adults has found that older adults show an overall deficit in memory performance compared to younger adults, but the magnitude of the generation effect is similar between the two age groups (M. M. Johnson et al., 1989; Rabinowitz, 1989; Taconnat & Isingrini, 2004; Whiting, 2003). That is, both age groups show a similar memory increase for generated items compared to controls. The present findings support this prior work. Overall, younger adults outperformed older adults, but both younger and older adults better remembered items that were in the generate conditions (lower- and higher-constraint) compared to read controls.

Looking at memory performance for both age groups together, we found that higher-constraint generation led to greater item recognition than lower-constraint, which is not as we expected. This finding is likely driven by younger adult memory performance in this task, and although it is not our expected finding, prior work has supported this outcome: First, my prior work has suggested that level of generation constraint is less impactful for item recognition performance in younger adults, where only one of three studies testing this memory type found an effect in favor of lower-constraint generation (McCurdy et al., 2017). Second, this finding is consistent with much of the generation effect literature to date that suggests the item memory benefits for self-generated materials are robust for both younger and older adults (Bertsch et al., 2007). Given that prior work has primarily used generation tasks that are highly constrained and a robust effect still emerges provides evidence that item recognition may be less affected by generation constraint. Lastly, and perhaps more simply, given the robust findings of prior work, it may be that there is little room for improvement for this memory type. That is, performance for this memory type is often very high, as was the case in the present study as well, therefore leaving little room for additional improvement from varying levels of constraint. Future studies using more stimuli to increase difficulty may be a way to directly test this idea.

Another aim of this study was to determine how the level of generation constraint impacted the context memory benefits of self-generation in younger and older adults. This aim was particularly pertinent for two reasons: One, the literature for younger adults has shown mixed context memory findings. Two, older adults show specific declines for this type of memory (Schacter et al., 1991; Spencer & Raz, 1995). Starting first with the younger adults, my prior work has shown robust and consistent benefits for a lower-constraint task compared to higher-constraint for context memory (McCurdy et al., 2017). The present study supported this finding, showing that in younger adults a lower-constraint task led to greater context memory compared to a higher-constraint task, providing more evidence that level of constraint influences the context memory benefits of self-generation in younger adults. Furthermore, the higher-constraint task provided no context memory benefit over read controls, suggesting that higher-constraint tasks may limit the context memory benefits of the generation effect, possibly accounting for the mixed findings in prior work. Interestingly, this pattern of results for context memory was in contrast to the pattern seen for item recognition in younger adults discussed above. This contrast further supports the idea that generation constraint may be less impactful for item recognition, where prior work has shown robust memory benefits. Moreover, for context memory where prior work has been mixed, generation constraints seem to matter more in which lower-constraint generation allows for the encoding of more details associated with an episode than higher-constraint tasks allow. Future work will be necessary to further address this hypothesis.

With regard to older adults and context memory, interestingly we found that the lower- and higher-constraint tasks provided equivalent context memory, yet both generation tasks provided context memory benefits over controls. There are two possible reasons for this outcome. First, prior work on older adults using higher-constraint tasks has shown consistent evidence that self-generation leads to context memory benefits over controls (Hashtroudi et al., 1989; Mitchell et al., 1986; Rabinowitz, 1989). This is in contrast to younger adults where some findings have been mixed for context memory (Marsh et al., 2001; Riefer et al., 2007). Given that prior work has shown consistent context memory benefits from self-generation even using higher-constraint tasks, it may be the case that older adults may be less affected by generation constraints. Second, this finding is strongly supported by prior work on reality monitoring in aging (Brown et al., 1995; Hashtroudi et al., 1989; M. K. Johnson et al., 1981). Reality monitoring is a term used to refer to the ability to distinguish between internally generated and externally experienced events. In this study both younger and older adults were effective at identifying the source of generated items (lower- and higher-constraint) compared to read control items, which prior work on reality monitoring predicts (Hashtroudi et al., 1989; M. K. Johnson et al., 1981; Rabinowitz, 1989). However, when older adults are asked to make a distinction between two types of internally generated information (also known as "source monitoring") they show particular deficits compared to younger adults (Brown et al., 1995; Hashtroudi et al., 1989), which is fully consistent with work showing older adults experience context memory deficits compared to the young (Schacter et al., 1991; Spencer & Raz, 1995). This idea is supported by the present study, with younger adults showing context (source) memory performance differences between the lower- and higher constraint generation tasks, while older adults showed similar context memory for both. Although these results suggest that lower-constraint generation improves context memory for younger adults, but not older adults, these results should be interpreted with caution. The context memory measure used in this study specifically requires participants to distinguish between lower-constraint and higher-constraint generation, which is a task that prior work on source monitoring has shown older adults to be particularly poor at (Rabinowitz, 1989). Therefore, although this study provides more evidence that older adults show source monitoring deficits compared to younger adults, it does not completely rule out that lower-constraint generation can provide greater context memory benefits in older adults. Future work testing a different contextual detail (such as font color) could provide more insight into whether lower-constraint generation provides greater context memory benefits for older adults, as we have shown in younger adults.

Cued recall has also shown robust benefits from self-generation for younger and older adults (Bertsch et al., 2007; Donaldson & Bass, 1980; Graf, 1980; M. K. Johnson et al., 1981; Rabinowitz, 1989). This study supports these findings by showing greater recall for generated items (lower- and higher-constraint) compared to read controls in both age groups. However, consistent with the other two memory measures, the level of constraint manipulation was again found to have an impact for younger adults but no impact for older adults. Specifically, younger adults showed marginally enhanced recall for lower-constraint items compared to higher-constraint items, while older adults showed no differences between the two generation tasks. In line with the other memory measures, these results also provide evidence that generation constraint seems to impact younger adults more so than older adults.

Interestingly for younger adults, this cued recall measure showed a different pattern of results from the item recognition measure, in which the higher-constraint task (anagram) led to greater recognition than the lower-constraint task (generate). This contrast between the results of recognition and recall memory tests supports a common idea in memory processing research that claims recollection and familiarity (recognition) rely on different processes (Yonelinas, 2002). It could be the case that retrieving materials generated in a lower-constraint task might rely more on recollection processes than retrieving materials generation in a higher-constraint task, thus providing a larger memory benefit for recall compared to recognition when using a lower-constraint generation task. Consistent with this idea is a wealth of literature that claims self-generation relies more heavily on recollection than familiarity (Dodson & Johnson, 1996; Jacoby, 1991; Jennings & Jacoby, 1993). Moreover, based on the ideas of transfer appropriate processing (Morris, Bransford, & Franks, 1977) it may be that the processing required at encoding by the lower-constraint task more closely matches the processes used when recalling these words than the processes required at encoding by a higher-constraint task. In other words, if generating a word in the lower-constraint task (e.g., open - _____) requires a similar processing as recalling that word from a cue at a later time (e.g., open - _____), transfer appropriate processing framework suggests that this task will experience a memory benefit over a task that is less similar between encoding and retrieval (e.g., higher-constraint task; see McCurdy et al., 2017, for further discussion of this prospect in younger adults). More work will be necessary to vet these possibilities.

V. CONCLUSION

This study compared two generation tasks that varied in the amount of generation constraint to determine the impact of level of constraint on item and context memory in younger and older adults. Overall, both age groups showed item and context memory benefits for generated information over read controls, providing more evidence that the generation effect is a powerful mnemonic that can improve memory in both younger and older adults. However, the level of constraint provided by a generation task only impacted younger, but not older adult memory performance. This suggests that younger and older adults process internally generated information differently, despite earlier evidence that both age groups benefit similarly from self-generation.

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Table I. Means and Standard Deviations (in parentheses) of responses for item and context recognition, and accuracy for cued recall by encoding condition and age.

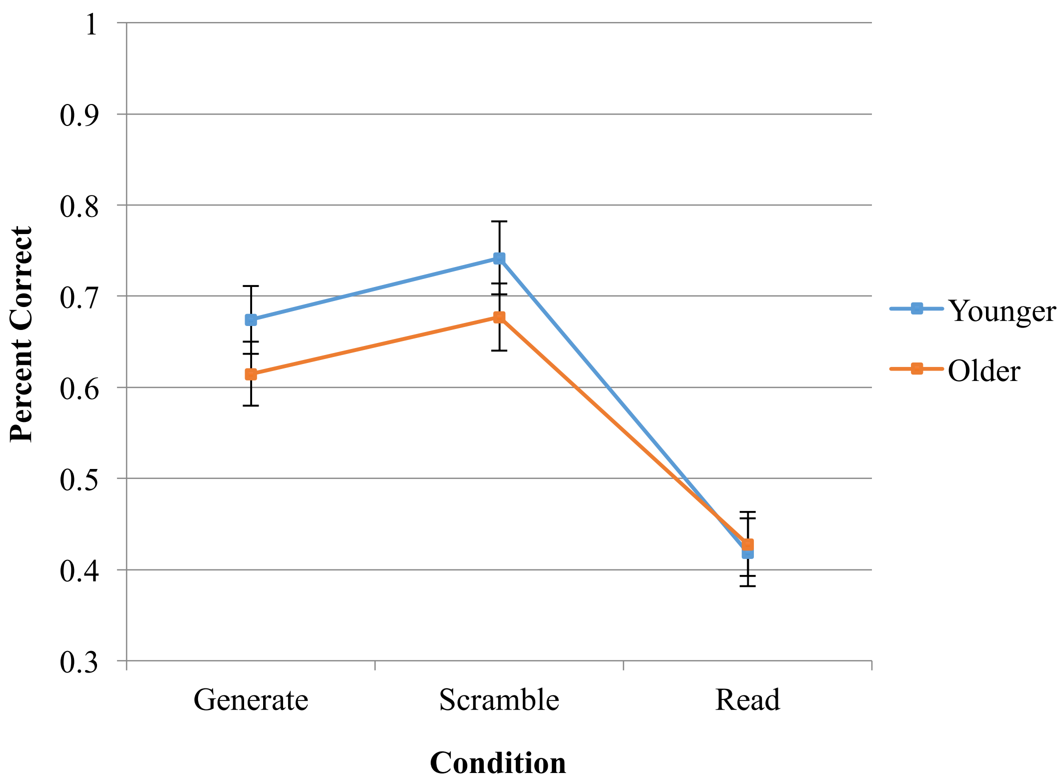
Younger Adults

Item Recognition				Context Recognition					Cued Recall		
Task	**Old**	**New**	**Don't Know**	**Task**	**Generate**	**Scramble**	**Read**	**Don't Know**	**Generate**	**Scramble**	**Read**
Generate	.84 (.11)	.11 (.11)	.05 (.07)	**Generate**	.85 (.10)	.06 (.07)	.07 (.07)	.02 (.03)	.96 (.06)	.93 (.07)	.80 (.15)
Scramble	.91 (.10)	.06 (.08)	.03 (.05)	**Scramble**	.07 (.06)	.74 (.16)	.16 (.14)	.03 (.06)			
Read	.59 (.21)	.29 (.25)	.12 (.20)	**Read**	.09 (.08)	.13 (.13)	.72 (.16)	.06 (.07)			
New	.17 (.12)	.62 (.33)	.21 (.28)	**New**	.03 (.05)	.04 (.05)	.11 (.10)	.82 (.14)			

Older Adults

Item Recognition				Context Recognition					Cued Recall		
Task	**Old**	**New**	**Don't Know**	**Task**	**Generate**	**Scramble**	**Read**	**Don't Know**	**Generate**	**Scramble**	**Read**
Generate	.76 (.16)	.19 (.13)	.05 (.10)	**Generate**	.69 (.26)	.13 (.21)	.15 (.17)	.03 (.06)	.88 (.16)	.87 (.13)	.79 (.19)
Scramble	.82 (.15)	.13 (.14)	.05 (.09)	**Scramble**	.12 (.09)	.70 (.18)	.16 (.14)	.02 (.03)			
Read	.57 (.16)	.33 (.18)	.10 (.16)	**Read**	.20 (.18)	.23 (.22)	.51 (.25)	.06 (.08)			
New	.14 (.11)	.70 (.24)	.16 (.21)	**New**	.05 (.07)	.05 (.05)	.15 (.28)	.75 (.28)			

Figure 1. Corrected item memory performance as a function of condition and age. Error bars represent standard errors of the mean.



Note: Item recognition was corrected for by calculating hits minus false alarms.

Figure 2. Conditional source memory performance as a function of condition and age. Error bars represent standard errors of the mean.

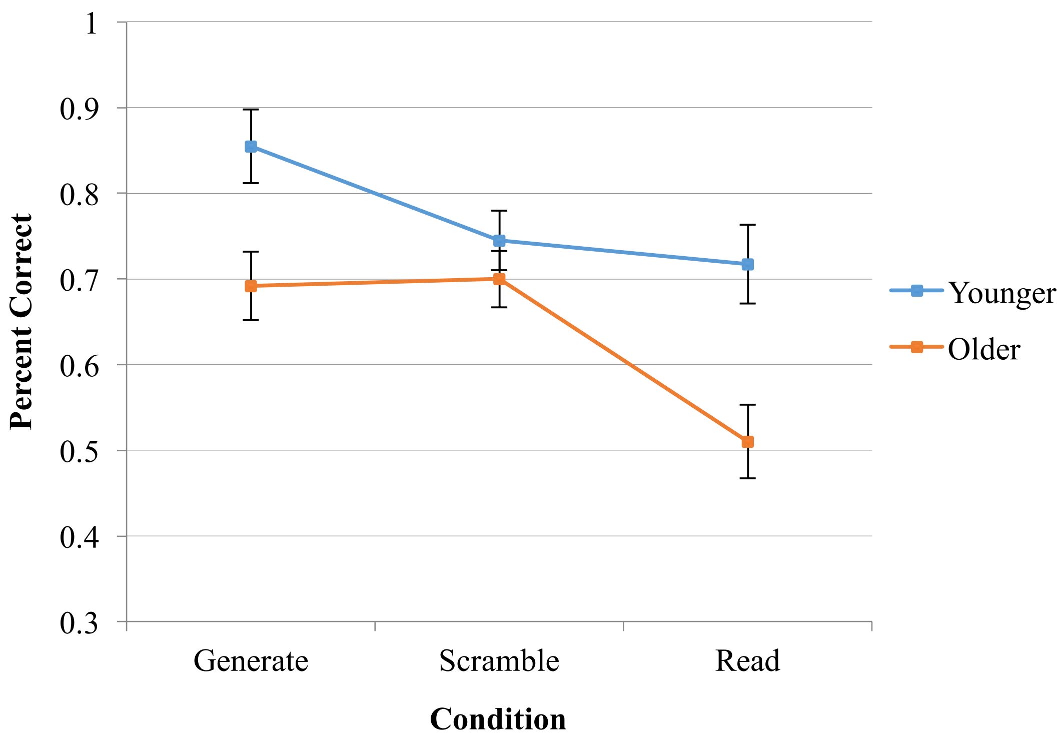


Figure 3. Cued recall performance by condition and age. Error bars represent standard errors of the mean.

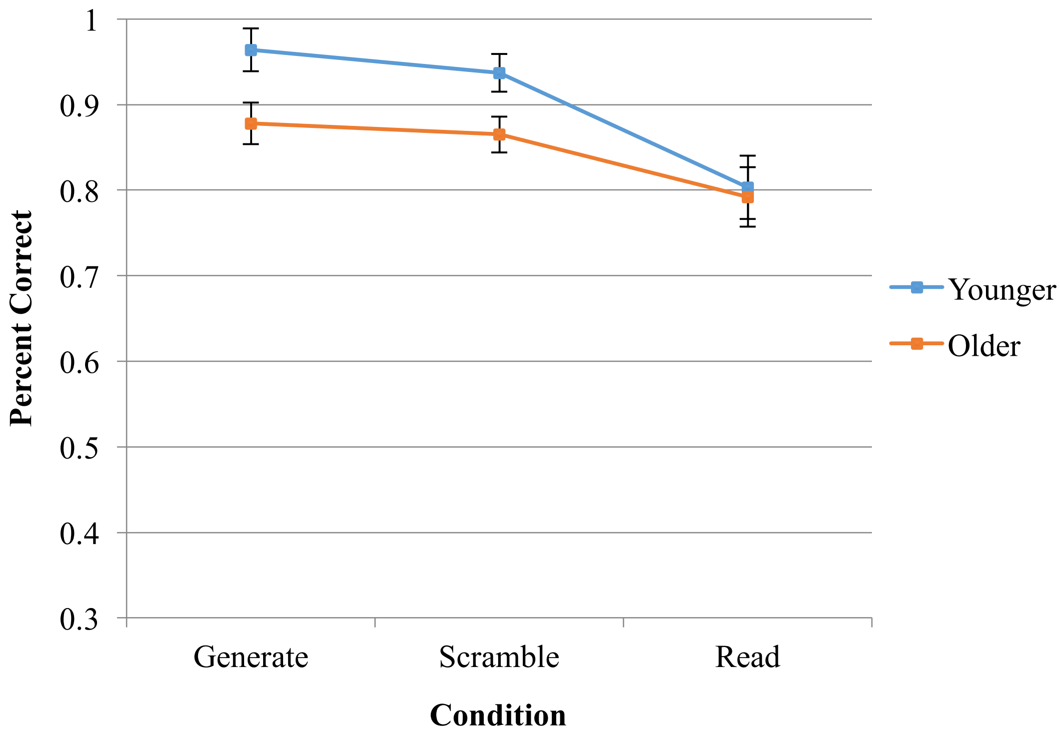
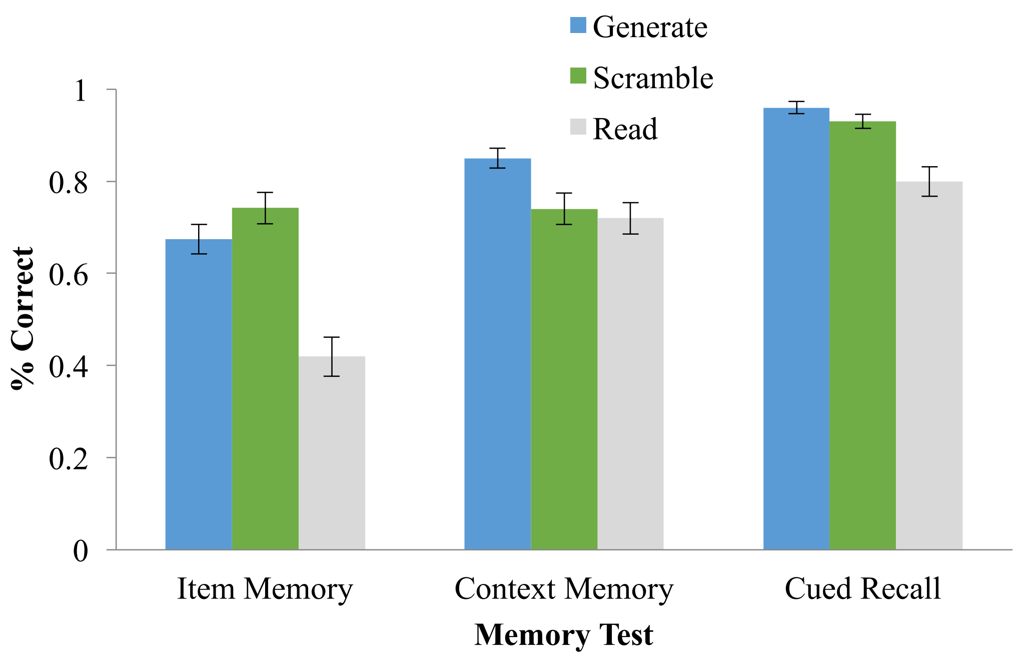
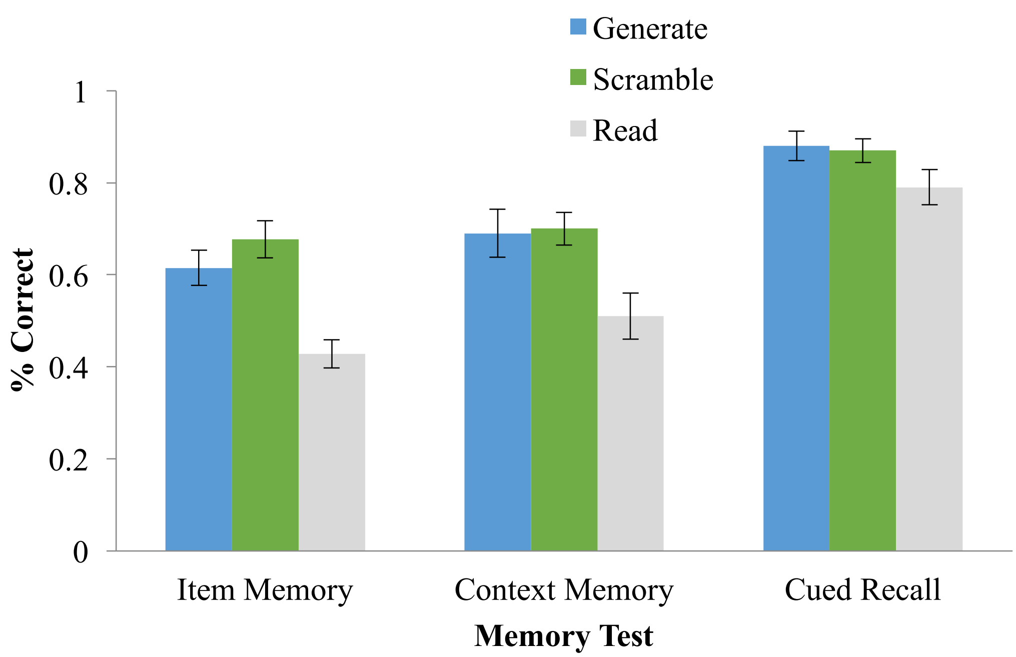


Figure 4. Accuracy by task for item recognition, context recognition, and cued recall for younger adults. Error bars represent standard errors of the mean.



Note: Item memory results reflect rates corrected for hits – false alarms. Context memory results reflect conditional source identification measure (CSIM) rates. Cued Recall results are raw proportion correct / all possible words.

Figure 5. Accuracy by task for item recognition, context recognition, and cued recall for older adults. Error bars represent standard errors of the mean.



Note: Item memory results reflect rates corrected for hits – false alarms. Context memory results reflect conditional source identification measure (CSIM) rates. Cued Recall results are raw proportion correct / all possible words.

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