The Consequences of Processing of Goal-Irrelevant Information during the Stroop Task in Younger and Older Adults

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The Consequences of Processing of Goal-Irrelevant Information during the Stroop Task in Younger and Older Adults

by

Jessica Nicosia

A thesis presented to
The Graduate School
of Washington University in
partial fulfillment of the
requirements for the degree
of Master of Arts

December 2018
St. Louis, Missouri
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Jessica Nicosia

Washington University in St. Louis

December, 2018
Abstract

The Consequences of Processing of Goal-Irrelevant Information during the Stroop Task in Younger and Older Adults

by

Jessica Nicosia

Master of Arts in Psychological & Brain Sciences

Washington University in St. Louis, 2018

Professor David Balota, Ph.D.

Recent evidence from memory paradigms indicates that older adults can sometimes benefit more from processing goal-irrelevant information than younger adults, however these studies have often failed to simultaneously provide evidence of age-related control deficits. In the present experiments, participants initially studied a list of words. They then received a color-naming Stroop task where neutral words were either previously studied or new words. Across three experiments, participants were given different types of memory tests to examine the lingering effects of the neutral words during color-naming in younger and older adults. The results from all three experiments (including an attempted replication study) yielded no evidence that older adults were more likely than younger adults to store the unattended neutral words in memory.
Chapter 1: Introduction

Attentional control is a critical component of everyday behavior that allows one to focus on relevant information and resist distracting stimuli in the environment. The Stroop task has been viewed as a quintessential test of attentional control (MacLeod, 1991; Stroop, 1935). In the Stroop task, participants are presented with color and non-color words printed in different colored ink and asked to name the ink color. For example, if the word BLUE is presented in RED ink, the participant must select the ink color (i.e., RED) and inhibit the irrelevant word information (i.e., BLUE) in order to respond correctly. Responses to incongruent trials (where the ink color and the color-word do not match) are slower and less accurate than congruent trials (where the ink color and color-word match). This Stroop interference effect has been shown to increase in older adults compared to younger adults (e.g., Cohn, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962; Hartley, 1993; Panek, Rush, & Slade, 1984; Spieler, Balota, and Faust, 1996), although there has been some controversy regarding whether the increase in Stroop interference in healthy older adults persists after controlling for overall changes in response latency (e.g., Verhaeghen & De Meersman, 1998). This age-related increase in interference from the goal-irrelevant word information may indicate that older adults are processing the irrelevant word dimension more than younger adults because of presumed failures in attentional control mechanisms.

1.1 Evidence of benefits from distraction in older adults

Although being able to inhibit irrelevant information (a function that declines with age; Zacks & Hasher, 1994) is often critical to task performance, Hasher and colleagues have argued that older adults’ decreased inhibitory control may, in some cases, result in increased processing
and improved memory of irrelevant information compared to younger adults (Amer, Campbell, & Hasher, 2016). For example, Biss, Ngo, Hasher, Campbell, and Rowe (2013) had younger and older adult participants study a list of words and then recall these words after a brief delay. After recalling as many words as possible (within 45 seconds) from the study list, participants were given a 1-back task of line drawings (Snodgrass & Vanderwart, 1980) with irrelevant word or letter strings superimposed on them. Participants were instructed to indicate whether consecutive pictures were identical and to ignore the words superimposed on the images. Critically, half of the to-be-ignored words superimposed on the pictures were previously studied words. After completing the 1-back task, participants were given a surprise recall task where they were again asked to recall aloud as many of the studied words as possible in 45 seconds. Although younger adults recalled more words overall than older adults, older adults recalled more repeated words (words studied and present in the 1-back task) than unpeated words (words only studied), whereas younger adults showed equivalent recall of repeated and unpeated words. The authors argued that older adults’ inability to sufficiently inhibit distracting information may actually benefit their recall of repeated studied items compared to younger adults.

Similarly, Amer and Hasher (2014) had younger and older adults perform a neutral color-naming Stroop task before taking a general knowledge test. Importantly, as compared to Biss et al. (2013), this study did not include an initial encoding of the list items. Critically, some of the words included in the initial Stroop task were answers on the later general knowledge test. Older adults showed greater priming on the general knowledge test for items previously presented during the Stroop task, whereas younger adults did not show any priming benefit. These results replicate the finding that older adults’ deficient inhibitory control may sometimes produce a benefit in situations where previously irrelevant information (i.e., words in the Stroop task)
becomes relevant in a subsequent task (i.e., answers in the general knowledge test) and extend this result to a context using a Stroop task rather than a 1-back task.

1.2 Evidence of distractor processing in younger and older adults

In a related study, Gopie, Craik, and Hasher (2011) provided evidence that both younger and older adults process distracting information but remember it in different ways due to age-differences in information processing at encoding and utilization of that information at retrieval. In this study, younger and older adult participants again performed a neutral color-naming Stroop task before completing either an implicit or explicit word-fragment completion task. Participants in the implicit memory condition were asked to complete word-fragments with the first word that came to mind whereas participants in the explicit memory condition were asked to complete word-fragments using words from the Stroop task. Results indicated that younger adults were better at completing the word-fragments in the explicit condition than the implicit condition but that older adults were better at completing the word-fragments in the implicit condition than the explicit condition – a double dissociation suggesting that both age groups may similarly process irrelevant information but retrieve the information differently.

However, Amer, Anderson, and Hasher (2018) recently failed to replicate the results of Gopie et al. (2011). Specifically, although younger adults showed above baseline memory of distractors from the word fragment completion task, they did not show better performance on the explicit test compared to the implicit test. The authors suggest that younger adults may have some ability to show perceptual priming from previous distractors and that the irrelevant information processed by younger adults may produce a weaker memory trace requiring a more sensitive memory measure to be assessed. Importantly, there was no older adult group of participants in this study for comparison purposes to the earlier Gopie et al. study.
Indeed, using a more sensitive memory measure, Hoffman, Bein, and Maril (2011) found evidence of younger adults processing previous distractor information as evidenced by later implicit memory performance. Specifically, younger adults performed a 1-back task, including pictures with words (and nonwords) superimposed on them, and were instructed to detect consecutive repetitions of pictures. Participants were then given a surprise recognition task including words from the 1-back task and new words. Participants responded using a confidence scale (1 = high-confidence “yes”; 2 = low-confidence “yes”; 3 = low-confidence “no”; 5 = high-confidence “no”) to indicate their memory of each of the words. Participants reported more low-confidence “no” responses for distractor than new words and more high-confidence “no” responses for new than distractor words, despite no differences in “yes” response confidence on these stimuli. The authors argued that these findings suggest that younger adults indeed have memory for unattended material, and “that previous null effects may have been due to insufficiently sensitive memory assessment” (Hoffman et al., 2011). However, the lack of an older adult sample in Hoffman et al. (2011) and the conflicting evidence from Gopie et al. (2011) and Amer et al., (2018) suggest that there is not a clear consensus on the extent to which younger and older adults process irrelevant information and whether the consequences on later criterion tasks are age-dependent or age-invariant.

1.3 Limitations in the extant literature

It is important to note that in previous studies that have used Stroop color-naming to examine the consequences of processing distractor information on later memory, typical Stroop congruent and incongruent trials were not included. Although previous studies have reported some empirical evidence that older adults indeed have failures in attentional control during initial encoding, there are some limitations in the way in which this has been measured. Specifically,
Biss et al. (2013) report that older adults had slower and less accurate 1-back task performance compared to younger adults and Amer and Hasher (2014) report that older adults were slower on the Stroop neutral task and slower and less accurate on the 1-back task. Neither study used standardized response times to assess age differences in the attentional control task, so these differences may be explained by age-related slowing (see Faust et al., 1999). Further, as mentioned above, the Stroop task used in Amer and Hasher (2014) only included Stroop neutral trials. Given the controversy regarding age-related changes in Stroop interference effects above and beyond general slowing, it is important to include congruent and incongruent conditions to ensure that the older adults are indeed producing more interference from the unattended dimension than younger adults. In this way, one can examine how specific breakdowns in attentional control are related to later memory performance.

1.4 Current Study

The present study addresses age-related differences in the consequence of processing goal-irrelevant information in a series of Stroop studies followed by memory tasks. Across experiments, we used a variety of memory paradigms to examine the effects on a range of memory processes. In the first experiment, we used a recognition memory test, assuming that more automatic familiarity-based processing will contribute to recognition performance. The second experiment used a demasking procedure as the criterion memory test, which places greater emphasis on implicit processing. Finally, in the third experiment we provide an attempted direct replication of the Amer and Hasher (2014) study, with their materials. Importantly, in the first two experiments we provide a measure of on-line Stroop interference to directly examine if older adults are having difficulty processing the irrelevant words more than the younger adults.
Chapter 2: Experiment 1

2.1 Introduction

In our first experiment, we attempted to extend the results of Biss et al. (2013) and Amer and Hasher (2014) to a task other than a recall or general knowledge test. It is possible that a general knowledge task may be particularly sensitive to priming in older adults because of their richer knowledge structure. Amer and Hasher (2014) addressed this issue by calculating a priming score by subtracting each age group’s average proportion of correctly answered baseline questions (questions with novel answers) from the individual’s proportion of correctly answered target questions (questions with answers shown during the Stroop task). Older adults, as expected, outperformed younger adults in their baseline general knowledge task performance and additionally showed greater conceptual priming (using the calculation described above). However, given that older adults have greater conceptual knowledge in this study, it is still possible that there may be interactive effects of pre-existing knowledge and priming that simple subtraction might not adequately control for. Specifically, it is possible that older adults are more easily primed due to their greater conceptual knowledge compared to younger adults. In order to extend the Amer and Hasher study, as noted, we used an episodic recognition task as the final criterion task since recognition has been shown to be dependent upon both a recollective process and a more automatic familiarity-based process. Importantly, there is evidence that familiarity-based processes are relatively intact in recognition in older adults (Jacoby, 1991; Yonelinas & Jacoby, 2012; Millar, Balota, Maddox, Duchek, Aschenbrenner, Fagan, Benzinger, & Morris, 2017). If older adults fail to inhibit and therefore process the goal-irrelevant dimension more than younger adults, one might expect this to carry over to the familiarity-based processes engaged in a recognition task, thereby extending the Amer and Hasher study to a recognition
memory task. On the other hand, given the results of Gopie et al. (2011) and Hoffman et al. (2011), suggesting that younger adults may also benefit from distractor knowledge, one might conversely expect both age groups to show improved recognition accuracy for words present in the Stroop task.

The General Method of Experiments 1, 2, and 3 is displayed in Error! Reference source not found..

**General Procedures**

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<td>1. Study Task</td>
<td>1. Stroop Task</td>
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<tr>
<td>2. Stroop Task</td>
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*Figure 1. General experimental procedures.*

As shown, this is a hybrid of Biss et al. (2013) and Amer and Hasher (2014). Specifically, in Experiments 1 and 2, participants first studied a list of words. They then received a Stroop task with congruent, incongruent, and neutral trials. Half of the neutral words were in the initial study list and half were new. Following the Stroop task, participants were given an episodic recognition test for the items they initially studied. Based on the argument that older adults are
more likely to process words that were not attended, one would expect that a) older adults would produce larger Stroop effects than younger adults after controlling for processing speed, and b) episodic recognition accuracy and speed for words present in the Stroop task would be better for older adults than younger adults.

2.2 Participants

Participants across all three studies were recruited from the Younger and Older Adult Subject Pools at Washington University in St. Louis and compensated at a rate of 1 credit/hour or $10/hour, respectively. Inclusion criteria for all three studies included native English-speaking ability and normal or corrected-to-normal vision. The demographic data for each study is displayed in Table 1.

<table>
<thead>
<tr>
<th>Experiment and Group</th>
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<th>Education (years)</th>
<th>Vocabulary Score</th>
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<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>p</td>
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<td>Younger</td>
<td>19.69</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>Older</td>
<td>74.29</td>
<td>7.25</td>
</tr>
<tr>
<td>Experiment 2 N = 42 per group</td>
<td>Younger</td>
<td>19.88</td>
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<td></td>
<td>Older</td>
<td>70.50</td>
<td>9.26</td>
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<tr>
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<td>Younger</td>
<td>19.66</td>
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<tr>
<td></td>
<td>Older</td>
<td>72.45</td>
<td>9.35</td>
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Table 1. Demographic data for Experiments 1, 2, and 3. ns = not significant, * = p < 0.05, ** = p < 0.01, and *** = p < 0.001.

2.3 Materials

Experiment 1 used a list of 120 concrete nouns generated from the English Lexicon Project (Balota et al., 2007). Using Hyperspace Analogue to Language (HAL) norms (Lund and Burgess, 1960), 60 of these words were selected to be high-frequency using a minimum HAL frequency of 4,353 as the boundary and 60 were selected to be low-frequency using a maximum
HAL frequency of 3,875 as the boundary\(^1\). Six counterbalancing conditions were created using the 120 generated words. All 120 words were rotated through the six different lists (i.e., study and Stroop, Stroop only, study only, and three sets of new words for comparison to the three other categories where words have been previously seen in some instance) so that each word appeared in a different list for each condition. Additionally, all words appeared equally often in all lists across participants and no word was repeated across lists within a participant. Equal numbers of participants completed the different counterbalance conditions. The breakdown of the stimuli is shown in Figure 1.

![Experiment 1 Procedure and Stimuli Breakdown](image)

Figure 1. Experiment 1 general procedure and stimuli breakdown.

\(^1\) We originally included both high- and low-frequency stimuli to investigate the influence of word frequency which contributes to item familiarity and attentional capture for high- and low-frequency words, respectively. However, these manipulations did not moderate any age-related influences in the final criterion task. We have therefore collapsed across word frequency in the present analyses.
2.4 Procedure

As described earlier and shown in Figure 1, each participant studied a set of 40 words. In the Stroop task, each participant performed 120 trials. Forty of the Stroop task trials were congruent, 40 were incongruent, and 40 were neutral trials. Of the 40 neutral trials, 20 of the words were previously studied during the study task and 20 were new words. During the recognition task, participants made recognition judgments on 120 words – twenty of these words were shown during both the study and Stroop tasks, 20 were shown only during the Stroop task, and 20 were shown only during the study task. Sixty new words were displayed during the recognition task.

Participants were told that they would be completing several unrelated tasks and then given instructions for the study task. During the study task, participants were asked to pronounce the word that appeared on the screen into a microphone placed in front of them and then study the word on the screen until it disappeared. Participants studied 40 words and each word was presented in white ink on a black screen for 4,000 milliseconds (ms).

During the Stroop task, participants were asked to name the ink color of the word presented on the screen. Each item was displayed in either red, blue, green, or yellow ink on a black screen. Each word was presented until response or until 4,000 ms passed, whichever came first, followed by 1,250 ms of a blank screen and a 250 ms fixation cross before the next word was presented. Participants were given an example followed by 16 random practice trials including several trials of each type (i.e., congruent, incongruent, and neutral). Participants then moved on to 120 randomly presented experimental trials. After completing the Stroop task, participants completed the Trails B task (Reitan & Wolfson, 1985) before taking a 10-minute
break, similar to the retention intervals included in Biss et al. (2013) and Amer and Hasher (2014). After the 10 minutes had passed, participants moved on to the recognition task.

During the recognition task, participants were presented with 120 words, one at a time until a response was made or until 4,000 ms had passed, whichever came first. Participants were instructed to press the “J” key if they remembered the word from the study task or the “F” key if they did not remember the word from the study task. Participants were correct if they pressed the “J” key for words that were only present in the study task or words that were present in both the study task and the Stroop task. Words only present in the Stroop task and new words were coded as lures.

After the recognition task, participants were given an awareness survey which asked (1) if they noticed a connection between any of the tasks and (2) if they consciously tried to use or avoid the overlapping items during the Stroop task and the final recognition task. While it has been demonstrated that awareness of a connection across tasks does not affect younger adults’ performance on the final criterion task (Thomas & Hasher, 2012), Campbell and Hasher (2018) argue that cross-task awareness may modulate older adults’ ability to delete irrelevant information. This issue is further examined in the General Discussion section of this paper.

Finally, participants were given the Shipley Vocabulary Task (Shipley, 1946), and debriefed.

2.5 Results

2.5.1 Statistical procedures

For all results reported, statistical significance was set at $p < 0.05$ two-tailed, unless otherwise noted. Effect sizes of partial eta squared ($\eta^2_p$, Olejnik & Algina, 2003) are reported for significant $F$ tests and Cohen’s $d$ ($d$, Cohen, 1988) for significant $t$ tests. Furthermore, for theoretically critical effects that did not reach significance, Bayes factors were calculated using
the BayesFactor package in R (More, Rouder, & Jamil, 2018; see Wagenmakers, Morey, & Lee, 2016, for more detail on Bayesian statistics). Specifically, Bayes factor (BF) assess the relative evidence in favor of an alternative model against a null model. This ratio is reported as BF$_{10}$. For reference, a BF$_{10}$ equal to 0.50 may be interpreted as twice as much evidence for the null compared to the alternative, while a BF$_{10}$ equal to 2.00 may be interpreted as twice as much evidence in favor of the alternative compared to the null. A BF$_{10}$ equal to 1.00 may be interpreted as equivocal evidence for both models. The BayesFactor package’s default priors were used for all analyses.

Response time (RT) data analyzed and reported for all tasks and experiments were screened for erroneous response times and accuracy. All response times faster than 250 ms (likely anticipation RTs) or slower than 2,500 ms (likely off-task RTs) were removed. Then, any response times less than -3 or greater than 3 standard deviations from an individual’s mean response time were removed. This trimming procedure eliminated 2.55% of trials for younger adults and 3.35% of trials for older adults in Experiment 1 and 3.02% of trials for younger adults and 2.51% of trials for older adults in Experiment 2. These procedures aim to avoid the influence of extreme scores.

Furthermore, we screened individuals’ recognition accuracy data for any hit minus false alarm rates less than -3 standard deviations from an age group’s mean. This was done so any participants with extremely low hit minus false alarm rates would not unduly influence the results. This screening procedure did not eliminate any participants’ recognition accuracy data.

In all tasks, we aimed to correct for general slowing by standardizing response times within each subject. The trimmed response times for each participant were transformed into z-scores on the basis of each participant’s overall trimmed mean response time and standard
deviation. This transformation accounts for age-related group differences in overall response time and variability (see Faust et al., 1999).

First, we present analyses on Stroop task standardized response times to examine if older adults produce a larger interference effect than younger adults. Second, we present results from the recognition task to examine if younger adults, older adults, or both age groups experience a boost in episodic recognition memory performance from processing irrelevant Stroop task neutral words, as compared to words that were only present in the study task.

2.5.2 Stroop Task Results

Standardized Stroop task response times as a function of trial type and age group are displayed in Figure 3.

![Figure 3. Mean standardized response latencies to name ink color for younger and older adults in Experiment 1.](image)
Response times were slower for incongruent trials compared to congruent trials. There were also age group differences in overall response latencies, with older adults responding more slowly than younger adults. These patterns were confirmed using a two-way age (young, old) by trial type (congruent, incongruent, neutral) ANOVA which indicated main effects of age, $F(1, 94) = 11.00, p < 0.01, \eta_p^2 = 0.08$, and trial type, $F(2, 188) = 325.00, p < 0.001, \eta_p^2 = 0.76$. These main effects were qualified by a highly reliable age by trial type interaction, $F(2, 188) = 21.00, p < 0.001, \eta_p^2 = 0.17$, which reflects a disproportionate increase in response latencies for older adults compared to younger adults, on incongruent trials compared to congruent trials. Follow up analyses confirm that both age groups were slower to respond to incongruent trial than congruent trials, $t(184.5) = 26.16, p < 0.001, d = 3.78$, and that younger adults were faster to respond than older adults across all conditions, $t(91.76) = 3.20, p < 0.01, d = 0.65$. Importantly, older adults were slower than younger adults on incongruent trials, $t(93.07) = 5.96, p < 0.001, d = 1.22$, but faster than younger adults on congruent trials, $t(93.94) = 4.64, p < 0.001, d = 0.95$, suggesting increased difficulty inhibiting the irrelevant word dimension for older adults, compared to younger adults\(^2\).

2.5.3 Recognition Task Results

For the recognition task data, we analyzed hit, false alarm, miss, and correct rejection rates for younger and older adults. If older adults’ reduced inhibitory control during the Stroop task allowed for increased processing of the neutral trial words, then one might predict that older adults showed an effect of word frequency whereas older adults did not. These patterns in the neutral trials were confirmed with a three-way age (young, old) by word frequency (low, high) by study (old, new) ANOVA which indicated main effects of word frequency, $F(1, 94) = 9.10, p < 0.01, \eta_p^2 = 0.02$, and study, $F(1, 94) = 5.10, p < 0.05, \eta_p^2 = 0.01$. There was additionally an interaction between age and word frequency, $F(1, 94) = 24.00, p < 0.001, \eta_p^2 = 0.05$. However, these effects were not replicated in Experiment 2 and therefore warrant further investigation.

\(^2\) There were also differences in response latencies for neutral trials, with participants responding more slowly for low-frequency words than high-frequency words and more slowly for new words than studied words. Furthermore, younger adults showed an effect of word frequency whereas older adults did not. These patterns in the neutral trials were confirmed with a three-way age (young, old) by word frequency (low, high) by study (old, new) ANOVA which indicated main effects of word frequency, $F(1, 94) = 9.10, p < 0.01, \eta_p^2 = 0.02$, and study, $F(1, 94) = 5.10, p < 0.05, \eta_p^2 = 0.01$. There was additionally an interaction between age and word frequency, $F(1, 94) = 24.00, p < 0.001, \eta_p^2 = 0.05$. However, these effects were not replicated in Experiment 2 and therefore warrant further investigation.
adults would have higher hit and false alarm rates but lower miss and correct rejection rates for words that were present in the Stroop task, compared to words absent from the Stroop task, than younger adults.

Figure 2 and 5 display the mean proportion of hits and false alarms, and misses and correct rejections, respectively, on the final recognition task for younger and older adults. Participants had more hits and false alarms for words that were present in the Stroop task compared to words that were absent from the Stroop task. However, contrary to our prediction that older adults would be more influenced by words that were present in the Stroop task due to age-related declines in inhibitory control, for neither hits nor false alarms were there interactions between age group and presence in the Stroop. Specifically, for hits (and misses), these patterns were confirmed by a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA which revealed a main effect of presence in Stroop task, $F(1, 94) = 30.66, p < 0.001, \eta^2_p = 0.07$. The critical age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 0.27, p = 0.61, BF_{10} = 0.32$. The estimated Bayes factor suggested that the data were 3.13 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction. For false alarms (and correct rejections), a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA yielded a main effect of presence in Stroop task, $F(1, 94) = 56.24, p < 0.001, \eta^2_p = 0.09$. The critical age by distractor interaction again did not reach significance, $F(1, 94) = 0.03, p = 0.87, BF_{10} = 0.22$. The estimated Bayes factor suggested that the data were 4.55 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction.

We also analyzed standardized response times in the recognition task to assess if older adults’
reduced inhibitory control during the Stroop task allows for increased processing of the neutral trial words. If this were the case, one might predict that older adults would be faster to correctly recognize and slower to false alarm, miss, and correctly reject words that were present in the Stroop task, compared to absent from the Stroop task, than younger adults.

Figure 2. Hits (left) and false alarms (right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.

Figure 3. Hits (left) and false alarms (right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.
Figure 5. Misses (left) and correct rejections (right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.

Figure 6 displays standardized response times for hits and false alarms on the recognition task for younger and older adults. Participants were faster to correctly identify words present in the Stroop task compared to words absent from the Stroop task and slower to false alarm to words present in the Stroop task compared to words absent from the Stroop task. However, for neither standardized hit response latencies nor false alarm response latencies were there interactions between age group and presence in the Stroop task. These results were confirmed by a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of standardized hit response latencies which revealed a main effect of presence in Stroop task, $F(1, 94) = 6.40, p < 0.05, \eta_p^2 = 0.02$. The age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 0.97, p = 0.33, BF_{10} = 0.39$. The estimated Bayes factor suggested that the data were 2.56 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction. For false alarms, a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of standardized false alarm response latencies did not yield any main effects. However, there was a numerical main effect of presence in Stroop task, $F(1, 94) = 2.87, p = 0.09, \eta_p^2 = 0.01$. There was no age by presence in Stroop task interaction, $F(1, 94) = 0.23, p = 0.64, BF_{10} = 0.24$. The estimated Bayes factor suggested that the data were 4.17 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction.
Figure 6. Standardized response times for hits (left) and false alarms (right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.

Figure 7 displays standardized response latencies for misses and correct rejections on the recognition task. Overall, older adults were slower to make misses and correct rejections and both age groups were slower to correctly reject words that were present in the Stroop task compared to words that were absent from the Stroop task. Again, for neither standardized miss response latencies nor correct rejection response latencies were there interactions between age group and presence in the Stroop. These results were confirmed by a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of standardized miss response latencies which indicated a main effect of age group, $F(1, 94) = 6.50$, $p < 0.05, \eta_p^2 = 0.03$. The age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 1.06, p = 0.31, BF_{10} = 0.36$. The estimated Bayes factor suggested that the data were 2.78 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction. For correct rejections, a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of standardized correct rejection response latencies yielded a main effect
of age group, $F(1, 94) = 5.04, p < 0.05, \eta^2_p = 0.03$, and presence in Stroop task, $F(1, 94) = 24.32, p < 0.001, \eta^2_p = 0.11$, but no age by presence in Stroop task interaction, $F(1, 94) < 0.01, p = 0.99$, BF$_{10} = 0.20$. The estimated Bayes factor suggested that the data were 5.00 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction.

*Figure 7.* Standardized response times for misses (left) and correct rejections (right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.

### 2.5.4 Awareness Questionnaire Results

Twenty-six younger adults and 11 older adults reported awareness of a connection between the tasks and conscious use of words from the Stroop task in the recognition task. However, exclusion of these individuals did not change the conclusions of any of the analyses reported here$^3$. The importance of the awareness questionnaire is further examined in the General Discussion of this paper.

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$^3$ Thomas and Hasher (2012) also reported that: (1) the pattern of results from aware younger adults did not differ from that of the unaware younger adults in their sample, (2) that aware young adults recalled a comparable number
2.6 Discussion

In summary, although the Stroop results confirm an age-related deficit in controlling goal-irrelevant information, there was no evidence that older adults recognized words present in both study and Stroop tasks over words only present in the study task, nor above the recognition hit rate for these words for younger adults. Furthermore, older adults did not false alarm more than younger adults to words that were absent from the study task but present in the Stroop task during the recognition task nor were they any slower to correctly reject these words.

One possible explanation for our failure to replicate the results from Amer and Hasher is that we used an explicit recognition memory task rather than an implicit memory task. We predicted that the familiarity component of recognition performance may be sensitive to increased processing of distracting information in our older adults. However, it is possible that the explicit nature of recognition memory tests may have minimized our sensitivity to detect the predicted age-related difference. Importantly, most previous studies (see Biss et al., 2013) that have used explicit memory tasks, such as recall, as the final criterion task have not used the Stroop task as the distractor task.

Chapter 3: Experiment 2

3.1 Introduction

In Experiment 2, we used an implicit memory task as the final criterion task to assess participants’ knowledge of items presented throughout the experiment. Specifically, in order to assess any potential carryover or benefit from the items in the Stroop task, we used a gradual demasking task (Ferrand et al., 2011) wherein participants were asked to press the spacebar as
soon as they could identify the word being revealed on the screen. Speed and accuracy of identification were analyzed with the prediction that older adults would be faster and/or more accurate than younger adults to identify words present in the Stroop task as compared to words absent from the Stroop task (i.e., only studied or completely new). Moreover, in order to increase the implicit nature of the design, instead of studying the items during the first phase participants made pleasantness ratings.

3.2 Participants

As shown in Table 1, older adults had more education than the younger adults, but did not differ on Shipley vocabulary measures.

3.3 Materials

Experiment 2 used a list of 144 words, which added 24 words to the 120 words from Experiment 1. Six counterbalancing conditions were created. All 144 words were rotated through the six different lists (i.e., study and Stroop, Stroop only, study only, new set 1, new set 2, new set 3) so that each word appeared in a different list for each condition. Additionally, all words appeared equally often in all lists across participants and no word was repeated across lists within a participant. Equal numbers of participants completed the different counterbalance conditions. The breakdown of the stimuli is shown in Figure 8.
3.4 Procedure

Participants were told they would be completing several unrelated tasks and then given instructions for the study task. During the first phase, participants were asked to rate the pleasantness of each word on a scale from 1 (unpleasant) to 5 (pleasant). Participants rated 48 words presented in white ink on a black screen until response or until 10,000 ms had passed. After completing this task, participants then rated each of the same 48 words on pleasantness a second time. We asked participants to make pleasantness ratings twice to increase depth of processing of the studied words in this experiment. We wanted to deepen the level of encoding in Experiment 2 to increase the chance that older adult participants would receive a boost for items studied and present in the Stroop task. This was followed by the Stroop task which was identical to Experiment 1.

After completing the Stroop task, participants completed the Trails B task before taking a 10-minute break. The 10-minute break was included as a retention interval buffer similar to what
was done in Biss et al. (2013). After the 10 minutes had passed, participants were given instructions for the gradual demasking task.

Third, during the gradual demasking task, each trial began with a presentation of pound signs (“#####”) for 500 ms followed by a presentation of the target word for 16 ms. The display alternated between presenting pound signs and the target word, decreasing time displaying pound signs and increasing time displaying the target word by 16 ms each iteration, until the participant hit the spacebar (indicating they recognized the word) or until 9,288 ms had passed. The final pound sign to target word display ratio was 1:1 with each being presented for 288 ms. After pressing the spacebar, the item on the screen disappeared from the screen and the participant was asked to tell the experimenter the word they saw. Of the 144 words presented during this task, 24 were present in both study and Stroop tasks, 24 were only present in the Stroop task, 24 were only present in the study task, and 72 new words were displayed during the gradual demasking task.

As in Experiment 1, after completing the computer tasks, participants were then given the awareness survey followed by the Shipley Vocabulary task (Shipley, 1946). The awareness survey was a bit more detailed in this experiment in which participants were asked (1) if they noticed a connection between any of the tasks, (2) if yes, what connection they noticed, (3) if they used their memory of the items to help them on the final task, and (4) if they used any other strategies to help them on the final task.

3.5 Results

3.5.1 Stroop Task Results

Figure 9 displays standardized Stroop task response times as a function of trial type and age group. Similar to our results from Experiment 1, older adults were overall slower to respond
than younger adults and response times for incongruent trials were slower than those for
congruent trials. These patterns were confirmed by a two-way age (young, old) by trial type
(congruent, incongruent, neutral) ANOVA which indicated main effects of age, $F(1, 82) = 25.00,$
$p < 0.001, \eta^2_p = 0.03,$ and trial type, $F(2, 164) = 270.00, p < 0.001, \eta^2_p = 0.75.$ These main
effects were qualified by a significant age by trial type interaction, $F(2, 164) = 12.00, p < .001,$
$\eta^2_p = 0.12.$ Follow up analyses confirm that younger adults were faster to respond than older
adults across all conditions, $t(78.58) = 4.76, p < 0.001, d = 1.04,$ and that both age groups were
slowest to respond to incongruent trials, $t(163.4) = 23.38, p < 0.001, d = 3.61.$ Most importantly,
older adults were slower than younger adults on incongruent trials, $t(81.87) = 5.92, p < 0.001, d$
$= 1.29,$ and numerically faster than younger adults on congruent trials, $t(79.83) = 1.58, p = 0.12,$
d$= 0.34,$ suggesting increased difficulty inhibiting the irrelevant word dimension for older
adults, compared to younger adults. These results replicate our findings from Experiment 1
confirming the control deficit in older adults after accounting for generalized slowing.
Figure 9. Mean standardized response latencies to name ink color for younger and older adults in Experiment 2.

3.5.2 Gradual Demasking Task Results

Figure 10 displays the mean proportion of correct responses on the gradual demasking task as a function of presence in the Stroop task and age group. As expected, all participants were near ceiling in accuracy this task. Overall, younger adults were more accurate than older adults and participants were more accurate in identifying words that were studied compared to words that were not studied. These results were confirmed by a three-way age (young, old) by study (studied, not studied) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA which revealed a main effect of age, $F(1, 82) = 16.33, p < 0.001, \eta_p^2 = 0.08$, and study, $F(1, 82) = 7.92, p < 0.05, \eta_p^2 = 0.02$.

If older adults benefited more than younger adults from increased processing of the
words present in the Stroop task, one would expect older adults to have higher accuracy identifying these words compared to younger adults, an age by presence in Stroop task interaction. However, this interaction did not approach significance, $F(1, 82) = 0.01, p = 0.93, BF_{10} = 0.16$. The estimated Bayes factor suggested that the data were 6.25 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction.

![Graph](image)

*Figure 10.* Mean proportion of correctly identified not studied (left) or studied (right) words in the gradual demasking task for younger and older adults in Experiment 2. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.

Figure 11 displays the mean standardized response latencies for correctly identifying the words during the demasking task. Overall, words that were present in either the study or Stroop task were identified more quickly than words that were absent from the study or Stroop task. Additionally, younger adults showed a greater priming effect (faster to identify studied words than non-studied words) than older adults. However, consistent with the demasking task
accuracy results and the results from Experiment 1, older adults did not show an advantage over younger adults in identifying words present in the Stroop task compared to words that were absent from the Stroop task. This occurred for both studied and non-studied words, and importantly, to the same degree for younger and older adults. These patterns were confirmed by a three-way age (young, old) by study (studied, not studied) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA which indicated a main effect of study, $F(1, 82) = 405.30, \ p < 0.001, \ \eta^2 = 0.23$, presence in Stroop task, $F(1, 82) = 24.39, \ p < 0.001, \ \eta^2 = 0.02$, and an interaction between age group and study, $F(1, 82) = 25.5, \ p < 0.001, \ \eta^2 = 0.02$. However, the critical age by distractor interaction did not reach significance, $F(1, 82) = 0.14, \ p = 0.71, \ BF_{10} = 0.12$. The estimated Bayes factor suggested that the data were 8.33 times more likely to occur under the main effects only model as compared to the model including the critical age by presence in Stroop task interaction.

![Figure 11](image)

*Figure 11.* Mean standardized response latency to identify not studied (left) or studied (right) words in the gradual demasking task for younger and older adults in Experiment 2. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task.
3.5.3 Awareness Questionnaire Results

Forty younger adults and 27 older adults reported awareness of a connection between the tasks and conscious use of words from the Stroop task in the gradual demasking task. As mentioned above, this issue is further discussed in the General Discussion.

3.6 Discussion

Results from the Stroop task in Experiment 2 replicate those found in Experiment 1 confirming an inhibitory processing deficit in older adults not simply explained by generalized slowing. Older adults showed disproportionate interference, after standardizing response latencies, which suggests an impaired ability to suppress the goal-irrelevant word dimension. However, we failed to find evidence in favor of increased distractor processing for older adults, compared to younger adults, in an implicit memory task. Of course, our failure to find any evidence of increased sensitivity to distractor information in the present paradigm may be due to the specific memory measures used in this study. That is, even the demasking paradigm, which is clearly sensitive to the presentation of distractor words in the Stroop task, may not be as sensitive as the general knowledge test used by Amer and Hasher. However, it should also be noted that in the original Amer and Hasher (2014) study, the effects were relatively small in a general knowledge test (i.e., the older adults produced a conceptual priming score of approximately 0.08, whereas younger adults produced a conceptual priming score of approximately 0.01, which reached standard levels of significance, $p < 0.05$). Hence, in order to test if this pattern is robust we decided to replicate this study with the identical conditions and stimuli, and sufficient statistical power.
Chapter 4: Experiment 3

4.1 Participants

An a priori power analysis was performed for sample size estimation, based on data from Amer and Hasher (2014; N = 34 per group). The effect size in this study was considered to be medium using Cohen’s (1988) criteria. With an alpha = 0.05 and power = 0.80, the projected sample size needed with this effect size (GPower 6) is 38 participants per group for the between group comparison.

As shown in Table 1, older adults had more years of education and higher vocabulary than younger adults.

4.2 Materials

Materials were the same items used by Amer and Hasher, which included two lists of 40 words (mostly common nouns) for the Stroop task. Each participant saw one of these lists during the experiment. Of the 40 words presented during the Stroop task, 20 of these words were designated as answers to questions presented during a later general knowledge task (i.e., critical items). The other 20 words in the list were matched, according to Amer and Hasher (2014), to the critical words in length, frequency of occurrence, naming time, and lexical decision accuracy using the English Lexicon Project database (Balota et al., 2007). The questions used on the general knowledge task and the corresponding critical words were selected from Blaxton (1989). Additionally, 12 words were added to serve as primacy and recency buffers. During the Stroop task, participants saw 52 words presented on a computer screen in red, blue, green, or yellow ink against a black background and the 52 questions for the general knowledge task were presented in white ink against a black background. In the general knowledge task, there were 20 critical questions, 20 filler questions, and 12 easy questions to boost morale and mask the task’s implicit
nature. Following Amer and Hasher, there were no congruent or incongruent trials in the Stroop task.

4.3 Procedure

The procedure was identical to that used by Amer and Hasher (2014). Briefly, participants completed two main tasks in this experiment: a Stroop task and a general knowledge task. During the Stroop task, participants responded to the color of the stimuli on the computer screen by pressing one of four colored buttons on a keyboard (red, blue, green, or yellow). Stimuli were presented one at a time in the center of the screen until response or until 2,000 ms had expired. Afterwards, the stimuli on the screen disappeared and a blank screen was presented for 1,750 ms followed by a fixation cross for 250 ms before the next stimuli was presented. Exactly as done by Amer and Hasher (2014), participants received a 7-item practice Stroop task including only congruent and incongruent trials. During the actual Stroop task, participants first saw 6 buffer words presented as a primacy buffer. Next, the 40 words from one of the two lists were presented (20 critical and 20 filler words) in random order. Finally, 6 more buffer words were presented as a recency buffer. Once participants completed all 52 trials of the Stroop task, participants performed a computerized version of Corsi’s 1972 Block-Tapping Test (adapted from Rowe, Hasher, & Turcotte, 2008) that was originally included to hide the connection between the Stroop and general knowledge tasks.

Next, the participants were then given instructions for the general knowledge task. Participants were told that they would see some general trivia questions and that their responses were being used to obtain norms for future research studies in the lab. They were told questions would be presented on the screen, one at a time, and that they should tell the experimenter the first response that came to mind for that particular question. Each question was presented for
10,000 ms, followed by 500 ms of a fixation cross before the next question appeared. Questions were presented randomly for each participant. After completing the general knowledge task, participants were asked about their awareness of any connection between the tasks and, if so, whether they had consciously used or avoided words from the Stroop task on the general knowledge task. Afterwards, participants completed a health and demographic questionnaire, the Morningness-Eveningness Questionnaire (Horne & Östberg, 1976), the Shipley (1946) vocabulary test, and a general trivia task comprised of 100 questions (drawn from Nelson & Narens, 1980 norms and used in Weinstein and Roediger, 2010). Lastly, older adults were administered the MMSE, SBT, and MoCA (in that order; Folstein et al., 1975; Katzman et al., 1983; Nasreddine et al., 2005) before being debriefed and informed that the final general knowledge task was indeed connected to the present study. It is important to note that all materials were the exact same materials used in Amer and Hasher (2014) except for the 100-question trivia task which was added as an additional measure of general knowledge.

4.4 Results

First, we present analyses on Stroop task response times to examine if there are any age-related differences. Second, and more importantly, the results are reported for the general knowledge task where we investigated whether or not older adults experience a boost from reduced inhibition of Stroop task items as compared to younger adults.

4.4.1 Stroop Task Results

Similar to what is reported in Amer and Hasher (2014), both younger (M = 98%, SD = 0.03%) and older adults (M = 98%, SD = 0.03%) performed near perfect on the Stroop color-naming task, and there was no significant difference between the two groups, \( t(73.98) = 0.17, p > 0.5, d = 0.04 \). Younger adults (M = 644.91 ms, SD = 81.28 ms) responded faster on the Stroop
task than older adults (M = 1016.42 ms, SD = 115.49 ms), t(66.43) = 16.22, p < 0.001, d = 3.72. Analyses on standardized response times also indicated that younger adults responded marginally faster on the Stroop task than older adults, t(55.44) = 1.89, p = 0.06, d = 0.43.

4.4.2 General Knowledge Test Results

In contrast to the findings of Amer and Hasher (2014), older adults (M = 0.22, SD = 0.13) did not correctly answer a larger proportion of baseline questions than younger adults (M = 0.23, SD = 0.15), t(72.37) = 0.34, p > 0.5, d = 0.08. Nonetheless, following the procedure outlined in Amer and Hasher (2014), a conceptual priming score for each participant was calculated. The conceptual priming score was determined by subtracting the corresponding group’s average proportion of correctly answered baseline questions from the individual’s proportion of correctly answered critical questions. As illustrated in Figure 12, older adults did not show an advantage over younger adults in conceptual priming for distractors, t(72.46) = 1.09, p = 0.28, d = 0.25, BF₁₀ = 0.32. The estimated Bayes factor suggested that the data were 3.13 times more likely to occur under the null hypothesis (μ₁ = μ₂) compared to the alternative hypothesis. Furthermore, in direct contrast to the findings reported in Amer and Hasher (2014), reliable conceptual priming was observed in younger adults, t(37) = 2.88, p < 0.01, d = 0.47, but not older adults, t(37) = 1.05, p = 0.30, d = 0.17.
Figure 12. Conceptual priming (individual proportion of correctly answered critical questions minus corresponding group average proportion of correctly answered baseline questions) for younger (gray bar) and older (black bar) adults in Experiment 3.

4.4.3 Awareness Questionnaire Results

Eight younger adults and 3 older adults reported both awareness of a connection between the tasks and conscious use of words from the Stroop task during the gradual demasking task. However, exclusion of these individuals did not change the conclusions of any of the analyses reported here.

4.5 Discussion

Results from Experiment 3 failed to provide evidence of conceptual processing of distractor information for older adults over that of younger adults. While Experiments 1 and 2 suggested that both younger and older adults processed the distractor words in the Stroop task, as
indexed by later recognition and gradual demasking task performance, Experiment 3 suggests that only younger adults benefited from the critical items (answers to the general knowledge task that were shown earlier as distractors during the Stroop task).

It is important to note that our older adult sample, unlike the sample included in Amer and Hasher (2014), did not show greater baseline performance on the general knowledge task than younger adults. Given that older adults’ greater pre-existing knowledge may impact the ease of priming, this is an important difference between the sample used in the original Amer and Hasher study and our replication. However, our older adult sample did outperform younger adults on the separate set of 100 trivia questions we included, $t(65.05) = 2.01$, $p < 0.05$, $d = 0.46$ (drawn from Nelson & Narens, 1980 norms and used in Weinstein and Roediger, 2010).
Chapter 5: General Discussion

Across three experiments, the hypothesis that older adults are more likely to benefit on a memory test from processing the goal-irrelevant word dimension in the Stroop task was tested. Results from the Stroop tasks from Experiments 1 and 2 confirm a greater inhibitory deficit in older adults than younger adults after controlling for age-related slowing. Older adults showed greater interference on incongruent trials and facilitation on congruent trials than younger adults – indicating an impaired suppression mechanism. As mentioned in the introduction, there has been some controversy regarding whether the age-related increase in Stroop interference persists after controlling for general slowing (e.g., Verhaeghen & De Meersman, 1998). In light of this view, the robust age differences in standardized Stroop interference effects replicated across Experiments 1 and 2 may be due to the proportion and nature of words used as neutral trials such that unique rather than repeated or attentionally capturing low-frequency words may modulate the size of the Stroop effect differently for younger and older adult participants. However, to our knowledge, there is no existing literature on whether or not neutral trial characteristics may affect age differences in the Stroop interference effect.

Despite the Stroop task data from Experiments 1 and 2 confirming an age-related inhibitory deficit, we failed to find evidence that older adults processed words present in the Stroop task more than younger adults, as indexed by episodic recognition performance, gradual demasking task performance, and conceptual priming scores (Experiments 1, 2, and 3, respectively). Hasher and colleagues have argued that an age difference in the ability to suppress goal-irrelevant information leads to increased processing, and later memory, of the goal-irrelevant information (Amer, Campbell, & Hasher, 2016). However, our results suggest that while older adults indeed struggle to inhibit irrelevant word information in the Stroop task more
than younger adults, both age groups seem to process and use this information on subsequent memory tasks to the same extent. As Dywan and Murphy (1996) argue, “the ability to inhibit the use of information does not necessarily imply that the information is not processed”.

Our third experiment was an exact replication which used an a priori power analysis and failed to find an age-difference in conceptual priming – directly contradicting the findings of the original source (Amer and Hasher, 2014). Given conflicting evidence in the literature (Amer et al., 2018; Dywan and Murphy, 1996; Gopie et al., 2011; Hoffman et al., 2011; Kemper et al., 2008), small effect sizes, and concerns about the reproducibility of psychological science, replications like this are critical in assessing the stability of effects reported in the extant literature.

However, there are several limitations of the studies presented here. Critically, we have only tested one version of suppression – inhibiting word dimension information in a color-naming Stroop task including congruent, incongruent, and neutral trials. The arguments presented in this paper, therefore, do not extend to other distractor tasks such as 1-back tasks (Biss et al., 2013) or reading-with-distraction tasks (Kim, Hasher, and Zacks, 2007; Thomas and Hasher, 2012) where Hasher and colleagues have found evidence of older adults processing more distracter information. Given these findings, it may be the case that specific features of the Stroop task, such as the strong, automatic response to read the word rather than name the ink color, may contribute to age-invariant processing of the distractor word as compared to 1-back or reading-with-distraction tasks.

Another important limitation of Experiments 1 and 2 is the issue of participant awareness. Hasher and colleagues report excluding participants, especially older adult participants, who report awareness of a connection across the tasks (i.e., consciously using or avoiding using their
knowledge of words that were present in the distractor task during the final criterion task).

Though we were able to confirm that there was no effect of awareness in Experiment 1, the majority of participants in Experiment 2 reported awareness of a connection across tasks (i.e., study, Stroop, and demasking) and we could therefore not confirm whether there was an effect of awareness on the how quickly or accurately participants identified words during the demasking task. While there is some evidence suggesting that older adults’ awareness may play a role in whether or not they show an effect of processing previous distractor information (Campbell and Hasher, 2018), the theory that older adults’ reduced inhibitory control may lead to increased processing and subsequent memory may need to be more clearly defined in future studies if it is indeed modulated by conscious awareness.

Together, these results suggest that while older adults indeed show an inhibitory deficit, they do not seem to process irrelevant word information in a Stroop task more than younger adults. In contrast, both age groups appear to benefit from, and be lured by, information that was present in the Stroop task in subsequent implicit and explicit memory tasks. Finally, it is important to keep in mind that although we did not find any increase in processing of distracting information for older adults, we did find a robust age-related decline in inhibitory processing not explained by general slowing suggesting a distinction between the mechanisms involved in priming or encoding and failures of inhibition.
References


