American Psychological Association

Psychology and Aging

0882-7974/20/$12.00

2020, Vol. 35, No. 5, 663–675
http://dx.doi.org/10.1037/pag0000371

The Consequences of Processing Goal-Irrelevant Information During the Stroop Task

Jessica Nicosia and David Balota
Washington University in St. Louis

Recent evidence indicates that older adults' decreased ability to inhibit irrelevant information may lead to increased processing and greater memory for distractor information compared with younger adults. The present experiments examine the generality of this finding in a series of Stroop studies. In Experiment 1, participants studied a list of words then received a Stroop color naming task, with to-be-remembered words embedded within the Stroop task. Although there was evidence of a disproportionate age-related Stroop effect, there was no evidence of an age difference in episodic recognition memory for words from the Stroop task. Experiment 2 extended this paradigm to a more implicit demasking task. Again, there was evidence of an age-related disproportionate Stroop effect, however, there were no differences in memory for unattended words in demasking performance. Experiment 3 was a direct replication of a previous study which reported age differences in the influence of unattended words, via implicit priming in a general knowledge test. The results did not replicate the original study such that younger adults showed slightly more priming from distractors than older adults. The results provide converging evidence that although older adults have more difficulty inhibiting irrelevant information in the Stroop task, distractor information does not seem to disproportionately influence later memory for older adults compared with younger adults. These studies suggest that it is critical to consider the locus of memory encoding in distractor tasks to better understand the relationship between inhibitory processes during the distractor task and later memory performance.

Keywords: attention, aging, memory

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 noncolor 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 effect has been shown to increase in older adults compared with younger adults (e.g., Cohn, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962; Hartley, 1993; Panek, Rush, & Slade, 1984; Spieler, Balota, & 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 process the irrelevant word dimension more than younger adults because of presumed failures in attentional control mechanisms.

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 improved memory of irrelevant information compared with 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 from the study list, participants were given a 1-back task of line drawings (Snodgrass & Vanderwart, 1980) with irrelevant words 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 superimposed to-be-ignored words were previously studied words. After completing the 1-back task, participants were given a surprise recall task where they were again asked to recall

Editor's Note. Karen L. Campbell served as the action editor for this article.

Jessica Nicosia and David Balota, Department of Psychological and Brain Sciences, Washington University in St. Louis.

Aspects of this article were presented to the Graduate School of Arts and Sciences at Washington University in St. Louis as a master's thesis by Jessica Nicosia. Aspects of this article were also presented in a poster at the 2017 Annual Meeting of the Psychonomic Society, in Vancouver, British Columbia, Canada.

Correspondence concerning this article should be addressed to Jessica Nicosia, Department of Psychological and Brain Sciences, Washington University in St. Louis, 1 Brookings Drive, CB 1125, St. Louis, MO 63130. E-mail: j.nicosia@wustl.edu

as many of the studied words as possible. 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 nonrepeated words (words only studied), whereas younger adults showed equivalent recall of repeated and nonrepeated words. The authors argued that older adults' inability to sufficiently inhibit distracting information may actually benefit their recall of repeated studied items compared with younger adults.

Turning to Stroop performance, 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 with Biss et al. (2013), this study did not include an initial encoding of the list items. Critically, some of the words included in the Stroop task were answers on the later general knowledge test. Older adults showed greater priming on the general knowledge test for items present during the Stroop task, whereas younger adults did not show any priming benefit. These results replicate the finding that older adults' deficient attentional 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 finding to a context using a Stroop task rather than a 1-back task.

In a related study, Gopie, Craik, and Hasher (2011) suggested that both younger and older adults process distracting information but remember it differently due to age-differences in encoding and retrieval processes. In this study, younger and older adult participants performed a color-naming Stroop task, using only noncolor word stimuli displayed in different ink colors, 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 process irrelevant information similarly but retrieve it differently.

In a more recent study, Amer, Anderson, and Hasher (2018) failed to replicate the results of Gopie et al. (2011). Specifically, although younger adults showed above baseline memory of distractors, they did not show better performance on the explicit test compared with the implicit test. The authors suggest that 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. (2011) study.

It is important to note that in the above-mentioned Stroop studies that have examined the consequences of processing distractor information on later memory, Stroop congruent and incongruent trials have not been included. Although these studies have reported some evidence that older adults have failures in attentional control during initial encoding, there may be some limitations to this argument. Specifically, Amer and Hasher (2014) reported that older adults were slower on the Stroop neutral task but this may simply reflect general slowing as opposed to disproportionate slowing for unattended information (see Faust, Balota, Spieler, & Ferraro, 1999). Gopie et al. (2011) only report accuracy for the Stroop neutral task. 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.

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 and to examine the generalizability of the age-related difference. In the first experiment, we used a speeded recognition memory test, assuming that more automatic familiarity-based processing will contribute to recognition performance, and hence one may find an age-related difference either in accuracy or response latencies. The second experiment used a gradual demasking procedure as the criterion memory test, which places greater emphasis on implicit processing. Finally, in the third experiment we attempted to directly replicate the original Amer and Hasher (2014) study, with their materials and procedures. Importantly, in the first two experiments we also provide a measure of online Stroop interference to directly examine if older adults have more difficulty inhibiting the irrelevant words than younger adults. Specifically, the inhibitory deficit theory would predict that older adults' "inefficient inhibition" would "enable the initial entrance into working memory of information that is off the goal path" (Hasher & Zacks, 1988) such that goal-irrelevant information in the Stroop task (i.e., the word dimension) may be better remembered by older adults compared with younger adults.

Experiment 1

In our first experiment, we attempted to extend Amer and Hasher (2014) and Gopie et al. (2011) to an episodic recognition task, because episodic recognition has been shown to depend upon both attention demanding recollective and more automatic familiarity-based processes. Importantly, familiarity-based processes are relatively intact in older adults (Millar et al., 2017; Yonelinas & Jacoby, 2012) and may contribute to age differences in various explicit memory tasks (Craik & McDowd, 1987). If older adults fail to inhibit the goal-irrelevant dimension more than younger adults, and this is particularly salient in implicit tasks, one might expect an episodic recognition memory task to be sensitive in detecting the relative benefit (for studied and unattended Stroop words) or cost (for words only present in the Stroop task) for the older adults, compared with the younger adults in the more implicit/familiarity component of recognition.

The General Procedures of Experiments 1, 2, and 3 are displayed in Figure 1. As shown, Experiments 1 and 2 are 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

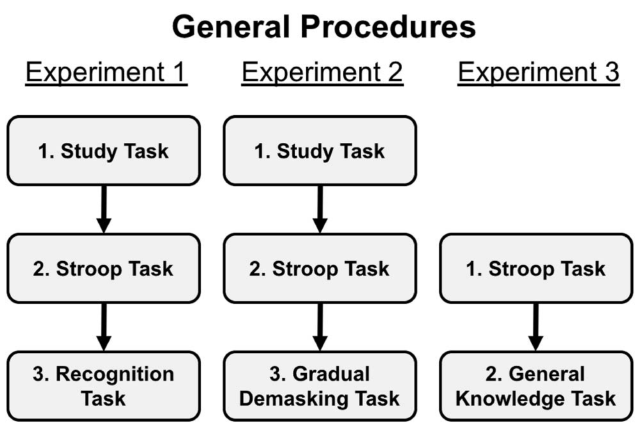

Figure 1. General experimental procedures.

and half were new. Following the Stroop task, participants were given an episodic recognition test for the items they initially studied including foils from the Stroop task and completely new words. Based on the argument that older adults are more likely to process unattended words, one would expect that (a) older adults would produce larger Stroop effects than younger adults after controlling for processing speed, and (b) that older adults would show higher episodic recognition accuracy and faster response latencies for words *present* in the Stroop task compared to *absent* from the Stroop task compared with younger adults.

Method

Participants. All methods reported here received approval from the Washington University in St. Louis Institutional Review Board. 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/hr. Inclusion criteria for all three studies included native English-speaking ability and normal or corrected-to-normal vision. The demographic data for each study are displayed in Table 1. Forty-eight younger and 48 older adult participants completed Experiment 1. In order to insure we had sufficient power to detect any age-related consequences of processing the Stroop neutral words in the final recognition memory task, we included a sample of 48 younger and 48 older adults, which affords power of 0.99 for an alpha of 0.05.

Materials. Experiment 1 used a list of 120 concrete nouns generated from the English Lexicon Project (Balota et al., 2007).[1] Six counterbalancing lists 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 new word lists to balance the overall proportion of new to previously seen words on the criterion task). Additionally, all words appeared equally often in all lists across participants and no word was repeated across lists within a participant. Eight participants completed each counterbalance list.

Procedure. Each participant initially studied a list of 40 words. Each word was presented centered on the screen in 20-point bold Arial font. A fixation cue was present for 1,500 ms before each stimulus appeared. Participants pronounced each word aloud and were given 4 s to study each word.

In the Stroop task, each participant named the color of each stimulus on 120 trials. On each trial, the following events occurred: (a) fixation cross at the center of the screen for 750 ms; (b) presentation of the colored word for 4,000 ms or until the participant produced the response; (c) the screen was cleared; (d) a 750-ms blank screen. The experimenter separately recorded the response or noted the response as a microphone error (e.g., stutters, false starts, responses that were too soft to trigger the microphone, etc.). Each stimulus was presented in 20-point bold Arial font, displayed in red, blue, green, or yellow ink (using E-Prime Version 2.0 defaults for these colors; Psychology Software Tools, 2016; Pittsburgh, PA). Participants were given an example and 16 practice trials including several trials of each type (i.e., congruent, incongruent, and neutral) before receiving the critical 120-item list. 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 presented in the earlier study list task and 20 were new words. After completing the Stroop task, participants completed the Trails B task (Reitan & Wolfson, 1985) before taking a 10-min break, similar to the retention intervals included in Biss et al. (2013) and Amer and Hasher (2014). After 10 min 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 list or the “F” key if they did not remember the word from the study list. During the recognition test, there were 20 words in each of the following conditions: study list items that were present in the Stroop task; study list items that were absent from the Stroop task; items that did not occur in the study list, but were present in the Stroop task. In addition, there were 60 totally new items. Participants were correct if they pressed the “J” key for words that were only present in the study list or words that were present in both the study list and the Stroop task. Participants were not given any warning about words that were present in the Stroop task but not in the study list aside from the instructions that they should press “J” if they remembered the word from the initial study list or “F” if they did not remember the word from the initial study list. Participants were told that they would have 4 s to make their response so they should try to make their decision relatively quickly and as accurately as possible.

After the recognition task, participants were given an awareness survey which asked (a) if they noticed a connection between any of the tasks and (b) if they consciously tried to use or avoid the overlapping items from the Stroop task during 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) argued that cross-task awareness may modulate older adults’ ability to delete irrelevant information. We return to this issue in the General Discussion section. Finally, participants

[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.

Table 1
Demographic Data for Experiments 1, 2, and 3

Experiment and group	Age (years)			Education (years)			Vocabulary score			Trails B (seconds)		
	M	*SD*	*p*	*M*	*SD*	*p*	*M*	*SD*	*p*	*M*	*SD*	*p*
Experiment 1 $N = 48$/group												
Younger	19.69	1.29	***	13.84	1.24	***	33.46	3.16	***	46.56	13.29	***
Older	74.29	7.25		16.29	2.44		35.44	3.20		91.90	43.74	
Experiment 2 $N = 42$/group												
Younger	19.88	1.31	***	13.98	1.09	***	33.00	2.73	ns	45.00	11.01	***
Older	70.50	9.26		15.69	2.60		33.43	3.96		91.48	51.66	
Experiment 3 $N = 38$/group												
Younger	19.66	1.15	**	13.83	1.43	***	32.24	2.71	***			
Older	72.45	9.35		15.95	2.72		34.26	4.00				

Note. ns = not significant.
** $p < .01$. *** $p < .001$.

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

Results

For all results reported, statistical significance was set at $p < .05$ two-tailed, unless otherwise noted. Effect sizes of partial eta squared (η_p^2, Olejnik & Algina, 2003) are reported for significant *F* tests and Cohen's *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 (Morey, Rouder, & Jamil, 2015; see Wagenmakers, Morey, & Lee, 2016, for more detail on Bayesian statistics). Specifically, Bayes factor (BF) assesses the relative evidence in favor of an alternative model against the 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 with the alternative, while a BF_{10} equal to 2.00 may be interpreted as twice as much evidence in favor of the alternative compared with 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 incorrect trials and trimmed based on procedures consistent with the extant literature (see Aschenbrenner & Balota, 2015). 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. For the Stroop task, this trimming procedure eliminated 2.6% of trials for younger adults and 3.4% of trials for older adults in Experiment 1 and 3.0% of trials for younger adults and 2.5% of trials for older adults in Experiment 2. For the recognition task, this trimming procedure eliminated 2.5% of trials for younger adults and 2.1% of trials for older adults. For the demasking task, this trimming procedure eliminated 2.4% of trials for younger adults and 6.1% of trials for older adults. These procedures aim to avoid the influence of extreme scores. After this trimming procedure, we correct for general slowing by z-scoring response times within each subject, i.e., z-scores. This transformation controls for age-related differences in response time and variability (see Faust et al., 1999).

Stroop task. Z-scored Stroop RTs as a function of trial type and age group are displayed in Figure 2. As shown, the difference between incongruent and congruent trials is larger in older adults than younger adults, indicating disproportionate Stroop effects. This pattern was confirmed by a two-way age (young, old) by trial type (congruent, incongruent, neutral) ANOVA which indicated a highly reliable age by trial type interaction, $F(2, 188) = 21.00$, $p < .001$, $\eta_p^2 = 0.17$. Follow-up analyses confirm that the incongruent condition was slower in older adults compared with younger adults, $t(93.07) = 5.96$, $p < .001$, $d = 1.22$, and the congruent condition was faster in older adults compared with younger adults, $t(93.94) = 4.64$, $p < .001$, $d = 0.95$, suggesting increased difficulty inhibiting the irrelevant word dimension for older adults, compared with younger adults.[2]

Recognition task. For the recognition task, we analyzed hit, false alarm, miss, and correct rejection rates for younger and older adults. If older adults' reduced attentional control during the Stroop task allowed for increased processing of the neutral trial words, then one might predict that, compared with younger adults, older 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 with absent from the Stroop task. Similarly, we would predict that older adults, compared with younger adults, increased processing of the goal-irrelevant word dimension should lead to faster hits for and slower false alarms to words present in the Stroop task compared with words absent from the Stroop task.

Figure 3 displays the mean proportion of hits, false alarms, misses, and correct rejections 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 with words that were absent from the Stroop task. However, there

[2] To test the possibility that this age effect might reflect older adults being less able to sustain attention to the color dimension over time, we tested the Stroop effect in the first versus the second half of the experiment for younger and older adults. A two-way age (young, old) by time (first half, second half) ANOVA revealed main effects of age, $F(1, 94) = 37$, $p < .001$, and time, $F(1, 94) = 14$, $p < .001$, but no interaction between the two, $F < 1$. These results suggest that younger and older adults show equivalent abilities to sustain attention to the color dimension at least in the context of this task. Furthermore, these results replicate in the data collected for Experiment 2 as well.

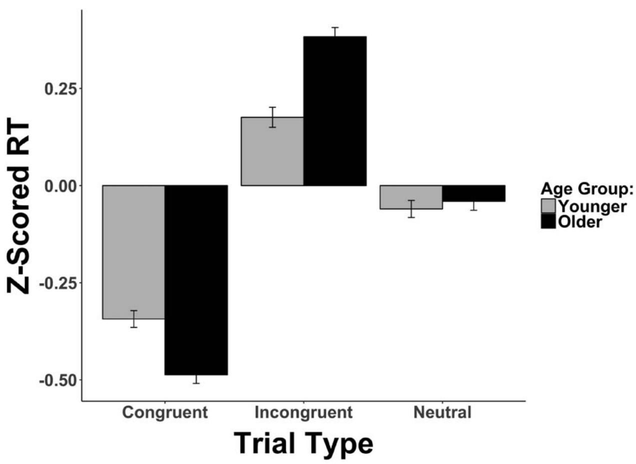

Figure 2. Mean z-scored RTs to name ink color for younger and older adults in Experiment 1. Error bars represent standard errors of the mean.

was no evidence that older adults were more influenced by the neutral words in the Stroop task compared with younger adults. Specifically, for hits, 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, $F(1, 94) = 30.66$, $p < .001$, $\eta_p^2 = 0.07$. The critical age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 0.27$, $p = .61$, $BF_{10} = 0.32$. For false alarms, 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, $F(1, 94) = 56.24$, $p < .001$, $\eta_p^2 = 0.09$. The critical age by distractor interaction again did not reach significance, $F(1, 94) = 0.03$, $p = .87$, $BF_{10} = 0.22$.

We also analyzed z-scored RTs in the recognition task to assess if older adults' reduced attentional control during the Stroop task allowed for increased processing of the neutral trial words, under the assumption that speed to make the recognition decision might be more implicitly influenced by the presence in the Stroop task than the explicit recognition task decision. Figure 4 displays z-scored RTs 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 with words absent from the Stroop task and slower to false alarm to words present in the Stroop task compared with words absent from the Stroop task. However, for neither z-scored hit RTs nor false alarm RTs 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 z-scored hit RTs which revealed a main effect of presence in Stroop task, $F(1, 94) = 6.40$, $p < .05$, $\eta_p^2 = 0.02$. The age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 0.97$, $p = .33$, $BF_{10} = 0.39$. For false alarms, a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of z-scored false alarm RTs did not yield any main effects. However, there was a numerical main effect of presence in Stroop task, $F(1, 94) = 2.87$, $p = .09$, $\eta_p^2 = 0.01$, in the predicted direction. There was again no age by presence in Stroop task interaction, $F(1, 94) = 0.23$, $p = .64$, $BF_{10} = 0.24$.

Figure 4 also displays z-scored RTs 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 with words that were absent from the Stroop task. Again, for neither z-scored miss RTs nor correct rejection RTs were there interactions between age group and presence in the Stroop. These results were confirmed by a two-way age (young,

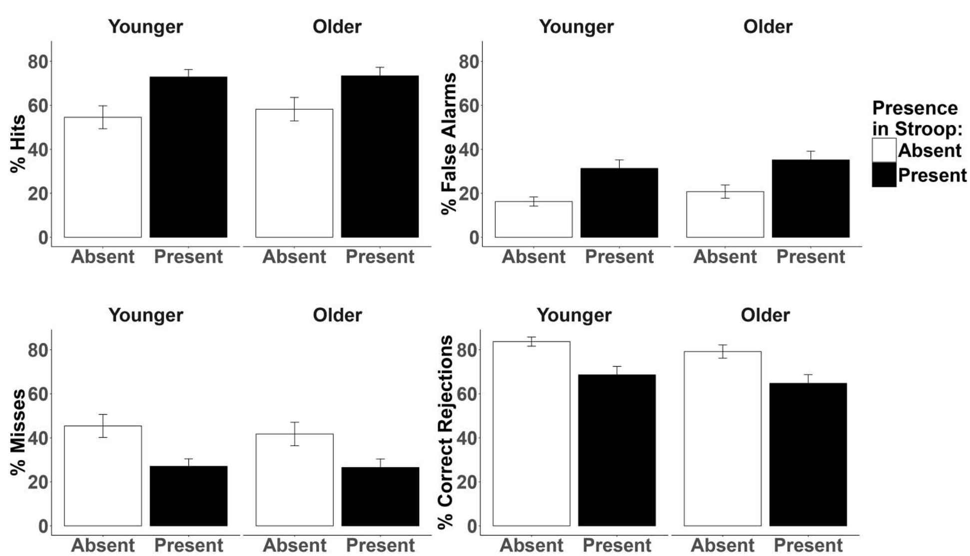

Figure 3. Hits (top left), false alarms (top right), misses (bottom left), and correct rejections (bottom right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task. Error bars represent standard errors of the mean.

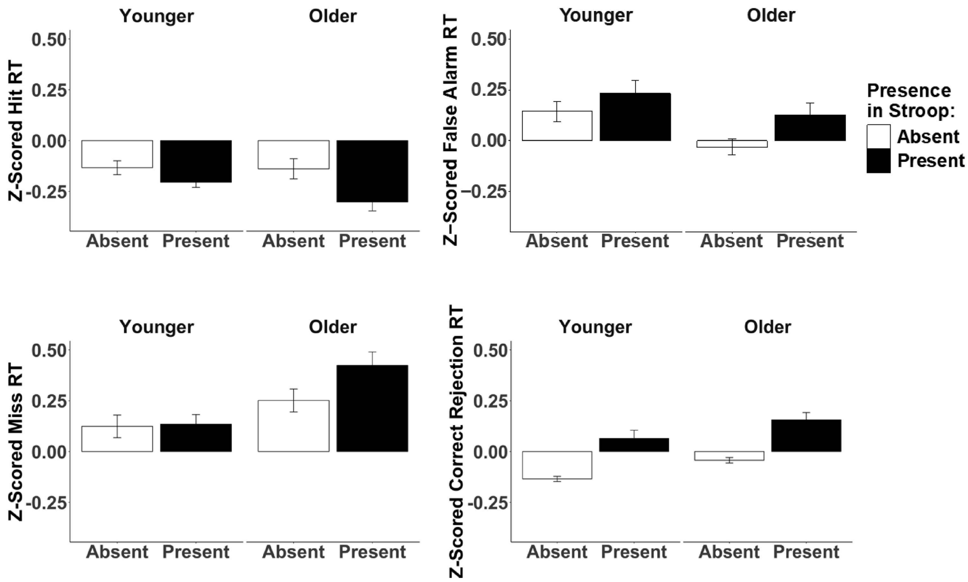

Figure 4. Z-Scored RTs for hits (top left), false alarms (top right), misses (bottom left), and correct rejections (bottom right) on the final recognition task in Experiment 1 by age group. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task. Error bars represent standard errors of the mean.

old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of z-scored miss RTs which indicated a main effect of age group, $F(1, 94) = 6.50$, $p < .05$, $\eta_p^2 = 0.03$. The age by presence in Stroop task interaction did not approach significance, $F(1, 94) = 1.06$, $p = .31$, $BF_{10} = 0.36$. For correct rejections, a two-way age (young, old) by presence in Stroop task (present in Stroop task, absent from Stroop task) ANOVA of z-scored correct rejection RTs yielded a main effect of age group, $F(1, 94) = 5.04$, $p < .05$, $\eta_p^2 = 0.03$, and presence in Stroop task, $F(1, 94) = 24.32$, $p < .001$, $\eta_p^2 = 0.11$, but no age by presence in Stroop task interaction, $F(1, 94) < 0.01$, $p = .99$, $BF_{10} = 0.20$.

Awareness questionnaire. 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]

Discussion

In summary, the Stroop results confirm an age-related deficit in controlling goal-irrelevant information. However, there was no evidence from the recognition task that there was any age-related difference in sensitivity to the words in the Stroop task, even though the recognition test was clearly sensitive to the presence of the words in the Stroop task. Both age groups were affected in a remarkably consistent way in recognition hit and false alarm rates along with z-scored latencies for hits, false alarms, misses, and correct rejections. Clearly, the results from Experiment 1 place constraints on the generalizability of older adults' memory being more susceptible to distracting words in the Stroop task, compared with younger adults.

Although we predicted that the familiarity component of recognition performance may be sensitive to increased processing of distracting information in our older adults, it is possible that the explicit nature of recognition memory tests may have minimized our sensitivity to detect the predicted age-related difference. Indeed, the results from Experiment 1 might be expected based on the results from Gopie et al. (2011). Specifically, Gopie et al. (2011) found that on explicit tasks, compared with older adults, younger adults were more influenced by the words presented in an earlier color naming Stroop task, whereas, in an implicit task, one finds that older are more influenced. Possibly, because recognition performance combines both explicit recollective processes and more implicit familiarity processes, these counteracted each other in the current study to yield a null effect. Of course, it should be noted that because Amer et al. (2018) did not replicate the earlier pattern with younger adults, one needs to be cautious about this interpretation. However, it is still possible that the more explicit contribution of episodic recognition is critical here so we therefore wanted to examine these effects using a more implicit memory task.

Experiment 2

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

[3] Thomas and Hasher (2012) also reported that: (a) the pattern of results from aware younger adults did not differ from that of the unaware younger adults in their sample, (b) that aware young adults recalled a comparable number of distracting words as new words, and (c) that when aware and unaware younger adult data was combined that the pattern of results was identical to those reported for only unaware participants.

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 that were earlier presented in the Stroop task as compared with 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 during the initial study task.

Method

Participants. As shown in Table 1, older adults had more education than the younger adults, but did not differ on Shipley vocabulary measures. Forty-two younger and 42 older adult participants completed Experiment 2. In order to insure we had sufficient power to detect any age-related consequences of processing the Stroop neutral words in the final gradual demasking task, we included a sample of 42 younger and 42 older adults, which affords power of 0.99 for an alpha of 0.05.

Materials. Experiment 2 used a list of 144 concrete nouns, which added 24 words to the 120 words from Experiment 1 to increase power. The same six list counterbalancing structure used in Experiment 1 was used in this experiment.

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 in size 20-point bold Arial font 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 the strength of the initial encoding and minimize potential age-differences in encoding. This pleasantness task was followed by the Stroop task which was identical to Experiment 1 with the exception of an increased number of trials in Experiment 2 to 48 words in the congruent, neutral, and incongruent conditions.

After completing the Stroop task, participants again completed the Trails B task before taking a 10-min break, which was followed by the instructions for the gradual demasking task.

During the gradual demasking task, each trial began with a presentation of pound signs ("#####") at the center of the screen for 500 ms followed by a presentation of the target word for 16 ms in size 20-point bold Arial font. 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. After pressing the spacebar, the word disappeared from the screen and the participant was asked to tell the experimenter the word they identified. 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 (a) if they noticed a connection between any of the tasks, (b) if yes, what connection they noticed, (c) if they used their memory of the items to help them on the final task, and (d) if they used any other strategies to help them on the final task.

Results

Stroop task. Figure 5 displays z-scored Stroop task RTs as a function of trial type and age group. Similar to our results from Experiment 1, older adults showed disproportionate Stroop interference compared with younger adults. This pattern was confirmed by an age (young, old) by trial type (congruent, incongruent, neutral) ANOVA which indicated a significant age by trial type interaction, $F(2, 164) = 12.00$, $p < .001$, $\eta_p^2 = 0.12$. Follow-up analyses confirm that the incongruent condition was slower in older adults compared with younger adults, $t(81.87) = 5.92$, $p < .001$, $d = 1.29$, and the congruent condition was numerically faster in older adults compared with younger adults, $t(79.83) = 1.58$, $p = .12$, $d = 0.34$, suggesting increased difficulty inhibiting the irrelevant word dimension for older adults, compared with younger adults. These results replicated our findings from Experiment 1 confirming the control deficit in older adults after accounting for generalized slowing.

Gradual demasking task. Figure 6 displays the mean proportion of correct responses on the demasking task as a function of presence in the Stroop task and age group. As expected, all participants were near ceiling in accuracy on this task. Overall, younger adults were slightly more accurate than older adults and participants were more accurate in identifying words that were studied compared with words that were not studied. These results were confirmed by an 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, $F(1, 82) = 16.33$, $p < .001$, $\eta_p^2 = 0.08$, and study, $F(1, 82) = 7.92$, $p < .05$, $\eta_p^2 = 0.02$. There was no evidence of an age by presence in Stroop task interaction, $F(1, 82) = 0.01$, $p = .93$, $BF_{10} = 0.16$.

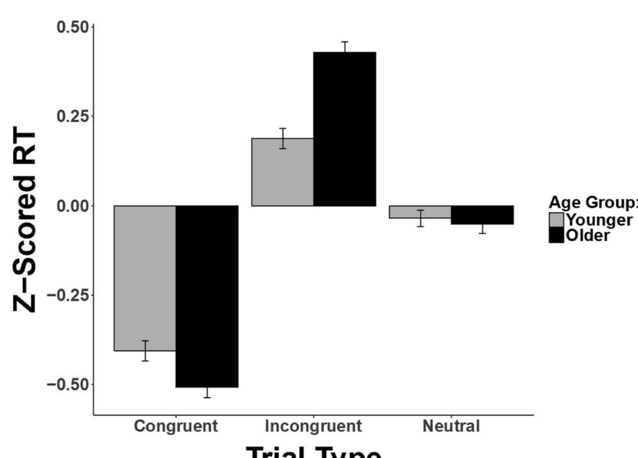

Figure 5. Mean z-scored RTs to name ink color for younger and older adults in Experiment 2. Error bars represent standard errors of the mean.

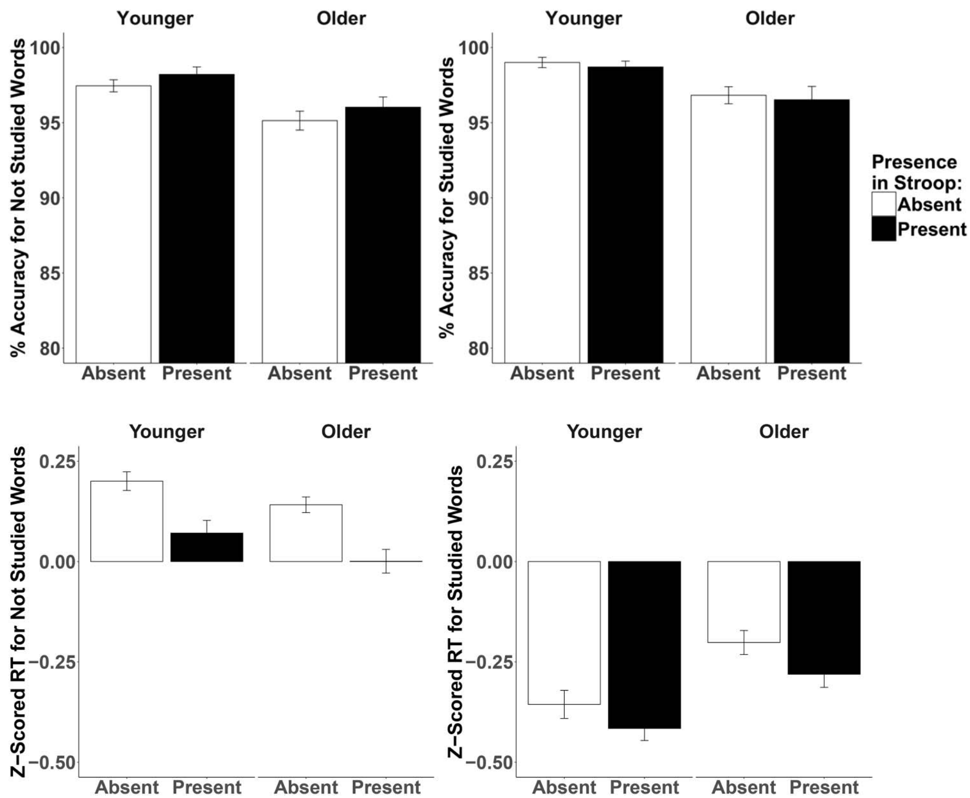

Figure 6. Mean proportion of correctly identified not studied (top left) or studied (top right) words in the gradual demasking task and mean z-scored RT to identify not studied (bottom left) or studied (bottom right) for younger and older adults in Experiment 2. Black bars indicate words that were present in the Stroop task as distractors and white bars indicate words that were absent from the Stroop task. Error bars represent standard errors of the mean.

Figure 6 also displays the more important mean z-scored RTs for correctly identifying the words during the demasking task. The notion here is that any implicit influence of the presence in the Stroop task should influence how quickly the stimuli can be identified in the demasking task. As expected, 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, that is, a type of repetition priming. Additionally, younger adults showed a greater priming effect (faster to identify studied words than nonstudied words) than older adults. However, consistent with the demasking task accuracy results and the results from Experiment 1, older adults did not show any advantage over younger adults in identifying words present in the Stroop task compared with words that were absent from the Stroop task. This occurred for both studied and nonstudied words, and importantly, to the same degree for younger and older adults. These observations were confirmed by an 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, $F(1, 82) = 405.30$, $p < .001$, $\eta_p^2 = 0.23$, presence in Stroop task, $F(1, 82) = 24.39$, $p < .001$, $\eta_p^2 = 0.02$, and an interaction between age and study, $F(1, 82) = 25.5$, $p < .001$, $\eta_p^2 = 0.02$. However, neither the critical age by distractor interaction, $F(1, 82) = 0.14$, $p = .71$, $BF_{10} = 0.12$, nor the age by study by presence in Stroop interaction approached significance, $F(1, 82) = 0.01$, $p = .93$.

Awareness questionnaire. 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.

Discussion

Results from the Stroop task in Experiment 2 replicated those found in Experiment 1 confirming an attentional control deficit in older adults, not explained by generalized slowing. Hence, compared with younger adults, older adults appeared to have an impaired ability to control the goal-irrelevant word dimension. Turning to the demasking results, we failed to find any evidence of older adults being more influenced by the words in the neutral condition compared with the younger adults. Of course, it is possible that the demasking task may not be as sensitive of an implicit measure as the general knowledge test used by Amer and Hasher (2014) study. This is purely speculative, since we are unaware of any direct comparisons of these tasks in the literature. At this point, it should be noted that the effects reported in the original Amer and Hasher (2014) study were relatively small (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, $p < .05$, and had a medium effect size of $d = 0.6$). Hence, in order to test if this pattern is robust we decided to attempt to replicate this original study with the identical conditions and stimuli, and sufficient statistical power.

Experiment 3

Method

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 $\alpha = .05$ and power $= 0.80$, the projected sample size needed with this effect size (GPower 6; Faul, Erdfelder, Lang, & Buchner, 2007) was 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.

Materials. Materials were the same items used by Amer and Hasher (2014), which included a Stroop task and a general knowledge task. Each participant saw 40 words during the Stroop task, 20 of these words were designated as answers to questions during the later general knowledge task (i.e., critical items). The other 20 words 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, following Amer and Hasher, 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. Stimuli were presented in 20-point bold Arial font. 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 (2014), there were no congruent or incongruent trials in the Stroop task.

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 followed by 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 a response was made or 2,000 ms had expired with a 2,000-ms ISI. Participants received a seven-item practice Stroop task including only congruent and incongruent trials. During the actual Stroop task, participants first saw six buffer words presented as a primacy buffer. Next, the 40 words were presented (20 critical and 20 filler words) in random order. Finally, six 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 minimize the connection between the Stroop and general knowledge tasks.

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 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. Afterward, participants completed a health and demographic questionnaire, the Morningness-Eveningness Questionnaire (Horne & Östberg, 1976), the Shipley vocabulary test (Shipley, 1946), and a general trivia task comprised of 100 questions (drawn from Nelson & Narens, 1980 norms and used in Weinstein & Roediger, 2010). Lastly, older adults were administered the MMSE (Mini-Mental State Examination), SBT (Short Blessed Test), and MoCA (Montreal Cognitive Assessment; in that order; Mini-Mental State Examination; Short Blessed Test; Montreal Cognitive Assessment; Folstein, Folstein, & McHugh, 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.

The procedure was identical to that used by Amer and Hasher (2014) with only two exceptions: (a) the addition of the Weinstein and Roediger, 2010 general trivia questionnaire at the end of the experiment session, and (b) the fact that we did not use a touch screen version of the Corsi block task and participants instead used a computer mouse to click on the squares on the screen rather than touching the squares with their fingers. Neither of these differences are likely to contribute to the differences across the two studies.

Results

First, we present analyses on Stroop task RTs 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 with younger adults.

Stroop task. 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, $t(73.98) = 0.17$, $p > .5$, $d = 0.04$. Also, as expected due to general slowing, and observed in Amer and Hasher (2014), younger adults ($M = 644$ ms, $SD = 81$ ms) responded faster on the Stroop task than older adults ($M = 1{,}016$ ms, $SD = 115$ ms), $t(66.43) = 16.22$, $p < .001$, $d = 3.72$.

General knowledge test. In contrast to the findings of Amer and Hasher (2014), older adults ($M = 0.22$, $SD = 0.13$) did not correctly answer more baseline questions than younger adults ($M = 0.23$, $SD = 0.15$), $t(72.37) = 0.34$, $p > .5$, $d = 0.08$.

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. Older adults did not show an advantage over younger adults in conceptual priming for distractors, $t(72.46) = 1.09$, $p = .28$, $d = 0.25$, $BF_{10} = 0.32$. Furthermore, in direct contrast to the findings reported in Amer and Hasher (2014), reliable conceptual priming was observed in younger adults,[4] $t(37) = 2.88$, $p < .01$, $d = 0.47$, but not older adults, $t(37) = 1.05$, $p = .30$, $d = 0.17$.

Awareness questionnaire. Eight younger adults and three 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.

Discussion

Results from Experiment 3 failed to provide evidence of more conceptual processing of distractor information for older adults over that of younger adults. While the results from Experiments 1 and 2 suggested that both younger and older adults processed the distractor words in the Stroop task, Experiment 3 suggested that only younger adults benefited from the critical items (general knowledge task answers displayed earlier 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 preexisting knowledge may impact the ease of priming, this is an important difference between the sample used in the original Amer and Hasher (2014) study and our replication. However, it is important to note that our older adult sample did outperform younger adults on the separate set of 100 trivia questions we included, $t(65.05) = 2.01$, $p < .05$, $d = 0.46$ (drawn from Nelson & Narens, 1980 norms and used in Weinstein & Roediger, 2010), and the Shipley vocabulary test ($p < .001$).

General Discussion

Across three experiments, the hypothesis that older adults are more likely to benefit on speed and accuracy of episodic recognition memory and implicit memory from processing goal-irrelevant word information in the Stroop task was tested. Results from the Stroop tasks from Experiments 1 and 2 confirmed an attentional control deficit in older adults after controlling for age-related slowing. 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 the z-scored Stroop effects replicated across Experiments 1 and 2 may be due to the relatively large set of different words used on the neutral trials, which may have led older adults to emphasize the word dimension more. 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.

Although the Stroop task yielded converging evidence from Experiments 1 and 2 that older adults had difficulty controlling the word dimension, we failed to find evidence that there was any lingering age-related difference on later memory measures, as indexed by episodic recognition performance, gradual demasking task performance, or conceptual priming scores (Experiments 1, 2, and 3, respectively).[5] Hasher and colleagues have argued that an age difference in the ability to suppress goal-irrelevant information in the Stroop task leads to increased processing, and later memory, of the goal-irrelevant information (Amer et al., 2016). However, our results suggest that while older adults indeed struggled to control the word information in the Stroop task more than younger adults, both age groups seemed to process and use this information on subsequent memory tasks to the same extent.

Our third experiment was an exact replication of Amer and Hasher (2014), which used an a priori power analysis and failed to find an age-difference in conceptual priming. Given conflicting evidence in the literature regarding the consequences of processing unattended information on later memory performance (Amer et al., 2018; Dywan & Murphy, 1996; Gopie, Craik, and Hasher, 2011; Hoffman, Bein, & Maril, 2011; Kemper, McDowd, Metcalf, & Liu, 2008), small effect sizes, and concerns about the reproducibility of psychological science (Open Science Collaboration, 2015), replications like this are useful in assessing the stability of effects reported in the extant literature.

Given that older adults in Experiments 1 and 2 reliably produced disproportionate Stroop interference effects compared with younger adults, indicating greater difficulty inhibiting irrelevant information, one might have expected better memory performance in the recognition and demasking memory tasks. On a theoretical level, we believe these results are consistent with the notion that memory, as indexed by these measures, is reflective of processes that occur outside the act of attentional selection in the Stroop task. Specifically, participants are processing these words in a shallow manner, independent of the selection process. Indeed, as noted in Footnote 5, there is no evidence of a relationship between the Stroop interference effect and memory performance in these tasks. In fact, one might argue that we have created conditions which are likely to produce age invariance. Specifically, the novel tasks we used to test the inhibition/memory hypothesis (e.g., recognition and demasking) provide considerable environmental support, which has been shown to produce relatively small age effects (e.g., Craik, 1983). Moreover, the encoding of the

[4] As one reviewer pointed out, there are multiple factors that have been identified which influence inhibitory effects in younger adults, such as time of day (May, 1999; Rowe, Valderrama, Hasher, & Lenartowicz, 2006), mood (Biss & Hasher, 2011), and cultural background (Amer, Ngo, & Hasher, 2017; Ngo, Amer, Man, & Hasher, 2018). Adding time of day and cultural background (optimal vs. nonoptimal, of East Asian descent vs. not of East Asian descent) to our ANOVA models from all three studies did not modulate any of the reported effects. However, given only a limited sample of our participants were of East Asian descent or were tested at their nonoptimal time of day, sample sizes may not be large enough to detect these differences.

[5] We also tested for a relationship between Stroop effect and memory or RT for words that were present in the Stroop task compared with absent from the Stroop task. We tested several regressions: (a) distractor recognition zRT ~ Stroop Effect * Age Group; (b) distractor recognition accuracy ~ Stroop Effect * Age Group; (c) distractor demasking zRT ~ Stroop Effect * Age Group; and (d) distractor demasking accuracy ~ Stroop Effect * Age Group and none showed any effects.

words during color naming could be considered a relatively shallow encoding task (akin to case judgments). Indeed, there is evidence that shallow encoding tasks produce smaller age effects compared with deeper encoding tasks (see, Duchek, 1984). Thus, although older adults may have more difficulty inhibiting goal-irrelevant information (as reflected by the disproportionate Stroop interference effect), this does not lead to increased memory because memory encoding in this task is reflective of processes engaged independent of selection. Ultimately, this view would not be inconsistent with the inhibitory deficit hypothesis but rather suggests that at least in the Stroop task, the memory encoding is not tied to the selection of the color, but rather tied to shallow encoding processes, independent of selection, which in the current tasks appear age-invariant.

Of course, it is important to note that we only tested one type of suppression task here, that is, the Stroop task. We decided to focus on a single task in this study to fully understand the ramifications of the consequences of a failure in attentional control on distinct memory measures. Therefore, the results and arguments presented in this article only address the Stroop task and cannot speak to other evidence in the literature using distractor tasks such as 1-back tasks (Biss et al., 2013) or reading-with-distraction tasks (Kim, Rasher, & Zacks, 2007; Thomas & 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, may have contributed to age-invariant processing of the distractor word, as compared with 1-back or reading-with-distraction tasks. Another limitation of the Stroop-specific paradigms employed here is that it may be the case that the inclusion of congruent and incongruent trials (not done in the original experiments) may have modulated participants attention to the neutral trial words. Indeed, evidence from Bugg, McDaniel, Scullin, and Braver (2011) and Tzelgov, Henik, and Berger (1992) suggests that the magnitude of Stroop interference can be manipulated by altering the proportion of congruent to incongruent trials as well as changing the percentage of color words in the paradigm. It is possible that younger adults were more sensitive to the presence of congruent and incongruent items in the current paradigm than the Hasher et al. studies, and this may have directed attention to the neutral items, increasing their memory for these items. Although possible, it is unclear why older adults would not also produce such an effect, especially in light of their increased overall Stroop interference effect.

A second potential limitation of Experiments 1 and 2 is the issue of participant awareness. Hasher and colleagues reported excluding participants who reported 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 how quickly or accurately participants identified words during the demasking task. Although 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 & Hasher, 2018), there is also evidence that this does not modulate performance (see Thomas & Hasher, 2012). The theory that older adults' reduced attentional control may lead to increased subsequent memory may need to be more clearly defined in future studies if it is indeed modulated by conscious awareness. Importantly, the results from Experiment 3 indicated that relatively few participants noticed a relationship and the exclusion of these participants did not modulate the results, and there was evidence of this modulating performance in Experiment 1.

In sum, the present results suggest that while older adults are disproportionately influenced by the word dimension in the Stroop task there is no evidence that their memory performance (across three tasks) was more likely to be influenced by such goal-unrelated information. Hence, we believe that further work is needed to better understand which conditions afford benefits of the age-related deficit in processing goal-irrelevant information.

References

Amer, T., Anderson, J. A. E., & Hasher, L. (2018). Do young adults show conceptual knowledge of previous distractors? *Memory, 26,* 251–259. http://dx.doi.org/10.1080/09658211.2017.1347187

Amer, T., Campbell, K. L., & Hasher, L. (2016). Cognitive control as a double-edged sword. *Trends in Cognitive Sciences, 20,* 905–915. http://dx.doi.org/10.1016/j.tics.2016.10.002

Amer, T., & Hasher, L. (2014). Conceptual processing of distractors by older but not younger adults. *Psychological Science, 25,* 2252–2258. http://dx.doi.org/10.1177/0956797614555725

Amer, T., Ngo, K. W., & Hasher, L. (2017). Cultural differences in visual attention: Implications for distraction processing. *British Journal of Psychology, 108,* 244–258. http://dx.doi.org/10.1111/bjop.12194

Aschenbrenner, A. J., & Balota, D. A. (2015). Interactive effects of working memory and trial history on Stroop interference in cognitively healthy aging. *Psychology and Aging, 30,* 1–8. http://dx.doi.org/10.1037/pag0000012

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., . . . Treiman, R. (2007). The English lexicon project. *Behavior Research Methods, 39,* 445–459. http://dx.doi.org/10.3758/BF03193014

Biss, R. K., & Hasher, L. (2011). Delighted and distracted: Positive affect increases priming for irrelevant information. *Emotion, 11,* 1474–1478. http://dx.doi.org/10.1037/a0023855

Biss, R. K., Ngo, K. W., Hasher, L., Campbell, K. L., & Rowe, G. (2013). Distraction can reduce age-related forgetting. *Psychological Science, 24,* 448–455. http://dx.doi.org/10.1177/0956797612457386

Blaxton, T. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 657–668. http://dx.doi.org/10.1037/0278-7393.15.4.657

Bugg, J. M., McDaniel, M. A., Scullin, M. K., & Braver, T. S. (2011). Revealing list-level control in the Stroop task by uncovering its benefits and a cost. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 1595–1606. http://dx.doi.org/10.1037/a0024670

Campbell, K. L., & Hasher, L. (2018). Hyper-binding only apparent under fully implicit test conditions. *Psychology and Aging, 33,* 176–181. http://dx.doi.org/10.1037/pag0000216

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cohn, N. B., Dustman, R. E., & Bradford, D. C. (1984). Age-related decrements in Stroop color test performance. *Journal of Clinical Psychology, 40,* 1244–1250. http://dx.doi.org/10.1002/1097-4679(198409)40:5<1244::AID-JCLP2270400521>3.0.CO;2-D

Comalli, P. E., Jr., Wapner, S., & Werner, H. (1962). Interference effects of Stroop color-word test in childhood, adulthood, and aging. *The Journal of Genetic Psychology, 100,* 47–53. http://dx.doi.org/10.1080/00221325.1962.10533572

Corsi, P. M. (1972). Human memory and the medial temporal region of the brain. *Dissertation Abstracts International, 34*(02), 819B. (University Microfilms No. AAI05-77717)

Craik, F. I. M. (1983). On the transfer of information from temporary to permanent memory. *Philosophical Transactions of the Royal Society of London Series B, Biological Sciences, 302,* 341–359. http://dx.doi.org/10.1098/rstb.1983.0059

Craik, F., & McDowd, J. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 474–479. http://dx.doi.org/10.1037/0278-7393.13.3.474

Duchek, J. (1984). Encoding and retrieval differences between young and old: The impact of attentional capacity usage. *Developmental Psychology, 20,* 1173–1180. http://dx.doi.org/10.1037/0012-1649.20.6.1173

Dywan, J., & Murphy, W. E. (1996). Aging and inhibitory control in text comprehension. *Psychology and Aging, 11,* 199–206. http://dx.doi.org/10.1037/0882-7974.11.2.199

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191. http://dx.doi.org/10.3758/BF03193146

Faust, M. E., Balota, D. A., Spieler, D. H., & Ferraro, F. R. (1999). Individual differences in information-processing rate and amount: Implications for group differences in response latency. *Psychological Bulletin, 125,* 777–799. http://dx.doi.org/10.1037/0033-2909.125.6.777

Ferrand, L., Brysbaert, M., Keuleers, E., New, B., Bonin, P., Méot, A., . . . Pallier, C. (2011). Comparing word processing times in naming, lexical decision, and progressive demasking: Evidence from Chronolex. *Frontiers in Psychology, 2,* 1–10. http://dx.doi.org/10.3389/fpsyg.2011.00306

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state:" A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198. http://dx.doi.org/10.1016/0022-3956(75)90026-6

Gopie, N., Craik, F. I., & Hasher, L. (2011). A double dissociation of implicit and explicit memory in younger and older adults. *Psychological Science, 22,* 634–640. http://dx.doi.org/10.1177/0956797611403321

Hartley, A. A. (1993). Evidence for the selective preservation of spatial selective attention in old age. *Psychology and Aging, 8,* 371–379. http://dx.doi.org/10.1037/0882-7974.8.3.371

Hasher, L., & Zacks, R. (1988). Working memory, comprehension, and aging: A review and a new view. *Psychology of Learning and Motivation, 22,* 193–225. http://dx.doi.org/10.1016/S0079-7421(08)60041-9

Hoffman, Y., Bein, O., & Maril, A. (2011). Explicit memory for unattended words: The importance of being in the "no." *Psychological Science, 22,* 1490–1493. http://dx.doi.org/10.1177/0956797611419674

Horne, J. A., & Östberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiology, 4,* 97–110.

Katzman, R., Brown, T., Fuld, P., Peck, A., Schechter, R., & Schimmel, H. (1983). Validation of a short orientation-memory-concentration test of cognitive impairment. *The American Journal of Psychiatry, 140,* 734–739. http://dx.doi.org/10.1176/ajp.140.6.734

Kemper, S., McDowd, J., Metcalf, K., & Liu, C. J. (2008). Young and older adults' reading of distracters. *Educational Gerontology, 34,* 489–502. http://dx.doi.org/10.1080/03601270701835858

Kim, S., Rasher, L., & Zacks, R. T. (2007). Aging and a benefit of distractibility. *Psychonomic Bulletin & Review, 14,* 301–305. http://dx.doi.org/10.3758/BF03194068

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109,* 163–203.

May, C. P. (1999). Synchrony effects in cognition: The costs and a benefit. *Psychonomic Bulletin & Review, 6,* 142–147. http://dx.doi.org/10.3758/BF03210822

Millar, P. R., Balota, D. A., Maddox, G. B., Duchek, J. M., Aschenbrenner, A. J., Fagan, A. M., . . . Morris, J. C. (2017). Process dissociation analyses of memory changes in healthy aging, preclinical, and very mild Alzheimer's disease: Evidence for isolated recollection deficits. *Neuropsychology, 31,* 708–723. http://dx.doi.org/10.1037/neu0000352

Morey, R. D., Rouder, J. N., & Jamil, T. (2015). BayesFactor: Computation of Bayes factors for common designs. *R package version 0, 9, 9*.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53,* 695–699. http://dx.doi.org/10.1111/j.1532-5415.2005.53221.x

Nelson, T., & Narens, L. (1980). Norms of 300 general-information questions: Accuracy of recall, latency of recall, and feeling-of-knowing ratings. *Journal of Verbal Learning and Verbal Behavior, 19,* 338–368. http://dx.doi.org/10.1016/S0022-5371(80)90266-2

Ngo, K. W. J., Amer, T., Man, L., & Hasher, L. (2018). Cultural differences in distraction processing: Influence of context at retrieval. *Memory, 26,* 1396–1401. http://dx.doi.org/10.1080/09658211.2018.1483517

Olejnik, S., & Algina, J. (2003). Generalized eta and omega squared statistics: Measures of effect size for some common research designs. *Psychological Methods, 8,* 434–447. http://dx.doi.org/10.1037/1082-989X.8.4.434

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science, 349,* aac4716. http://dx.doi.org/10.1126/science.aac4716

Panek, P., Rush, M., & Slade, L. (1984). Locus of the age-Stroop interference relationship. *The Journal of Genetic Psychology, 145,* 209–216. http://dx.doi.org/10.1080/00221325.1984.10532268

Psychology Software Tools, Inc. (2016). Retrieved from https://www.pstnet.com

Reitan, R., & Wolfson, D. (1985). *The Halstead-Reitan Neuropsychological Test Battery: Therapy and clinical interpretation*. Tucson, AZ: Neuropsychological Press.

Rowe, G., Hasher, L., & Turcotte, J. (2008). Age differences in visuospatial working memory. *Psychology and Aging, 23,* 79–84. http://dx.doi.org/10.1037/0882-7974.23.1.79

Rowe, G., Valderrama, S., Hasher, L., & Lenartowicz, A. (2006). Attentional disregulation: A benefit for implicit memory. *Psychology and Aging, 21,* 826–830. http://dx.doi.org/10.1037/0882-7974.21.4.826

Shipley, W. (1946). *The Shipley Institute of Living Scale*. Los Angeles, CA: Western Psychological Services.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 174–215. http://dx.doi.org/10.1037/0278-7393.6.2.174

Spieler, D. H., Balota, D. A., & Faust, M. E. (1996). Stroop performance in healthy younger and older adults and in individuals with dementia of the Alzheimer's type. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 461–479. http://dx.doi.org/10.1037/0096-1523.22.2.461

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662. http://dx.doi.org/10.1037/h0054651

Thomas, R. C., & Hasher, L. (2012). Reflections of distraction in memory: Transfer of previous distraction improves recall in younger and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 30–39. http://dx.doi.org/10.1037/a0024882

Tzelgov, J., Henik, A., & Berger, J. (1992). Controlling Stroop effects by manipulating expectations for color words. *Memory & Cognition, 20,* 727–735. http://dx.doi.org/10.3758/BF03202722

Verhaeghen, P., & De Meersman, L. (1998). Aging and the Stroop effect: A meta-analysis. *Psychology and Aging, 13,* 120–126. http://dx.doi.org/10.1037/0882-7974.13.1.120

Wagenmakers, E. J., Morey, R. D., & Lee, M. D. (2016). Bayesian benefits for the pragmatic researcher. *Current Directions in Psychological Science, 25,* 169–176. http://dx.doi.org/10.1177/0963721416643289

Weinstein, Y., & Roediger, H. L., III. (2010). Retrospective bias in test performance: Providing easy items at the beginning of a test makes students believe they did better on it. *Memory & Cognition, 38,* 366–376. http://dx.doi.org/10.3758/MC.38.3.366

Yonelinas, A. P., & Jacoby, L. L. (2012). The process-dissociation approach two decades later: Convergence, boundary conditions, and new directions. *Memory & Cognition, 40,* 663–680. http://dx.doi.org/10.3758/s13421-012-0205-5

Zacks, R., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 241–264). San Diego, CA: Academic Press.

Received January 8, 2019
Revision received May 8, 2019
Accepted May 11, 2019 ■