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Research Article

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The Impact of Focusing on Different Features During Encoding on Young and Older Adults' Source Memory

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Abstract: Age-related source memory deficits result, in part, because young and older adults attend to different information. We asked whether focusing young and older adults' attention on specific features at encoding would result in similar subjective experiences of the vividness of the features and how this might affect source memory. Ratings of the vividness of visual detail, emotion, and associations were similar for young and older adults both when they were perceiving pictures and when they were thinking about them after a brief delay. Although young adults had better source memory than older adults, source accuracy did not differ depending on feature attended, and correlations between ratings and source memory showed that focus on the different types of information was equally predictive of source memory accuracy for young and older adults. Although preliminary, the results suggest that when attention is focused on specific information at encoding, young and older adults later use the various categories of source-specifying information similarly in making source attributions. Nevertheless, older adults did worse on the source test, suggesting they had less discriminable source information overall, this information was not well bound, and/or they experienced difficulty in strategic retrieval and monitoring processes.

Keywords: Aging, Encoding, Focused Attention, Source Memory

Accumulating evidence suggests that older adults focus on (i.e., consider, weight, use) different, and often less diagnostic, information in making episodic memory judgments, compared to young adults (Gallo, 2013; Johnson, Kuhl, Mitchell, Ankudowich, & Durbin, 2015; Mitchell, Ankudowich, Durbin, Greene, & Johnson, 2013). For example, whereas young adults tend to rely on perceptual details in assessing their memories, older adults tend to rely more on semantic, conceptual, or emotional information than perceptual information (Hashtroudi, Johnson, & Chrosniak, 1990; Ly, Murray, & Yassa, 2013; May, Rahhal, Berry, & Leighton, 2005; Mitchell et al., 2013; Rahhal, May, & Hasher, 2002)—even when implicit measures suggest older adults have encoded perceptual detail (Koutstaal, 2003). Relative to young adults, older adults provide more semantic details in recalling autobiographical events (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002) and produce more semantically-related memory errors (e.g., Balota et al., 1999; Kouststaal, Reddy, Jackson, Prince, Cendan, & Schacter, 2003; Mitchell, Johnson, & Mather, 2003).

Thus, one possibility regarding older adults' typically poorer episodic memory, relative to young adults, is that regardless of whether and what specific features may be probed in a memory task, older adults'

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responses are more influenced by non-diagnostic information. Older adults may consider more (or more different kinds) of information when evaluating their memories than do young adults. This may especially influence performance on tasks that require controlled or strategic use of specific details, such as source identification tasks, and subjective memory measures such as confidence or vividness. For example, in rating the *visual* vividness of their memories older adults may consider how they felt about the item or how it relates to other things they know (Johnson et al., 2015) rather than focus exclusively on perceptual details. Consistent with such a hypothesis, in spite of objectively worse memory for specific details, older adults often do not give lower ratings, and sometimes even give higher ratings, of their subjective experience of the qualitative characteristics of their episodic memories relative to young adults (e.g., Comblain, D'Argembeau, & Van der Linden, 2005; Hashtroudi et al., 1990; Henkel, Johnson, & De Leonardis, 1998; Karpel, Hoyer, & Toglia, 2001; McDonough, Cervantes, Gray, & Gallo, 2014; McGinnis & Roberts, 1996; Norman & Schacter, 1997; Rubin & Schulkind, 1997). In short, evidence seems to suggest that older adults' episodic memory problems may arise not simply because they have less information available during remembering than young adults (Campbell, Grady, Ng, & Hasher, 2012), but rather what is being monitored (attended to, focused on, revived, evaluated, used) at any given time may sometimes not be the most diagnostic information (Gallo 2013; Johnson et al., 2015; Mitchell et al., 2013). Whether such differences in focus occur at encoding or during remembering or both is not yet clear.

One approach used to explore this issue has been to orthogonally cross to-be-tested features within each stimulus at encoding (e.g., visual and affective details), such that every stimulus contains both features, and then test memory for each feature separately (e.g., May et al., 2005; Mitchell et al., 2013; Rahhal et al., 2002). At study, participants are typically just told to remember all the information (i.e., intentional encoding, e.g., May et al., 2005; Rahhal et al., 2002), or are given an unrelated encoding task (i.e., incidental encoding, e.g., Mitchell et al., 2013). The assumption is that young and older participants encode both features, and thus any differences must reflect differences at test. However, this procedure does not necessarily constrain young and older adults' focus on the same details at encoding-- they still could differentially attend to the features, either as they view the items (what we call *perceptual focus*) or as they continue to think about the items later (what we call *reflective focus*). One possible reason for such differential encoding in spite of the features co-occuring could be older adults' difficulty restricting their attention to relevant information (e.g., Hasher, Lustig, & Zacks, 2007; Lustig, Hasher, & Zacks, 2007), especially during reflection (Mitchell, Johnson, Higgins, & Johnson, 2010).

Here we took a different approach to better control, and presumably equate, young and older adults' attention at encoding. We explicitly constrained which features of the items were attended via direct focus manipulations (e.g., Hashtroudi, Johnson, Vnek, & Ferguson, 1994; Johnson, Nolde, & De Leonardis, 1996). We explored whether focusing young and older adults' attention on the same information at encoding might attenuate the usual age-related difference in source memory. Young and older adults saw individual pictures and rated how much visual, emotional, and associative detail they experienced as they looked at the picture (*See* trials). They then thought about half of those pictures after they were no longer visible and rated each on only one of these dimensions (visual or emotional or associative; *Think* trials). We compared young and older adults' online ratings of their subjective experience during encoding when they were seeing pictures (*focused perception*, the *See* condition) and when they were thinking about them *(focused reflection*, the *Think* condition). We also tested later source memory for the pictures, and looked at the correlations between ratings during encoding and source memory.

Our key questions were: (1) If young and older adults' focus at encoding is adequately controlled via a focus manipulation, will the two age groups have similar subjective experiences of the three types of features (visual, emotional, association)? We expected young and older adults' online ratings of the various features during encoding would be similar, given the explicit support for attending to the same information provided by our direct focus manipulation. (2) How will equating focus on the various features affect source memory? For example, might it attenuate age-related differences in source memory (e.g., Hashtroudi et al., 1994). The literature is mixed on whether equating encoding strategies between young and older adults attenuates source memory differences (e.g., Glisky, Rubin, & Davidson, 2001; Kuhlmann & Touron, 2012), so this was an open question. (3) Regardless of overall age-related differences in accuracy of source memory, will young and older adults show differential effects of focusing on the three types of features on later source memory? For example, consistent with the literature discussed previously, might visual ratings be more strongly associated with accurate source memory for young adults but emotion or association ratings be more strongly associated with accurate source memory for older adults? We expected that, under these very controlled circumstances, the different types of information might be equally diagnostic of source for young and older adults. However, we presumed that this might not necessarily attenuate the typical age-related difference in source memory performance, perhaps due to age-related difficulties in retrieval and monitoring processes (e.g., Amer, Giovanello, Grady, & Hasher, 2018; Cohn, Emrich, & Moscovitch, 2008; Mitchell, Johnson, Raye, Mather, & D'Esposito, 2000).

Method

Participants and Design

Our target n's were 24 young and 24 older adults, based on studies in the literature that contributed to our rationale (e.g., Koutstaal, 2003; May et al., 2005; Mitchell et al., 2013; Rahhal et al., 2002). Data were collected from 53 participants, but three were excluded: one older adult failed to complete the long-term memory test, one older and one younger adult scored more than 2 standard deviations below their peer group on long- term item recognition memory. Thus, the final analyses included 27 young adults and 23 older adults.

The 27 young adults included in the analyses were college students (18 females, *M age* = 19.8 yrs [*SD* = 2.5 yrs; range = 18 – 28 yrs]; one young adult did not report their age); the 23 older adults were healthy, independently living adults from surrounding communities (15 females, *M age* = 74.0 yrs [*SD* = 7.7 yrs; range = 61 – 88 yrs]). We did not collect education information from the young adults, but all were college undergraduates recruited from a pool of students in their first or second year of college (typically 12-13 completed years of education). The mean education of the older adults was 15.6 completed years (range 12-22 yrs). On a scale from 1 to 5, where 5 = *excellent*, young and older participants reported similar physical health on the day of the study (*M*s = 3.8, 4.2 for young and older adults, respectively; $p > .10$) and over the past year (*M*s = 4.2, 4.0 for young and older adults, respectively; $p > .10$), as well as similar mood on the day of the study (*M*s = 3.9, 4.0 for young and older adults, respectively; $p > .10$) and over the past year (*M*s = 3.9, 3.8 for young and older adults, respectively; $p > .10$). Older adults scored high on the Folstein Mini Mental State Examination (MMSE; $M = 28.7$ [$SD = 1.2$]; max possible = 30). The recommended MMSE cut-off for mild cognitive impairment varies, depending on the source one consults and various subject characteristics such as exact age and education level (for review and discussion see, e.g., Bravo & Hébert, 1997; Mitchell, 2009). Although one participant scored 25 on the MMSE, all others ranged from 27-30. The participant who scored 25 had a verbal WAIS score above the older adults' mean and had item recognition within one standard deviation of the older adults' mean and thus was left in the analysis. There were no age-group differences on an abbreviated version of the verbal subscale of the WAIS (*Myoung* = 23.4 [*SD* = 3.3], *Molder* = 24.0 [*SD* = 3.7], $p > .10$; max possible = 30). Informed consent was obtained from all participants. All participants were paid.

We used a 2 (Age: young, older) X 2 (Trial Type: see, think) X 3 (Feature Type: visual, emotion, association) experimental design. Age (young, older) was a between subject factor, and Trial Type and Feature Type were manipulated within subjects.

Stimuli

Pictures were culled from several sources, including the Internet (mostly via Google Images), lab archives, and the first author's personal collection of photos. They were edited for size and content. Stimuli, more specific details about sources, and any available characteristics' ratings (see below) can be obtained from the first author. Stimuli were primarily full-color photographs with a few monochromatic and black-and-white photographs, and edited to 400 x 400 pixels (see Figure 1 for samples). To maintain interest and ensure variability on the subjective ratings participants made, the pictures were complex scenes with and without people and social interactions and they varied on valence (positive, negative, neutral, as rated by a lab assistant). A short label (single word, 2- or 3-word phrase) for each picture was created and agreed upon by two raters as clearly describing the scene at a basic or subordinate level. No pictures had the same label.

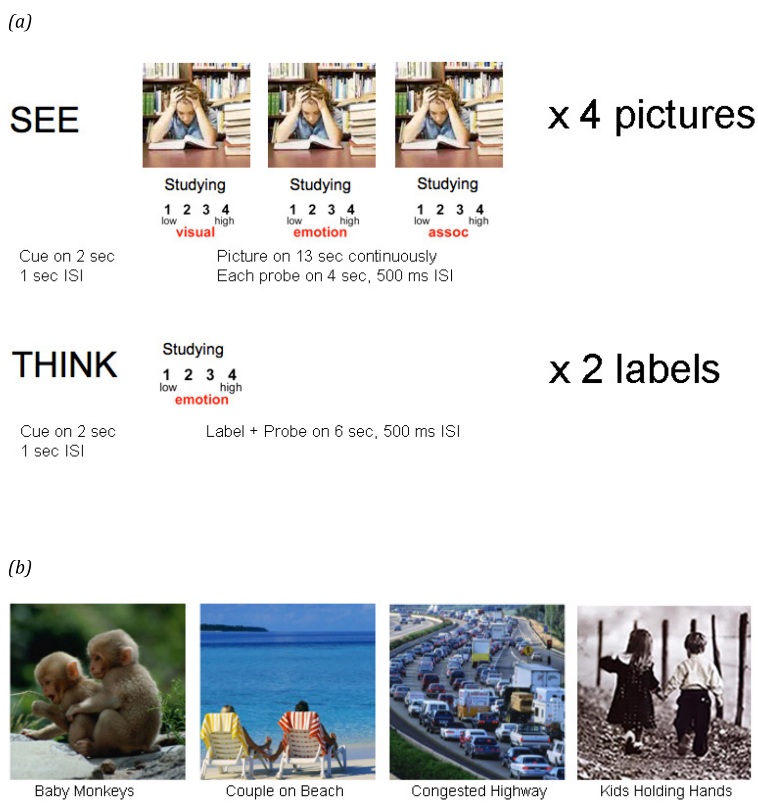

Figure 1. (a) Encoding procedure timeline; (b) Additional example stimuli.

Procedure

Participants were verbally instructed on the tasks before each phase, and practiced using stimuli not included in other phases. Instructions were clarified as necessary, and participants were permitted to practice until they were comfortable with the tasks.

Each of the 8 encoding runs had 6 See-Think cycles; each cycle was composed of 4 See trials and 2 Think trials. As shown in Figure 1, the See trials began with a 4 second cue period (cue on for 2 seconds with a 1 second blank before and after) during which participants saw the word *SEE* to remind them of the task. This was followed by 4 See trials during which each picture appeared for 13 seconds, and each of the 3 characteristics (i.e., visual, emotion, association) were probed sequentially, in the same order for all participants. Each feature probe appeared under the picture for 4 seconds with a 500 ms interstimulus interval (ISI), which produced a brief "flash" that alerted the participant that the probe was changing. Participants were instructed that when the *visual* probe appeared, they should rate the picture's visual characteristics, such as color, brightness, sharpness, and composition. They were told that when the *emotion* probe appeared they were to rate the degree, or amount, of emotion that the picture evoked, regardless of whether the emotion was positive or negative. Lastly, for the *association (assoc)* probe participants rated the extent to which the picture evoked personal associations, thoughts, or memories. It was emphasized that they should make their ratings while they were looking at the picture, and that the ratings were intended to measure their *perceptual* experience. All rating judgments for the characteristics during both the See and Think phases were made on a scale from 1 (low) to 4 (high).

After all 4 See trials were presented, participants saw the cue *THINK* presented for 2 seconds (with a 1 second blank before and after) followed by the labels that corresponded to two of the pictures seen during the just-previous See trials, presented sequentially for 6 sec each with a 500 ms ISI. A probe for just one of the characteristics (e.g., emotion) was pseudorandomly presented during each Think trial, and within each cycle both Think trials probed the same feature. Participants were instructed that when each label appeared, they should imagine the picture that had previously appeared with that label and then rate the mental image, or memory, of the picture they brought to mind with respect to the probed feature. It was emphasized that these Think ratings should be based on the same criteria described above, but that they should be based only on the image the participant could bring to mind. They were told that this rating was intended to measure their *reflective,* i.e., *mental*, experience, which was to be considered independent of their previous See ratings.

For purposes of creating balanced lists, a lab assistant determined if each photo was color/monochrome/black-and-white, positive/negative/neutral, contained people (0, 1, 2, >2), represented social interaction (yes, no), contained animals (yes, no), contained objects (0, Few, Many), was only a scene (yes, no), and was indoor/outdoor. Across different See and Think lists, items were balanced on these characteristics. Across the 12 study lists, each picture appeared equally often as See Only or See+Think, on Think trials items were chosen equally often from each ordinal See position, and items were thought about equally often with respect to each of the three features. Young and older adults received parallel lists; some lists were repeated. Each participant got 192 unique pictures during the See trials and thought about 96 of those pictures during the Think trials (32 each feature).

After the encoding phase, participants were given a surprise source memory test in which all 192 old pictures were pseudorandomly intermixed with 96 new pictures. Pictures were displayed in the middle of the screen, without the corresponding label, and for each picture participants were instructed to decide whether they had only seen the picture during the first part of the study (*See Only*), if they had seen it and thought about it during the think phase (*See+Think*), or if it was a new picture that they had never seen before in this study (*New*). The picture, as well as the response options, were displayed on the screen for 3 seconds followed by a 1 second ISI. Participants were instructed to respond while the picture was still on the screen, though responses were captured during the ISI as well. There were 4 cycles of 72 pictures each (288 items total) and within each cycle See only, See+Think, and New items were evenly and pseudorandomly distributed, as was the type of feature that was rated during the Think trials. No more than 4 old or new items appeared in succession.

Results

Online Ratings

To assess whether young and older adults' subjective experience was similar at encoding, mean ratings during See and Think trials were submitted to a 2 (Age: young, older) X 2 (Trial Type: see, think) X 3 (Feature: visual, emotion, association) mixed ANOVA, with age a between subjects factor and the other factors within subjects. See Figure 2.

The main effect of Age was not significant ($F < 1$), nor were any of the interactions involving Age (all *p*s > .10). As might be expected, there was a significant main effect of Trial Type showing that items were rated higher on See (M=2.59) than Think (M=2.49) trials (F[1,48]=20.14, p<.001, η_p^2=.30). There was also a main effect of Feature (Visual [M=2.73] > Emotion [M=2.46] = Association [M=2.43]; F[2,96]=14.89, p<.001, η_p^2=.24), as well as a significant interaction of these two factors (F[2,96]=3.21, p<.05, η_p^2=.06). This interaction resulted because whereas See ratings were higher than Think ratings for both the Visual (*M*s = 2.81, 2.63 for See and Think, respectively; t[49]=3.76, p<.001, d=.53) and Emotional features (*M*s = 2.51, 2.41 for See and Think, respectively; t[49]=3.37, p=.001, d=.48), this was not the case for Associations (*M*s = 2.45, 2.41 for See and Think, respectively; p > .10).

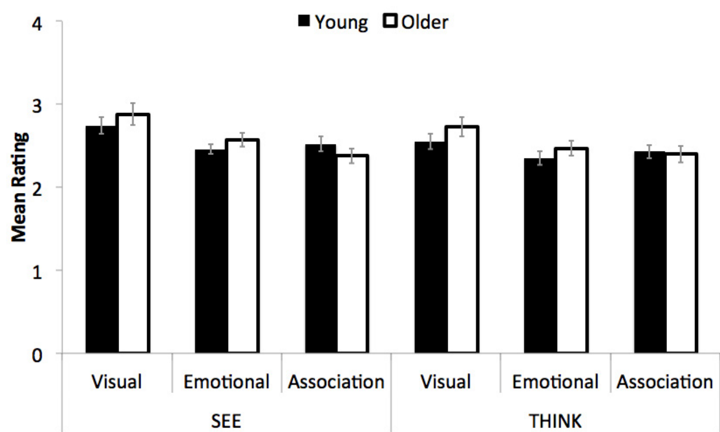

Figure 2. Young and older adults' mean online ratings during See and Think Trials for each feature type. Error bars are standard error of the mean for that bar. Maximum rating = 4.

Old-New Recognition Memory

Because one cannot identify the source of an item that is not recognized, we first assessed long-term item recognition memory for the pictures, regardless of the source attribution, using a corrected recognition score (Hits [i.e., responding See or See+Think to an old item]/Number of Old items] minus False Alarms [i.e., responding See or See+Think to a new item]/Number of New Items]). The means are shown in Table 1. Because we were primarily interested in any differential impact of type of encoding on the two age groups, we used a 2 (Age: young, older) X 4 (Encoding Condition: See Only, See+Think Visual, See+Think Emotion, See+Think Association) mixed design, with Age a between subject factor and Condition a within subject factor.

There was a main effect of Age (Young [*M*=.93] > Older [*M*=.83]; *F*[1,48]=14.28, *p*<.001, η_p^2=.23). There were no other significant main effects or interactions (all *p's* > .10).

Table 1. Mean proportion corrected old-new item recognition performance (hits minus false alarms) and standard error of the mean, regardless of source attribution, for young and older adults for items in each encoding condition

	See Only	See+Think Visual	See+Think Emotion	See+Think Associations
Young Adults	.92 [.01]	.92 [.01]	.94 [.01]	.93 [.01]
Older Adults	.83 [.03]	.83 [.03]	.84 [.02]	.84 [.03]

Source Memory

Because of the age difference in item recognition, we conditionalized source memory on old-new recognition (e.g., p[See Only response given item was See Only]/p[See or See+Think response/Number of See Items]). The means are shown in Figure 3. As with item recognition, we used a 2 (Age: young, older) X 4 (Encoding Condition: See Only, See+Think Visual, See+Think Emotion, See+Think Association) mixed design.

There was a main effect of Age (Young [*M*=.63] > Older [*M*=.51]; *F*[1,48]=8.92, *p*<.01, η_p^2=.16). There was also a main effect of Condition *F*[3,48]=4.18, *p*<.01, η_p^2=.08): See Only (*M*=.69) > See+Think Visual (*M*=.55) = See+Think Emotional (*M*=.52) = See+Think Association (*M*=.54). The Age X Condition interaction was not significant (*p*>.10).

Although false alarms to new items were fairly low, we looked at young and older adults' source misattributions as a proportion of all falsely recognized old items. We focused the analysis on "See" errors ("See" to a new item / "See" to a new item + "See+Think" to a new item [i.e., all false alarms]). For those participants making false alarms, the rate of See misattributions did not differ from .50 for either the young

(M=.60; t[22]=1.36, p=.188) or older (M=.57 t[21]=.882, p=.388) adults. There also was no significant difference between young and older adults (t[43]=.30, p=.766). (Note: 4 young and 1 older adult were removed from this analysis because they had no false alarms.)

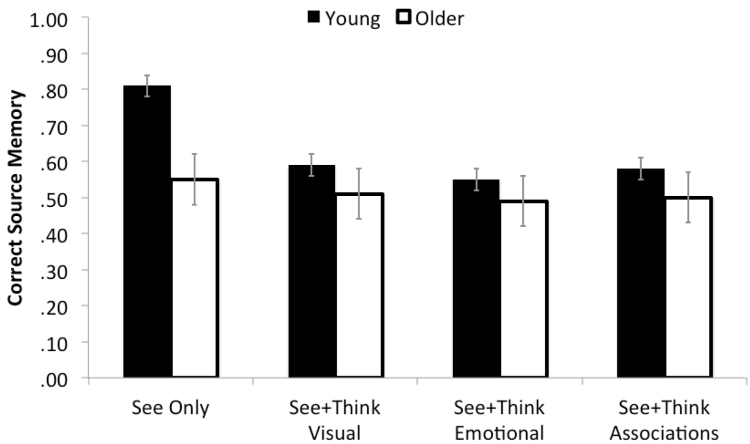

Figure 3. Young and older adults' mean correct source memory for recognized pictures for each encoding trial type. Error bars are standard error of the mean for that bar. Chance source memory would be .33 given three response options.

Correlations between Ratings and Source Memory

To more directly assess how focusing on particular features impacted source memory, we conducted point biserial correlations between ratings on each feature and source memory performance in See and Think trials for young and older adults separately. See and Think analyses were run separately because the Think items for each rating were a subset of the See items. As shown in Table 2, correlations were significant for both young and older adults between each of the Think ratings and source memory. There were no significant correlations with See ratings. To assess whether there were differential relationships between feature ratings and source memory for young and older adults (e.g., if the association between Visual ratings and source memory was stronger for young than older adults and/or the association between Emotion ratings and source memory was stronger for older than young adults, as might be suggested by other findings in the literature, e.g., Hashtroudi et al., 1990; Rahhal et al., 2002), we used each participant's rs from the point biserial analysis as the dependent variable in mixed Age (young, old) X Feature (Visual, Emotion, Association) ANOVAs on See and Think trials separately. There were no significant effects (all p>.10).

Table 2. Bivariate Point Biserial Correlations between Ratings at Encoding and Source Memory Performance

	See Visual	See Emotional	See Association	Think Visual	Think Emotional	Think Association
Overall	r_{pb} = .006	r_{pb} = -.003	r_{pb} = .017	r_{pb} = .135**	r_{pb} = .131**	r_{pb} = .098**
	p = .572	p = .784	p = .109	p < .001	p < .001	p < .001
	n = 9117	n = 9340	n = 9308	n = 1544	n = 1453	n = 1542
Young	r_{pb} = .018	r_{pb} = .001	r_{pb} = -.005	r_{pb} = .100*	r_{pb} = .119*	r_{pb} = .095*
	p = .209	p = .956	p = .704	p = .004	p = .001	p = .006
	n = 5027	n = 5042	n = 5048	n = 829	n = 738	n = 831
Older	r_{pb} = .021	r_{pb} = .017	r_{pb} = .016	r_{pb} = .214**	r_{pb} = .156**	r_{pb} = .101*
	p = .182	p = .267	p = .300	p < .001	p < .001	p = .007
	n = 4090	n = 4298	n = 4260	n = 715	n = 715	n = 711

Note. n represents number of individual trials included in correlation computation. * p <.05, ** p < .001

Discussion

We similarly focused young and older adults' perceptual and reflective attention during encoding and measured their self-report of their subjective experience, assessed age-related differences in long-term source memory, and examined the relationship between online ratings and later source memory.

For the online ratings of subjective experience, See trials were rated higher than Think trials, and there was an interaction of Trial Type and Feature. These findings suggest that people were able to independently rate their subjective experience when perceiving and when thinking about the same items after they were no longer visible, as intended. That See ratings were higher than Think ratings for visual detail seems unsurprising, as one would expect people typically, all things being equal, to be able to see visual detail more vividly than they can imagine it (e.g., Ganis, Thompson, & Kosslyn, 2004; O'Craven, & Kanwisher, 2000), especially under controlled experimental conditions where we ensured all participants could see the stimuli clearly and were focused on them (via the ratings task). See and Think ratings were similar for associations, which also seems reasonable given that bringing associations to mind is a mental act whether one is looking at the stimulus or not. These two findings thus lend face validity to the ratings. That See ratings were higher than Think ratings for emotion suggests that perhaps, at least for complex pictures, strong emotion is more easily evoked during perception than reflection.

Consistent with our expectations, there were no significant differences between young and older adults for the ratings. Given our ability to establish age effects on item recognition and source memory, we do not believe this null finding was related to insufficient power. Thus, it seems that, at least when encoding involves focused perception and relatively short-term focused reflection, young and older adults report having very similar subjective experiences with respect to the vividness of visual, emotional, and associative details of complex pictures. Although the current findings should be replicated before firm conclusions are drawn, we note that this similarity of subjective ratings is reminiscent of those found in many long-term episodic memory studies when young and older adults rate their subjective experience during remembering (Comblain et al., 2005; Hashtroudi et al., 1990; Henkel et al., 1998; Karpel et al., 2001; McDonough et al., 2014; McGinnis & Roberts, 1996; Norman & Schacter, 1997; Rubin & Schulkind, 1997). We are not suggesting that ratings of subjective experience will always be similar between young and older adults during focused encoding. Nevertheless, we do seem to have produced a set of complex picture stimuli for which young and older adults reported having subjectively similar experiences of these particular features during encoding[1]. Importantly, the online ratings suggest that both groups did what we asked them to do at encoding. Our question focused on what would happen to source memory when young and older adults have subjectively similar experiences at encoding.

Although there is evidence to suggest that even brief immediate reflection during encoding results in better long-term memory, at least for young adults (Johnson, Reeder, Raye, & Mitchell, 2002), participants had better source memory for See than See+Think items. One possibility is that this reflects some sort of general bias to say See when one is unsure about the source of an item that is experienced visually at some point and/or when pictures are re-presented as test probes. However, our analysis of source attributions for new items erroneously called old (i.e., false alarms) argues against this explanation. See misattributions to

1 It seems reasonable to wonder if the subjective ratings show no difference between the groups simply because of differences in the way young and older adults interpret or use Likert-type scales. Perhaps, according to this view, their subjective experiences are quite different and only appear similar because of the way they use the rating scales. Bloise (2008) examined young and older adults' subjective ratings of memory characteristics on a long-term source memory task, comparing ratings with a Likert scale, such as used in the current study, to a General Labeled Magnitude Scale (gLM), which minimizes differences in scale interpretation between groups (Bartoshuk, Duffy, Fast, Green, & Snyder, 2001). The findings suggested that the typical dissociation between older adults' memory accuracy and their subjective reports of the vividness of characteristics was not attributable to how they interpret and use Likert scales. Although the focus in the current study is different, Bloise's findings argue against the idea that the similarity in ratings between young and older adults is due merely to how the two groups use the scale. More systematic research is clearly needed on this issue. A slightly different idea is that older adults recalibrate their subjective ratings given their experience of reduced availability of some details (e.g., perceptual information; McDonough, Cervantes, Gray, & Gallo, 2014). The current data cannot address this possibility.

new items did not differ from .50 in either group, suggesting no bias. Hence we speculate instead that the pattern of See > See+Think suggests that participants lacked, or did not access or sufficiently weight, unique memorial evidence indicating that they also thought about a picture (i.e., specific information about the cognitive operations performed during reflection; e.g., Johnson, Raye, Foley, & Foley, 1981). This particular procedure likely strengthened the features already focused on during See trials and did not enhance the unique information associated with thinking, per se. That is, thinking about the various features may have enhanced the amount of qualitative information in memory, without enhancing evidence that this information was generated reflectively. Hence, all items seemed like See items at test.

The particular wording of the Think instructions could have contributed to this effect. Recall that we asked participants to “bring to mind, *as fully as you can*, the picture that had just previously appeared with that label,” and then rate their reflective experience of the probed characteristic. It could be that bringing the picture back to mind fully in order to do the ratings enhanced the visual features of the representation further, regardless of what feature was probed, supporting the later (mis)attribution that the item was only seen.

One way to investigate the possibility that our manipulation failed to provide adequately discriminable source cues that information was thought about would be to focus participants on one set of characteristics during perception and a different set during reflection. Under these circumstances we would predict equal or better source memory for See+Think items compared to See items, as reflection would provide *unique* source cues associated with thinking. This manipulation might be bolstered by making the reflection a bit more elaborative or effortful, which should in turn provide stronger cues regarding the cognitive operations engaged (e.g., Finke, Johnson, & Shyi, 1988). For example, the delay between seeing the pictures and thinking about them could be lengthened to make it harder to bring them to mind, or participants might be asked to think of a consequent or extension of the scene. Of particular interest would be whether young and older adults’ source memory looks different for See vs See+Think trials under these conditions.

Consistent with the source memory and aging literature, in spite of equivalent ratings, young adults’ source memory performance was better than older adults’ (see Bäckman, Small, & Wahlin, 2001; Cansino, 2009; Naveh-Benjamin & Old, 2008; Spaniol, 2016; Zacks & Hasher, 2006, for reviews). One possibility is that older adults’ feature information was weaker overall during remembering, in spite of similar ratings at encoding. Whatever older adults did with the feature information may have been less efficient/effective for creating detailed, discriminable representations, compared to young adults. We tentatively offer several possibilities that would need to be explored in future studies: Consistent with other literature, one possibility is that older adults were less likely or less able to bind specific source-specifying information to items than were young adults (Chalfonte & Johnson, 1996; Mitchell, Johnson, Raye, & D’Esposito, 2000; Mitchell et al., 2000; Naveh-Benjamin, 2000; see Dennis & McCormick-Huhn, 2018 for a review). Another possibility, not mutually exclusive, is that older adults were less likely to revive, access, or appropriately monitor the most diagnostic, source-specifying information at test. We know that older adults generally have a problem with selective attention (e.g., ignoring irrelevant information; Campbell et al., 2012; Lustig et al., 2007), and that this problem is worse for reflection than perception (Mitchell et al., 2010). This interpretation is also consistent with neuroimaging findings suggesting that, during selective remembering, older adults’ deficit seems to be less about not having adequate memorial information and more about difficulty selecting and/or evaluating the qualities that are most relevant for the current memory agenda (e.g., Mitchell et al., 2013). Whether it is possible, and if so how, to provide older adults enough environmental support to bolster these strategic monitoring processes during remembering remains to be determined (see, e.g., Morcom, 2016 for discussion).

We were particularly interested in the relative impact of focusing on various features during encoding on young and older adults’ later source memory. Looking just at group source memory performance, there were no differences in source memory between the various types of Think trials (Visual, Emotion, Association), nor was there an Age X Encoding Condition interaction. This might seem surprising at first blush, given other findings in the literature that older adults seem to rely on different information when making their source decisions than young adults (e.g., Hashtroudi et al., 1990; Ly et al., 2013; May et al., 2005; Mitchell et al., 2013; Rahhal et al., 2002; Balota et al., 1999; Kouststaal et al., 2003; Mitchell et al., 2003). But, recall that there were no differences in the pattern of feature ratings between the age groups at encoding. To the extent young and older adults were focusing on, and thus encoding, similar information it should perhaps not be surprising that the two groups had similar patterns in the association between focusing on the different features during encoding and their source memory.

Of course, further systematic study is needed before strong conclusions are drawn, but for now the finding is consistent with others (e.g., Hashtroudi et al., 1994) in suggesting that older adults can, when explicitly supported to do so, strategically focus on various features of an experience during encoding (both perceptually and reflectively). Moreover, in this case, when they did so, different categories of features (e.g., perceptual, emotional, associations) were equally diagnostic of later source memory for old and young adults. As in some other studies showing young and older adults can be equated on encoding strategies (e.g., Kuhlmann & Touron, 2012), older adults nevertheless demonstrated poorer source memory than young adults. However, the evidence suggests that this did not seem to be differentially because of any particular feature, relative to young adults.

As an aside, these findings may provide a caution about the approach of confounding two features at encoding as an incidental way of equating young and older adults' encoding of multiple features (e.g., May et al., 2005; Mitchell et al., 2013; Rahhal et al., 2002). At a minimum it argues against the idea that, because the features are confounded in each studied item, age-related differences in source memory necessarily are due only to the type of information retrieved (e.g., Rahhal et al., 2002, p. 12). Older adults may need more support to ensure they actually are encoding the same featural information to the same extent as young adults (e.g., equally encoding perceptual and affective or associative information). Without such support (e.g., via focus manipulations) young and older adults still may focus on and encode different kinds of information, for example because of differences in interest value, motivation, or emotion regulation (see, e.g., Carstensen, Mikels, & Mather, 2006 for a review), and these differences may influence later memory.

Of course, even if different categories of features are encoded similarly by young and older adults it does not necessarily mean the different kinds of features will have the same impact on later source memory. The correlations between ratings and source memory provide some preliminary evidence on this issue. One finding was that, for both young and older adults, the more vivid the processing during Think trials (as indicated by higher ratings) the better the memory that the item was thought about. That we did not see such differences on See trials is not surprising because all features were rated on See trials, hence, there is no reason to believe any one type of rating would predict See source memory better than any other. That the three different Think ratings each significantly predicted source accuracy, and to the same degree, suggests that people were doing additional processing on these trials, and that the more vivid this processing, the better the source memory. This provides face validity that people were indeed doing what we asked them to do, and that such brief additional reflective processing can have consequences for source memory. Given that the source test asked only if participants saw the picture or saw+thought about it—i.e., we did not ask them to remember *how* they thought about it (what rating they made)---we would not necessarily predict that there would be differential correlations between the various ratings and Think source memory accuracy. It seems that all of the features provided equivalently diagnostic, even if qualitatively different, information about having thought about it.

What is perhaps surprising given the other literature discussed in the Introduction (e.g., Hashtroudi et al., 1990; Ly et al., 2013; May et al., 2005; Mitchell et al., 2013; Rahhal et al., 2002), is that there were no significant differences between young and older adults in the association between their think ratings and their source memory —i.e., no Age X Feature interaction. We might have expected, for example, based on the literature, that visual ratings would show a stronger relationship with source memory for young adults but association or emotion ratings would show a stronger relationship for older adults. Although we acknowledge that the findings of no age effect or interaction are preliminary and need replication before strong conclusions are drawn, one theoretically plausible explanation is the one we proposed in the Introduction: When young and older adults' attention is carefully focused on the same information at encoding, young and older adults later will use the various categories of source-specifying information similarly in making a source attribution. That is, the types of information are equally predictive for young and older adults under these very controlled circumstances. Hence, although young adults may have had more source information overall than older adults and/or this information was better bound, and hence young adults had overall better source memory, there is little evidence of differential encoding of or reliance on different features in this case. Future studies might gain leverage on this question by more directly assessing the characteristics that influence young and older adults' source memory decisions after focused encoding, for example, by using a Memory Characteristics Questionnaire (e.g., Johnson, Foley, Suengas, & Raye, 1988) or otherwise asking participants at test about the basis for their source judgments (e.g., Gardiner, Ramponi, & Richardson-Klavehn, 1998).

In conclusion, this study provides preliminary evidence that when young and older adults' perceptual and reflective focus is constrained at encoding to minimize differences in what is attended, and young and older adults report having similar perceptual and reflective experiences with respect to vividness of specific features at encoding, older adults nevertheless show deficits in source memory relative to young adults. This in spite of the fact that under these conditions the various types of features seemed equally diagnostic of source for young and older adults. Future studies should more systematically explore the relative contributions of other age-related encoding problems, such as binding/associative deficits, vs age-related retrieval and monitoring problems to older adults' source memory deficits under these circumstances (see, e.g., see Dennis & McCormick-Huhn, 2018 for a review).

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