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Identifying Age-Invariant and Age-Limited Mechanisms for Enhanced Memory Performance: Insights From Self-Referential Processing in Younger and Older Adults

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Self-referential processing has been identified as a possible tool for supporting effective encoding processes in the elderly population. However, the importance of self-reference per se, relative to the increase in meaningful elaboration normally associated with self-reference instructions, remains unclear. The present study sought to explore this issue further by examining self-referential encoding strategies that inherently involve more extensive stimulus elaboration: episodic autobiographical memory (AM) retrieval and semantic AM retrieval. These were compared with an analogous task involving retrieval of general semantic knowledge, as well as traditional binary self-referential and semantic encoding judgments. We found that both AM retrieval and general semantic retrieval at encoding resulted in substantial enhancements to recall and recognition memory of concrete nouns relative to binary encoding judgments across both age groups. Furthermore, older adults exhibited larger benefits from this additional elaboration than did younger adults, leading to elimination of age-related deficits in recognition memory. However, younger adults showed an additional boost to subsequent memory following episodic, relative to semantic, AM retrieval during free recall that was not exhibited by older adults. This may be because of greater demands on frontally mediated control processes and cognitive resources associated with the use of this strategy. Taken together, the results suggest that the mnemonic benefits associated with self-referential processing vary substantially depending on the specific nature of the encoding strategy, and suggest that, under certain conditions, semantic processing and self-referential processing are equally effective in mitigating age-related deficits in memory performance.

Keywords: ageing, episodic memory, environmental support, autobiographical retrieval, semantic processing

The critical influence of cognitive operations on stimulus representations and subsequent memory performance has been explored extensively in episodic memory research. These ideas form the basis of the depth of processing framework, which states that deeper levels of processing, such as evaluating a word based on its meaning, produce richer and more elaborate memory traces than processing of superficial characteristics, such as perceptual attributes, by facilitating more extensive stimulus differentiation and integration with existing knowledge (Craik & Tulving, 1975). The depth of processing framework was extended by Rogers, Kuiper, and Kirker (1977) to include self-referential processing, with the observation that relating verbal stimuli to the self led to better retention than did semantic processing. This pattern, which has been replicated extensively using similar paradigms (see Symons & Johnson, 1997, for review), has led to the proposal that self-referential processing engages a unique form of stimulus elaboration that leads to the formation of richer and more differentiated memory traces than that produced by analogous stimulus processing in the semantic domain. These observations have generated a great deal of interest, particularly with respect to the potential application of self-referential processing as a mnemonic strategy in memory-impaired populations.

Of particular relevance in the present study is the recent proposal that self-referential processing may be especially well suited to mitigating episodic memory impairment in older adults. These declines in episodic memory are driven in part by age-related

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deficits in initiating effective stimulus elaboration during encoding, which results in the formation of memory representations that lack differentiation and are more prone to interference, giving rise to increases in memory errors (Craik, 1983). This encoding deficit is thought to arise because of declines in frontal lobe function and the availability of cognitive resources with age, which are critical for initiating elaborative encoding processes (Anderson, Craik, & Naveh-Benjamin, 1998; Craik, 1983; Craik & Byrd, 1982; Moscovitch & Winocur, 1995). Nevertheless, memory performance in older adults can be substantially improved when environmental support is provided at encoding to facilitate elaborative stimulus processing (Craik & Rose, 2012, for a review). Accordingly, the discovery of encoding strategies that older adults can implement successfully in the face of concomitant declines in cognitive resources and frontally mediated control mechanisms remains an important focus for ameliorating age-related impairments in episodic memory. However, the extent to which self-referential processing represents a unique form of stimulus elaboration that can serve as a particularly useful mnemonic device for older adults remains unclear.

Some studies have found that the self-reference effect remains intact with age, with older adults showing boosts to memory performance equivalent to those in younger adults following self-referencing relative to semantic processing (Dulas, Newsome, & Duarte, 2011; Glisky & Marquine, 2009; Hamami, Serbun, & Gutchess, 2011; Leshikar, Dulas, & Duarte, 2014; Rosa & Gutchess, 2013) or referencing a distant other (Gutchess, Kensinger, & Schacter, 2010; Gutchess, Kensinger, Yoon, & Schacter, 2007; Mueller, Wonderlich, & Dugan, 1986; Rosa & Gutchess, 2011; Yang, Truong, Fuss, & Bislimovic, 2012). Indeed, observations of an intact self-reference effect in older adults, as well as findings from divided attention studies in younger adults (Yang et al., 2012), have led to the suggestion that the mnemonic benefits of self-referencing occur relatively automatically and do not rely on controlled attentional processes. Such evidence suggests that self-referential processing might be particularly useful for older adults because of declines in frontal lobe function (Moscovitch & Winocur, 1995) and the availability of cognitive resources (Craik & Byrd, 1982). In contrast, some findings have indicated that the ability to benefit from self-referencing depends on executive function and resource availability (Gutchess et al., 2007; Turk et al., 2013) and is reduced in advanced old age (Glisky & Marquine, 2009) and therefore its potential utility for older adults may be limited. Finally, there is also evidence to suggest that self-referencing increases veridical recognition by enhancing fluency, and therefore also leads to age-related increases in false recognition, thus failing to produce a net improvement in memory performance (Rosa & Gutchess, 2013). These latter findings suggest that self-referencing may not prove to be an ideal strategy for older adults.

Critically, irrespective of the paradigm used or the specific pattern of results observed, none of the studies described previously report a reduction or elimination of age-related differences in memory performance following the use of self-referential encoding strategies. This remains true even when age differences in retrieval processes are controlled for by providing a high level of environmental support at test, suggesting that differences in the quality of encoding give rise to the discrepancy in memory performance. One possible interpretation of these findings is that self-referencing is not an effective means of stimulus elaboration for older adults. However, an alternative explanation is that the simple orienting tasks (e.g., binary self-referential judgments, self-descriptiveness rating scales) that are typically used to assess the benefits of self-referencing are accompanied by additional, self-initiated elaboration in younger adults, which is not carried out spontaneously by older individuals (Gutchess et al., 2007; Rabinowitz, Craik, & Ackerman, 1982; Luo, Hendriks, & Craik, 2007; Treat & Reese, 1976), resulting in persistent age differences in memory performance. For instance, when deciding whether a trait is self-descriptive, younger adults may retrieve a memory of an occasion during which they exemplified that trait (Rogers et al., 1977), thus forming a richer stimulus representation, whereas older adults may recruit only the necessary abstract self-knowledge required to make the decision.

To investigate this possibility, the present study will explore the benefits of self-referential processing in older and younger adults using encoding strategies that inherently require participants to engage in more extensive stimulus elaboration, thereby better equating the nature and amount of stimulus differentiation performed across age groups. In particular, we will compare traditional self-referential judgments with more elaborative self-referential encoding strategies that involve autobiographical memory retrieval, which can be divided into two subcomponents. These include an episodic element that consists of specific memories from one's personal past and a semantic element that consists of personal knowledge of oneself and one's life experiences (Conway, 2005).

Importantly, a growing body of research indicates that these two forms of self-knowledge are functionally and anatomically distinct from one another. For instance, neuroimaging research has demonstrated that episodic and semantic autobiographical memory retrieval elicit separable patterns of neural activity (Addis, McIntosh, Moscovitch, Crawley, & McAndrews, 2004; Levine et al., 2004), and patients with neurological damage have been shown to exhibit intact self-knowledge coupled with impaired episodic retrieval (Grilli & Verfaellie, 2014; Klein, Loftus, & Kihlstrom, 1996; Tulving, Schacter, McLachlan, & Moscovitch, 1988), providing further evidence for a dissociation.

Consistent with the above evidence and most relevant to the current investigation is the observation that older adults exhibit declines in the specificity and richness of their autobiographical memories, coupled with intact and even preferential retrieval of personal and general semantic details (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). This pattern has been attributed to the additional demands that episodic memory retrieval places on prefrontal cortical function, which declines with age, relative to retrieval of conceptual information (Levine et al., 2002; Levine et al., 2004; St. Jacques, Rubin, & Cabeza, 2012). Despite this distinction, no studies to date have compared the efficacy of episodic compared with semantic autobiographical elaboration on subsequent memory performance in older adults, nor how these encoding operations may improve retention beyond simple self-referential judgments.

Thus, the current investigation assessed memory for concrete nouns in older and younger adults following the use of self-referential and semantic orienting tasks that varied in response style, or the degree to which overt stimulus elaboration was inherently involved in making responses (Figure 1). Specifically, we

compared traditional self-referential and semantic binary judgments to three orienting tasks that involve more extensive stimulus elaboration through what we term "narrative responses." These included a semantic strategy (providing a definition of the target stimulus) and two self-referential strategies that varied in the component of autobiographical memory used for elaboration: an episodic autobiographical retrieval task that involved recalling a personal memory related to the stimulus, and a semantic autobiographical retrieval task that involved describing personal facts relating to the stimulus.

The efficacy of these encoding strategies was assessed by obtaining measures of memory performance at different levels of retrieval support, including free recall, cued recall, and recognition memory. This was motivated by the relative absence of research exploring the benefits of self-referencing on recall performance in older adults relative to that in younger adults (Bower & Gilligan, 1979; Klein, Loftus, & Burton, 1989; Warren, Chattin, Thompson, & Tomsky, 1983) and neurological patients (Grilli & Glisky, 2013; but see Mueller et al., 1986), despite age-related memory deficits being most pronounced under these conditions (Craik & McDowd, 1987). Thus, in the present study we extend previous findings to determine whether self-referencing can provide a mnemonic benefit to older adults in the absence of retrieval support, relative to analogous strategies in the semantic domain. We predicted that the amount of explicit elaboration involved in performing the task at encoding, and the component of autobiographical memory used for elaboration, would play an important role in determining this outcome.

Specifically, we predicted that more elaborative encoding strategies would provide substantial increases in memory performance relative to simple encoding judgments in both age groups, by virtue of their inherent access to a larger and more varied selection of stimulus attributes that should aid in the creation of a differentiated memory trace. However, because of age-related declines in the ability to self-initiate such processes, we expected older adults to exhibit larger benefits through the use of these strategies than younger adults, potentially mitigating age differences in memory performance relative to traditional encoding judgments. Among the encoding strategies in each response style, we predicted a self-reference benefit following traditional self-referential and semantic encoding judgments in both age groups, consistent with previous research. However, the pattern of performance expected with respect to the autobiographical and semantic narrative tasks was less clear.

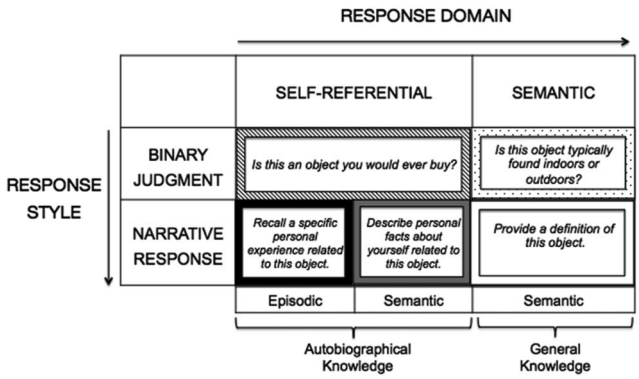

Figure 1. Experiment design. During encoding, participants used four different orienting tasks to study a series of concrete nouns. Three out of the four orienting tasks were common to all participants, whereas the self-referential narrative response varied according to which subgroup participants were allocated. Those in the Episodic subgroup completed an autobiographical memory retrieval task, whereas those in the Semantic subgroup completed a task involving retrieval of conceptual knowledge about the self. The borders surrounding each orienting task correspond to the pattern/color of the bar depicting performance on that task in the graphs in Figures 2 and 3.

In particular, previous research in younger adults suggests that episodic and semantic components of autobiographical memory provide equivalent mnemonic benefits, albeit through distinct mechanisms (Klein et al., 1989). Thus, it may be the case that performance in younger adults does not differ between these conditions. However, other research regarding episodic elaboration suggests that episodic self-referencing may provide some mnemonic benefits beyond that conferred by semantic self-knowledge (McDonough & Gallo, 2008). This is because of the additional complex cognitive operations involved in event construction and elaboration (e.g., scene construction, visual imagery, retrieval of sensory and emotional details) that aid in the creation of a unique and highly distinctive contextual cue to aid subsequent retrieval. However, if any additional benefit is observed in younger adults, it is less likely to extend to older adults. Consistent with previous research in memory-impaired patients described by Grilli and Glisky (2013), older adults may be limited in their ability to apply an encoding strategy that relies on episodic autobiographical retrieval, owing to the additional demands placed on frontally-mediated control processes and cognitive resources that decline with age (Craik & Byrd, 1982; Moscovitch & Winocur, 1995; St. Jacques et al., 2012).

In contrast, older adults should be able to use both personal semantic knowledge and general semantic knowledge just as effectively as younger adults to aid stimulus differentiation at encoding, because semantic retrieval remains intact with age (Allen, Sliwinski, Bowie, & Madden, 2002; Levine et al., 2002; Nyberg, Bäckman, Erngrund, Olofsson, & Nilsson, 1996). It is less clear how these two strategies will compare with one another. Although some previous research suggests that a self-reference benefit on memory should also emerge in such comparisons (Klein et al., 1989; Grilli & Glisky, 2013), few studies have compared two tasks that are matched with respect to the retrieval of a varied selection of stimulus attributes and differ only with respect to the involvement of the self. Thus, unless it is the case that self-referential processing provides a unique form of elaboration that cannot be achieved by semantic processing, we may find that elaborative semantic processing produces equivalent memory benefits as the retrieval of self-knowledge in both older and younger adults. Investigating this outcome in the present study will help to determine the utility of self-referential encoding strategies for enhancing recollection with age.

Method

Participants

Forty-eight younger adults (ages 18–30 years) and 48 older adults (ages 60–80 years) participated in the study. All participants were native English speakers. The younger adults were students from the University of Cambridge, and the older adults were healthy, community-dwelling volunteers. Older and younger

adults did not differ with respect to years of formal education, $t(94) = 1.49$, $p > .1$, and older adults scored higher than younger adults on the Vocabulary subtest of the Shipley Inventory of Living Scale, as is common in studies of cognitive aging (Shipley, 1986), $t(94) = 8.36$, $p < .001$. Twenty-four participants in each age group were randomly allocated to the episodic or semantic self-referencing condition. The demographic characteristics of these subgroups are displayed in Table 1. The participants in each subgroup were matched for age, education, and vocabulary scores ($ps > .3$). The older participants were additionally tested using the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), a brief screening tool for mild cognitive impairment, and performance on this measure did not differ between the episodic and semantic subgroups ($t < 1$). All participants provided written informed consent prior to beginning the experiment using methods approved by the Cambridge Psychology Research Ethics Committee and received monetary compensation at a rate of £7.50 per hour for participation.

Design

In the present study, we varied domain (self-referential, semantic) and response style (binary judgments, narrative responses) within-subjects in a factorial design to produce four different types of encoding strategies: a binary semantic task, a binary self-referential task, a narrative semantic task, and a narrative self-referential task (Figure 1). Three out of the four orienting tasks were common to all participants, whereas the self-referential narrative response was varied between-subjects, with half of participants allocated to the episodic autobiographical subgroup and half of participants allocated to the semantic autobiographical subgroup. To summarize, the experiment design consisted of two within-subjects variables: domain (self-referential, semantic) and response style (binary judgment, narrative response) and two between-subjects variables: autobiographical condition (episodic, semantic) and age (younger, older).

Materials

A total of 144 concrete nouns between 4 and 8 letters long were chosen from the Medical Research Council Psycholinguistic Database and used as stimuli. These words were divided into nine 16-item lists that served as stimuli in the study and test phases of the experiment. The lists were matched for concreteness, familiarity, imaginability, Kuceira-Francis frequency, and word length (all $Fs < 1$). Allocation of the lists to each condition during study and for use as foils in the test phase was counterbalanced across participants.

Procedure

The experiment consisted of six study-recall blocks followed by a recognition test at the end of the session. Three consecutive blocks consisted of self-referential responses, while the other three consecutive blocks consisted of semantic responses, with the order of the two sets of blocks counterbalanced across participants. A practice block preceded each three-block phase to ensure participants understood how to provide the appropriate self-referential and semantic responses.

Each of the six blocks began with a study phase wherein participants made responses to 16 words, 8 of which prompted binary judgments and 8 of which prompted narrative responses. The response type varied in an alternating fashion every two trials, with the name of the response to be performed located at the top of the screen and the word presented centrally. The self-referential binary judgment was termed the *buy* response, and participants answered yes or no to the question, "*Is this an object you would buy in the next year?*" The semantic binary judgment was termed the *location* response, and participants answered indoors or outdoors to the question, "*Is this object typically found indoors or outdoors?*" The self-referential narrative response came in two forms; in the episodic autobiographical condition, participants provided a *memory* response, and were asked to "*Recall and describe a specific episode from your past relating to this object*," whereas in the semantic autobiographical condition, participants provided a *personal* response, and were asked to "*Describe personal facts about yourself relating to this object*." The semantic narrative response was termed the *definition* response, and participants were asked to "*Provide a definition for this object*." Contrary to previous experiments using autobiographical retrieval or definition tasks (Grilli & Glisky, 2013; Klein et al., 1989; McDonough & Gallo, 2008), participants were required to give their narrative responses aloud so that we could be sure that they were performing the tasks correctly and with a sufficient level of detail. Furthermore, responding aloud enabled us to minimize the possibility of any response blending across tasks, or performing the incorrect task on a given trial, which is of particular concern in older adults who experience difficulties with task switching. Participants were provided with a maximum of 30 s to respond to each word and were encouraged to use all of the time they needed to perform the tasks effectively. This response window was motivated by previous research suggesting that response latencies for

Table 1
Participant Demographic Information

Variable	Younger adults		Older adults	
	Episodic subgroup	Semantic subgroup	Episodic subgroup	Semantic subgroup
N	24	24	24	24
Age, *M* (*SD*)	21.5 (2.57)	22.29 (2.79)	70.46 (6.06)	69.21 (4.85)
Gender	11M, 13F	10M, 14F	10M, 14F	6M, 18F
Years of education, *M* (*SD*)	16.29 (1.33)	16.62 (1.74)	17.75 (2.38)	16.58 (3.30)
Shipley Vocabulary, *M* (*SD*)	33.42 (3.59)	33.42 (3.40)	37.92 (1.44)	37.96 (1.49)
Montreal Cognitive Assessment, *M* (*SD*)	—	—	27.13 (1.39)	27.58 (1.86)

autobiographical retrieval can span up to 30 s (Conway, 2005) and enabled both older and younger participants to complete all narrative responses successfully.

The study phase was followed by a filled interval of counting backward by threes for 30 s. This was immediately followed by a 2-min free recall period, in which participants were asked to write down as many words as they could remember from the preceding study list. Next, participants were provided with the first two letters of each word from the study list in the order they were presented, with words that had already been successfully recalled filled in, and given a chance to recall any additional words from the list. After all six blocks were complete, participants completed a self-paced recognition test which consisted of all 96 studied words and 48 foils presented in random order. The vocabulary subtest of the Shipley Institute of Living Scale and the Montreal Cognitive Assessment (older adults only) were administered at the end of the experiment session.

Results

We first assessed how memory performance was affected by response style, domain, and age by conducting a 2 × 2 × 2 mixed analysis of variance (ANOVA) on performance in each subgroup with Age (younger, older) as a between-subjects factor and Domain (self, semantic) and Response Style (binary, narrative) as within-subject factors. This ANOVA was conducted in both the episodic and semantic autobiographical retrieval subgroups, which differ only with respect to the nature of the self-referential narrative encoding strategy (see Figure 1 for a schematic of the experimental design). This analysis was performed on data from each level of retrieval support. However, because the cued recall performance paralleled that of free recall, only free recall and recognition data are presented below.

Recognition

Corrected recognition scores were calculated using the condition-specific hit rate, corrected by the pooled false alarm rate across conditions, and are depicted in Figure 2 and Table 2. The 2 × 2 × 2 mixed ANOVA revealed a Domain × Response Style interaction in both the episodic, $F(1, 46) = 31.44$, $p < .001$, $\eta_p^2 = 0.406$, and semantic, $F(1, 46) = 19.88$, $p < .001$, $\eta_p^2 = 0.302$, subgroups. To explore this interaction, we conducted follow-up paired-sample t tests comparing self-referential and semantic strategies in each response style (e.g., binary judgments, narrative tasks). This revealed a self-reference benefit following binary encoding judgments in both subgroups, episodic: $t(47) = 2.95$, $p < .005$); semantic: $t(47) = 4.11$, $p < .001$, replicating previous findings of a self-reference effect in both older and younger adults. In contrast, the opposite effect was observed following narrative encoding strategies. Here, we observe a benefit of semantic processing in both the episodic, $t(47) = 3.44$, $p < .005$ and semantic, $t(47) = 2.02$, $p < .05$, subgroups.

The ANOVA additionally revealed a Response Style × Age interaction in both subgroups, episodic: $F(1, 46) = 7.37$, $p < .01$, $\eta_p^2 = 0.138$; semantic: $F(1, 46) = 13.67$, $p < .005$, $\eta_p^2 = 0.229$. To explore this interaction, we conducted follow-up independent t tests comparing recognition performance between age groups for words studied using binary judgments and narrative encoding strategies. These revealed persistent age-related deficits in performance following binary judgments, episodic: $t(46) = 1.83$, $p = .074$; semantic: $t(46) = 2.26$, $p < .05$, which were eliminated following the use of narrative encoding strategies in both subgroups ($ps > .20$). These results indicate that older adults exhibited a larger benefit from the use of narrative encoding strategies relative to binary encoding judgments than did younger adults.

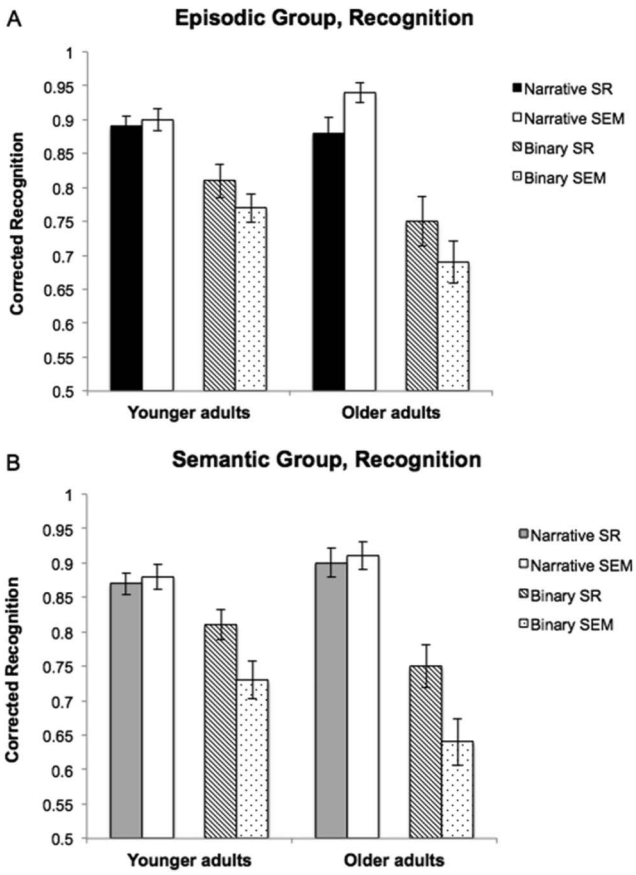

Figure 2. Recognition memory performance in the (A) episodic autobiographical condition and (B) semantic autobiographical condition across narrative and binary orienting tasks. In both conditions we observe a self-reference benefit on memory following the use of binary encoding judgments, but not narrative encoding responses. We additionally observe an age-related deficit in memory performance following the binary encoding judgments, which is eliminated following the use of narrative encoding responses.

Free Recall

Participants' free recall scores reflect the proportion of total words correctly recalled from each condition across the three study blocks and are depicted in Figure 3 and Table 3. The 2 × 2 × 2 mixed ANOVA revealed a main effect of Age in both subgroups, episodic: $F(1, 46) = 74.24$, $p < .001$, $\eta_p^2 = 0.617$; semantic: $F(1, 46) = 19.38$, $p < .001$, $\eta_p^2 = 0.296$, illustrating a significant

Table 2
Recognition Memory Performance

	Episodic condition				Semantic condition			
	Narrative response		Binary judgment		Narrative response		Binary judgment	
Group	SR	SEM	SR	SEM	SR	SEM	SR	SEM
Younger	.89 (.08)	.90 (.08)	.81 (.12)	.77 (.10)	.87 (.08)	.88 (.09)	.81 (.11)	.73 (.13)
Older	.88 (.11)	.94 (.07)	.75 (.18)	.69 (.15)	.90 (.10)	.91 (.10)	.75 (.15)	.64 (.17)

Note. SR = self-referential, SEM = semantic. Mean (SD) recognition scores correspond to corrected recognition performance (hits-false alarms).

age-related deficit in recall performance across encoding strategies. We also observed a main effect of Response Style, episodic: $F(1, 46) = 94.38$, $p < .001$, $\eta_p^2 = 0.672$; semantic: $F(1, 46) = 77.52$, $p < .001$, $\eta_p^2 = 0.628$, indicating a substantial benefit to recall performance in both age groups following the use of narrative encoding strategies relative to binary encoding judgments in both subgroups. Furthermore, a Domain × Response Style × Age interaction emerged in the episodic subgroup, $F(1, 46) = 4.67$, $p < .05$, $\eta_p^2 = 0.092$, but was not present in the semantic subgroup ($F < 1$).

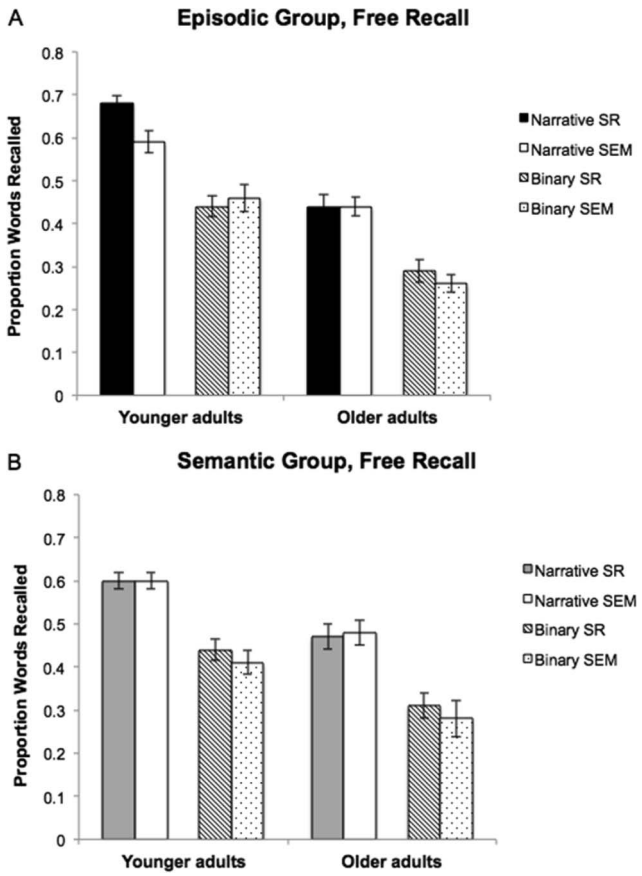

Figure 3. Free recall performance in the (A) episodic and (B) semantic autobiographical conditions across narrative and binary orienting tasks. In both conditions, both older and younger adults recall more words following narrative responses relative to binary judgments, and older adults recall fewer words than do younger adults. In the episodic autobiographical condition (A), we observe a self-reference benefit following the narrative self-referential response in younger adults, but the same benefit is not observed in older adults. Neither age group exhibits a self-reference benefit following the binary judgments. In the semantic autobiographical condition (B), we do not observe a self-reference benefit following the narrative responses or the binary judgments in either age group.

To explore this interaction observed in the episodic subgroup, we conducted a 2 × 2 ANOVA with Age as a between-subjects variable and Domain as a within-subjects variable for each response style (e.g., binary, narrative). With respect to binary encoding judgments, we failed to detect a significant effect of Domain or a Domain × Age interaction (Fs < 1). In contrast, the same ANOVA with respect to narrative encoding strategies revealed a main effect of Domain, $F(1, 46) = 4.43$, $p < .05$, $\eta_p^2 = 0.088$, which was qualified by a Domain × Age interaction, $F(1, 46) = 5.54$, $p < .05$, $\eta_p^2 = 0.107$. This interaction was driven by a self-reference benefit in younger adults that was absent from older adults, who recalled a similar number of words following episodic autobiographical elaboration and general semantic elaboration.

We next sought to determine whether recall performance following episodic autobiographical elaboration is indeed greater than recall performance following semantic autobiographical elaboration, and whether this is unique to younger adults. To address this question, we conducted a 2 × 2 ANOVA with Condition (episodic, semantic) and Age (younger, older) as between-subjects variables on free recall performance following the use of self-referential narrative strategies. This revealed an Age × Condition interaction, $F(1, 92) = 5.51$, $p < .05$, $\eta_p^2 = 0.056$, confirming that episodic autobiographical elaboration supported superior recall to semantic autobiographical elaboration, and that this benefit was limited to younger adults.

Discussion

The present study sought to extend previous work exploring the self-reference effect in memory and further characterize its potential applicability as a mnemonic strategy to enhance recollection in older adults. To this end, we compared traditional self-referential and semantic encoding judgments that align closely with those used in past aging research, to strategies that inherently provide more extensive stimulus elaboration through either retrieval of general semantic knowledge, or retrieval of episodic or semantic aspects of autobiographical memory.

Self-Referential and Semantic Encoding Judgments

With respect to self-referential and semantic binary encoding judgments, the present results replicate previous work demonstrat-

Table 3
Free Recall Performance

	Episodic condition				Semantic condition			
	Narrative response		Binary judgment		Narrative response		Binary judgment	
Group	SR	SEM	SR	SEM	SR	SEM	SR	SEM
Younger	.68 (.08)	.59 (.12)	.44 (.12)	.46 (.16)	.60 (.10)	.60 (.10)	.44 (.13)	.41 (.14)
Older	.44 (.13)	.44 (.11)	.29 (.13)	.26 (.10)	.47 (.14)	.48 (.14)	.31 (.14)	.28 (.20)

Note. SR = self-referential, SEM = semantic. Mean (SD) free recall scores correspond to the proportion of total words correctly recalled.

ing a self-reference benefit on recognition memory in younger and older adults (Glisky & Marquine, 2009; Hamami et al., 2011; Leshikar et al., 2014; Rosa & Gutchess, 2013) and extend them to memory for concrete nouns studied using a novel combination of self-referential and semantic orienting questions. However, the same pattern did not emerge during free recall, where memory performance was equivalent between the two conditions, suggesting that items encoded in relation to the self possessed greater potential memorability than those encoded using semantic judgments, but that this potential could not be realized in the absence of retrieval support. This may be because of the small proportion of "yes" responses made to the self-referential encoding question, which made up less than half of total responses in both age groups. The high frequency of negative responses likely led to unsuccessful integration between words and the self-descriptive orienting question, which is thought to be more critical during free recall compared with recognition, when retrieval cues are absent from the environment and the encoding context becomes a vital internal cue for retrieval (Fisher & Craik, 1980).

Nevertheless, the observation that older and younger adults exhibited equivalent patterns of memory performance across both recognition and recall test conditions lends additional support to the proposition that the self-reference effect is intact with age. Furthermore, just as in previous work (Glisky & Marquine, 2009; Hamami et al., 2011; Leshikar et al., 2014; Rosa & Gutchess, 2013), older adults in the present study demonstrated significant impairments in recognition memory following the use of these strategies, as well as in recall performance. These results reinforce the idea that such simple orienting tasks perhaps rely too strongly on further spontaneous elaboration by participants at encoding, or the initiation of more strategic and controlled retrieval processes to target a less distinctive memory trace. As such, simple encoding judgments do not appear to provide optimal encoding support for older adults, even when they involve self-referential processing.

Episodic Versus Semantic Autobiographical Retrieval

Self-referencing in the context of narrative encoding strategies yielded a strikingly different pattern of performance, which differed between age groups. A comparison of episodic and semantic autobiographical retrieval revealed that younger adults recalled more words for which they had associated personal memories, a benefit that was not observed in older adults. Although previous work has indicated that these two forms of self-knowledge are functionally dissociable (Grilli & Glisky, 2013; Klein et al., 1989; Klein et al., 1996; Levine et al., 2004; Tulving et al., 1988), the results from the present study are the first to suggest that retrieving different aspects of autobiographical memory during encoding elicits distinct mechanisms of stimulus elaboration that support varying levels of memory performance in healthy younger adults.

It is interesting that this benefit of episodic elaboration was specific to free recall; when words were provided as retrieval cues, this advantage was no longer evident. This pattern suggests that the primary benefit of episodic relative to semantic autobiographical elaboration is the superior ability for specific events from memory to serve as effective internal cues for retrieval, relative to a series of personal facts about oneself related to the stimulus. This is consistent with previous research demonstrating that the uniqueness and ease of reconstruction of a cue is positively correlated with its ability to support retrieval of target information (Moscovitch & Craik, 1976), a benefit that has a greater influence on performance when external cues are not provided by the environment (e.g., free recall; Fisher & Craik, 1980). Although this benefit of episodic elaboration on free recall diverges from previous work comparing episodic and semantic forms of autobiographical elaboration (Klein et al., 1989; Grilli & Glisky, 2013), it is likely that methodological differences between studies contributed to these differences. For example, previous studies that imposed stricter time constraints at encoding may have reduced participants' ability to reconstruct and elaborate a given episode, thus limiting the efficacy of this strategy.

In contrast to the pattern described above in younger adults, older adults did not demonstrate an additional enhancement to memory performance following episodic autobiographical elaboration, but exhibited equivalent recall of words that had been related to episodic and semantic components of the self. These results align with our predictions and are consistent with previous research demonstrating that aging is associated with a reduced ability to use specific contextual cues co-occurring in the encoding environment, a unique episodic memory in this case, to aid subsequent recall (Craik & Simon, 1980; Rabinowitz et al., 1982). This impairment has been attributed to declines in frontally mediated control processes and cognitive resources with age, which are essential for guiding the formation and retrieval of a strong, unique association between a study item and specific cue from the encoding context (Rabinowitz et al., 1982). In the present study, this deficit could have hindered the use of this strategy by older adults in a few different ways.

On the one hand, older adults may have been impaired in creating associations between episodic memories and stimulus words during encoding, an idea that is consistent with the associative deficit hypothesis of aging (Naveh-Benjamin, 2000). As an alternative, older adults may have created less specific associations

during encoding, binding extraneous information that co-occurred in the encoding environment along with the target word, such as other elements of the episode, or items that are semantically related to the episode concepts, a proposition consistent with the hyper-binding theory of aging (Campbell, Hasher, & Thomas, 2010; Campbell, Trelle, & Hasher, 2014). In either case, generation of a given memory at retrieval could have been less effective in uniquely targeting a list item, but rather led to high rates of intrusions of non-studied words by older adults.

An additional possibility is that older adults retrieved event memories that were less specific and rich in episodic detail, thus lacking the distinctive contextual nature that characterized younger adults' responses (Levine et al., 2002). As a result, they might bear greater similarity to the responses provided during semantic autobiographical retrieval, resulting in equivalent memory benefits. Although this is a plausible explanation of the results, detailed analysis of participant responses was not possible in the current study. Thus, the present results do not adjudicate between these interpretations but identify a set of circumstances under which older adults are limited in their ability to apply self-referential encoding strategies in the same manner as younger adults. Future research should investigate whether a relationship exists between the quality of retrieved episodes and the efficacy of episodic encoding strategies in older adults, or whether this pattern is best explained by domain-general attentional control deficits or age-related changes in relational binding.

Personal and General Knowledge Retrieval

In contrast to the results described above, older adults were not impaired in their ability to implement encoding strategies that relied on the retrieval of personal or general knowledge from memory. This pattern is consistent with our predictions, and aligns with previous work indicating the retrieval of conceptual self-knowledge and general semantic knowledge remains intact with age (Allen et al., 2002; Levine et al., 2002; Nyberg et al., 1996). With the use of these narrative strategies, older adults exhibited memory performance at a level that was substantially greater than that achieved using binary encoding judgments. Moreover, during recognition this benefit was larger than that exhibited by younger adults, eliminating age differences in performance. This pattern lends support to the idea that previous observations of persistent age-related deficits in recognition memory following traditional self-referential and semantic encoding strategies emerged because of the spontaneous initiation of more extensive stimulus elaboration by younger adults, which was not carried out by the older group. Here, we observe that these age differences can be eliminated through the use of either self-referential or semantic strategies that inherently involve more extensive stimulus elaboration, combined with the provision of environmental support during retrieval.

Critically, the use of these narrative strategies not only enhanced recognition memory, but also free recall performance. This suggests that the increased number of stimulus attributes accessed in the service of these tasks facilitated the creation of distinctive and highly differentiated memory traces that were more accessible during retrieval. This was evident even in older adults, who typically exhibit deficits in self-initiated retrieval search and monitoring processes in the absence of external support (Craik & McDowd, 1987; Dodson & Schacter, 2002). The amelioration of this deficit using the narrative encoding strategies in the present study indicates that older adults can also use cognitive operations to confer distinctiveness onto stimuli to aid recollection, a phenomenon that has only previously been observed in younger adults (Gallo, Meadow, Johnson, & Foster, 2008; McDonough & Gallo, 2008). Although these tasks were also associated with significantly longer study durations than the binary judgments, response latencies during encoding were not correlated with performance across any of the narrative strategies, and it is unlikely that extended exposure to stimuli alone could explain the pattern of memory performance observed here. In particular, enhancement in recall performance suggests that the narrative encoding strategies did not simply increase stimulus familiarity, but supported the use of recollection-based retrieval processes such as the distinctiveness heuristic (Dodson & Schacter, 2002; Gallo, Cotel, Moore, & Schacter, 2007).

It is interesting that we did not observe an advantage of self-referencing in our comparison of personal and general semantic encoding strategies in either age group. This pattern suggests that the memory benefits typically associated with self-referencing result from an increase in stimulus elaboration, or access to a greater number of stimulus attributes (e.g., general knowledge about the stimulus, as well as knowledge about the self in relation to the stimulus) relative to analogous semantic judgments, rather than a deeper or more meaningful form of stimulus elaboration uniquely associated with the self. As a result, when extensive elaboration is accomplished through access to a wide array of stimulus attributes in both semantic and self-referential orienting tasks, the degree to which one relates the stimulus to the self may be of little consequence to the quality of the resulting memory trace. In the present study, this pattern was observed even in the absence of retrieval support, which indicates that integration of the stimulus into the "self-schema" is not necessary to provide useful cues for retrieval, as has been suggested previously (Rogers et al., 1977; Bower & Gilligan, 1979); integration with general knowledge works just as well. Thus, conceptual processing involving general and self-relevant knowledge may be thought of as alternative, yet comparably meaningful forms of elaboration for both younger and older adults.

Potential Limitations

It is important to note differences between the present study and previous research that may have contributed to the results obtained here. In particular, we elected to use concrete nouns as opposed to trait adjectives as stimuli, adopting self-referential and semantic encoding judgments that could be applied appropriately (Hamami et al., 2011; Hayama & Rugg, 2009). Although a previous meta-analysis of the self-reference effect in memory suggests that the effect is more variable when concrete nouns are used in place of trait adjectives (Symons & Johnson, 1997), numerous studies have observed a self-reference effect using non-trait adjective stimuli across a variety of different memory tests and populations (Bower & Gilligan, 1979; Dulas et al., 2011; Grilli & Glisky, 2010, 2011; Hamami et al., 2011; Serbun, Shih, & Gutchess, 2011; Rosa & Gutchess, 2011; Warren et al., 1983). In light of these previous findings, as well as our replication of a self-reference benefit among contrasts that most resembled those conducted in previous

research, it is unlikely that our choice of stimuli can explain selected instances where a self-reference benefit did not emerge in the current results. Nevertheless, future research should aim to replicate and extend the present findings using a range of stimuli to assess their generalizability to different experimental contexts.

Conclusions

Taken together, the present results indicate that the mnemonic value of self-referencing differs substantially depending on the nature of the orienting tasks used to investigate the effect. In particular, the involvement of the self per se appears to have a smaller impact on subsequent memory performance compared with other characteristics of the encoding strategy, including the degree to which extensive stimulus elaboration occurs spontaneously through implementation of a given task set, and whether the strategy involves the retrieval of episodic or conceptual details from memory. Thus, the data presented here are consistent with previous suggestions that the self is not a special mnemonic entity that operates via a specific, unitary mechanism (Gillihan & Farah, 2005). Rather, we propose that the self simply represents a meaningful construct that can be applied flexibly to both contextual and conceptual encoding processes to aid stimulus differentiation and integration.

The observation that older adults can apply both self-referential and semantic encoding strategies that rely on existing knowledge just as well as younger adults, but are limited in their application of episodic self-referencing, indicates that the involvement of the self is neither necessary, nor sufficient, to enhance encoding operations in older adults. Thus, the present findings advance our understanding of appropriate encoding strategies for the elderly, which need not be self-referential in nature, but can similarly take advantage of the steady accumulation of general knowledge with age. Unfortunately, even the most effective encoding strategies in the present study did not eliminate recall deficits in our elderly group. This highlights the fact that age-related decline in episodic memory has a number of contributors, and enhancement of encoding operations can only go so far in diminishing this impairment. Thus, future research should focus on combining these strategies with those that can improve older adults' ability to initiate successful retrieval processes in the absence of environmental support to facilitate accurate recollection throughout the lifespan.

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