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Running Head: SELF-REFERENCE MODE IN MEMORY AND AGING

Reduction of the Self-Reference Effect in Younger and Older Adults

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Abstract

Relating information to the self improves memory. However, this self-reference effect (SRE) is typically studied through explicit self-judgments on individual trials. The current study assessed whether a self-referential mode of thought, induced through a writing task, also induced an SRE on a later task. The study also tested the effects of aging on the SRE, given that a long-lasting mnemonic strategy may be especially relevant for this group. Ninety-two younger adults and 60 older adults were assigned to different writing conditions and then completed an unrelated SRE task. Across younger and older adults, the classic SRE effect was observed in the narrative writing condition, reduced in the semantic self-reference condition, and further reduced in the episodic self-reference condition. These results support the induction of a self-referential mode of thought, but this mode does not enhance memory. The classic SRE effect can be reduced after thinking about the self by reflecting on autobiographical memories. Results argue for a single shared self-referential mechanism that can be accessed through self-focused writing or the classic SRE task.

Keywords: self-reference, autobiographical memory, aging, self, recall

Reduction of the Self-Reference Effect in Younger and Older Adults

Over the past 60 years, research has consistently demonstrated that relating information to oneself is an efficient, robust encoding strategy (e.g., Cartwright, 1956; Kelley et al., 2002; Klein, 2012; Leshikar & Duarte, 2012, 2014; Leshikar, Dulas, & Duarte, 2015; Rogers, Kuiper, & Kirker, 1977; Serbun, Shih, & Gutchess, 2011; Symons & Johnson, 1997). Typical self-referential paradigms involve learning a list of items, individually encoded with respect to oneself (e.g., “does this word describe me?”) or another non-self condition, such as another individual (e.g., “does this word describe the president?”), orthographic features (e.g., “is the word in upper case?”), or a semantic category (e.g., “is this a positive trait?”) (Symons & Johnson, 1997). Behavioral, neuroimaging, and lesion studies have further revealed that the self-referential encoding effect (SRE) is distinct from traditional levels of processing effects, typically resulting in larger effects on memory (Kelley et al., 2002; Rogers, Kuiper, & Kirker, 1977; Sui & Humphreys, 2013; Symons & Johnson, 1997; van der Meer et al., 2010). Moreover, the dissociation between SRE and typical episodic memory processes is further substantiated by the recruitment of distinct brain areas, with cortical midline structures, such as medial prefrontal cortex, recruited for SRE, and medial temporal lobe and lateral prefrontal regions recruited for episodic memory (Craig et al., 1999; Genon et al., 2013; Gutchess et al., 2010, 2015; Kelley et al., 2002; Leshikar & Duarte, 2012; Macrae et al., 2004; Philippi et al., 2012; Rosa et al., 2014).

Although the SRE is widely considered to be an effective strategy of memory encoding, research indicates that the self may be best understood as a range of overlapping but functionally independent categories (Grilli & Glisky, 2013; Klein, 1989,

2010, 2012; Klein & Gangi, 2010; Northoff et al., 2006; Prebble et al., 2013). Self-reference is typically divided into semantic and episodic categories (Lalanne et al., 2013; Levine et al., 2002; Piolino et al., 2002; Prebble et al., 2013; Symons & Johnson, 1997), although some researchers describe a rich family of self-referencing processes (e.g., Klein, 2010, 2012; Klein & Gangi, 2010) or interconnected but separable episodic and autobiographical memory systems (Conway, 2001; 2005; and Conway & Bekerian, 1987). Semantic self-reference refers to the activation of semantic autobiographical information. This may include relatively stable trait-based descriptions of the physical self (e.g., height, eye colour, place of residence), one's personality (e.g., temperament, mood), or other prominent characteristics of one's appearance and behavioral tendencies (Jones, Sensening, & Haley, 1974). Episodic self-reference, in contrast, typically requires specific detailed memories or autobiographical simulations that occur within a narrow window of time, for example, accessing a memory from one's past and mentally re-experiencing the event (e.g., the time I went bowling with friends in high school). Although episodic self-reference may incorporate some semantic information, semantic and episodic self-reference are assumed to be distinct (Klein 2010, 2012; Klein & Gangi, 2010; Piolino et al., 2006; Prebble et al., 2013; Symons & Johnson, 1997). Generally, episodic self-reference has been found to generate larger SREs in memory encoding than semantic self-reference (Symons & Johnson, 1997), perhaps because episodic self-referencing is unlikely to occur in isolation. That is, episodic self-reference may be a more powerful encoding strategy because it may contain elements of semantic and auto-noetic self-reference, while semantic self-reference is less likely to activate the self in multiple ways (Lalanne et al., 2013).

Despite the plenitude of research investigating the SRE, a critical limitation in classical research designs concerns the breadth of and ability to sustain the induced effect. Generally, an SRE paradigm requires participants to incidentally encode a list of items, with participants deliberately oriented to the self for some items (e.g., “does this word describe you?”), but not others. Thus, self-referential encoding is invoked at the level of the individual stimulus; that is, a self-referential judgment is made on an individual trial within a list (Symons & Johnson, 1997). This design not only explicitly directs attention to the self, but it also restricts the period of inducement for the SRE to the duration of an individual stimulus. Thus it is unclear whether the SRE may be temporally extended beyond an individually-encoded list item, or invoked without a specific cue presented at the time of each piece of information to be remembered. The ability to flexibly and generally induce an SRE across a wide variety of situations is an important theoretical consideration, but may also demonstrate that the SRE can be deployed in real-world environments, where trial-level judgments are less feasible. Self-referential encoding strategies may be harnessed to sustain self-referential encoding strategies over consecutive trials or perhaps entire stimulus lists, potentially conferring a memorial advantage relative to strategies that are not self-oriented. This may be possible given that invoking self-referential memory is not effortful (Yang, Truong, Fuss, & Bislimovic, 2012) and utilises neuroanatomical structures that are regularly activated across a broad range of circumstances in everyday life (Sui & Humphreys, 2013; Symons & Johnson, 1997; van der Meer et al., 2010). Additionally, there is some evidence that lingering task-related effects and intrusive thoughts may be linked to thinking about oneself (Johannessen & Berntsen, 2010; Killingsworth & Gilbert, 2010; Klinger, 1999;

Smallwood et al., 2009; Stawarczyk et al., 2013). If these lingering self-relevant effects could be harnessed as a type of sustained SRE, it seems likely that an episodic SRE may further strengthen the effect relative to a sustained semantic SRE.

This approach to inducing a self-referential mode of thought that can be sustained across subsequently presented information is analogous to other manipulations employed to improve memory and heighten access to self concepts. After an episodic specificity induction, in which experimenters instruct participants to retrieve information in as much detail as possible and prompts to elicit even more detail, younger and older adults remembered more episodic details on a separate set of stimuli (Madore et al., 2014; 2016). In addition, retrieving autobiographical memories increased the generation of self-defining statements (Charlesworth, Allen, Havelka, & Moulin, 2015). This example not only reveals a way in which autobiographical memory can have sustained effects on other processes, but it also indicates the link between autobiographical memory and the self.

Investigating these questions within the context of age may also shed light on cognitive and neuroanatomical mechanisms implicated in the SRE (Gutchess, Kensinger, Yoon, & Schacter, 2007), especially for older adults, whose well-documented declines in memory may benefit the most from a robust, temporally-extended mnemonic strategy. Interestingly, a lack of age-related differences in the self-referencing benefit has been relatively consistent across a range of studies. Despite well-documented overall declines with age in memory (e.g., Buckner, 2004; Park & Gutchess, 2004; Spencer & Raz, 1995) and executive function (e.g., Verhaeghen & Cerella, 2002; Salthouse, 2010; Salthouse, Atkinson, & Berish, 2003), older adults' SRE is typically comparable to that of younger adults (Glisky & Marquine, 2009; Gutchess, Kensinger, Yoon, & Schacter, 2007;

Gutchess et al., 2015; Hamami et al., 2011; Lalanne et al., 2013; Leshikar, Park, & Gutchess, 2015; Mueller, Wonderlich, & Dugan, 1986; St. Jacques & Levine, 2007; Trelle, Simons, & Henson, 2015). Neuroimaging has revealed that older adults activate the same structures in medial prefrontal cortex that support the SRE as their younger counterparts (Gutchess, Kensinger, & Schacter, 2007; Gutchess et al., 2015; Kalenzaga et al., 2015). The work from cognitive psychology and neuroimaging together therefore suggests that the mechanism driving the SRE may occur outside of areas traditionally associated with reliable age effects.

Given the limited investigations of semantic versus episodic self-reference memory in older adults, it may be worth considering age-related studies of autobiographical memory, a cognitive phenomenon that shares some overlap with the SRE (Conway, 2001; 2005; Conway & Bekerian, 1987; Kim, 2012; Kross, Davidson, Weber, & Ochsner, 2009; Northoff & Bermpohl, 2004). Limited research from autobiographical memory suggests that older adults' semantic self-referential memory remains largely intact whereas episodic self-referential memory declines (Cohen, 1998; Glisky & Marquine, 2009; Levine et al., 2002; Piolino et al., 2002; Trelle, Simons, & Henson, 2015). Although younger and older adults may benefit equally from both kinds of SRE, this evidence implies that older adults may benefit most from semantic self-referential memory encoding strategies, whereas younger adults may equally benefit from episodic and semantic self-referential memory encoding strategies.

In order to induce an extended self-referential mode of memory encoding, as well as to compare the contributions of episodic and semantic components of self-referencing, the current study employed a writing task immediately before completion of a classic

SRE paradigm. This technique is frequently used in autobiographical narrative tasks (e.g., Johannessen & Berntsen, 2010), and allows for a comparison of the effects of episodic and semantic self-referential modes of processing against an active, non-self-oriented control condition. Participants in the current study wrote for ten minutes regarding an episodic self-referential memory, a semantic self-referential concept, or a narrative story unrelated to the self. The present study used this design to explore the generalizability of the semantic and episodic SRE in younger and older adults. Namely, we investigated whether episodic and semantic modes of self-reference can influence the SRE in a typical self-referential memory task. That is, it may be possible to induce a self-referential mode of processing that is temporally-extended, supporting the encoding of multiple, rather than individual, stimuli without explicitly evoking the self on each trial.

We predicted that it would be possible to induce this novel SRE strategy separately from the effect observed in a classic SRE paradigm, and that this sustained SRE would confer general self-reference benefits over multiple items within an encoded list. The sustained SRE therefore may be induced via a self-focused relative to non-self-focused writing task, inspired from the autobiographical memory literature. It is possible that the sustained SRE could eliminate the SRE typically seen within the classic paradigm, as a self-referential mode could offset stimulus-level SRE benefits. According to this possibility, all items might nominally be processed as self-referential, diluting the encoding benefit observed at the item level in typical SRE paradigms. On the other hand, the sustained and stimulus-level SREs could be additive or interactive, lending a larger benefit to self-relevant trials in the classic SRE paradigm. These effects may also interact with the writing task. Following the autobiographical and self-referential literature, self-

referential effects should be moderately stronger for the episodic SRE manipulation, invoked via an autobiographical writing task, relative to the semantic SRE manipulation, invoked via a self-descriptive writing task, for younger adults. However given that older adults' episodic memory is more compromised relative to semantic memory, and that these effects extend at least somewhat to self-reference paradigms (e.g., Glisky & Marquine, 2009; Trelle, Simons, & Henson, 2015), we anticipated stronger semantic SRE effects for older adults, and equivalent effects for younger adults across semantic and episodic manipulations. It was anticipated that both self-oriented writing conditions would produce higher levels of recall relative to the narrative writing condition.

Method

Participants. Ninety-three younger adults (66 female), aged 18-24 ($M = 19.0$; $SD = 1.2$) and 60 older adults (41 female), aged 57-95 ($M = 77.2$; $SD = 8.6$) participated in the study and provided written informed consent for a protocol approved by the Brandeis University IRB. Younger participants were recruited from an undergraduate research pool and were given credit in partial fulfillment of course requirements. Older adults were recruited from the community and compensated for their time. Exclusion criteria included history of stroke or brain damage, and for older adults, scores of less than 25 on the Mini-Mental Status Exam (Folstein, Folstein, & McHugh, 1975). Demographic data are summarised in Table 1. Older adults were more highly educated than younger adults, $t(62.75) = 7.69$, $p < .001$. No group differences in years of education or mini-mental scores emerged as a function of writing condition, all $ps > .36$. Four older adults (1 from each of the writing conditions, and 2 from the narrative condition) retrieved zero items at recall, and were excluded from the analysis.

Design. The study was a 2 (Younger Adult / Older Adult) \times 3 (Episodic Self / Semantic Self / Narrative) \times 2 (Self-Referential / Commonness) mixed-model experiment. Participants completed a writing task, with the nature of the task varying between-subjects, followed by a within-subjects item encoding task.

Writing task. Participants were randomly assigned to one of three writing conditions intended to induce different modes of processing: Thirty-one younger adults and 19 older adults completed the Episodic Self writing condition, 31 younger adults and 21 older adults completed the Semantic Self writing condition, and 31 younger adults and 20 older adults completed the Narrative writing condition. Instructions were delivered via an LCD monitor, and participants completed the writing task by hand on sheets of college-ruled lined paper.

Participants in the Episodic Self writing condition were instructed to write about “a specific memory of an event from your personal past. The event must be one you were personally involved in, and you must have a strong enough memory of the event to tell a detailed story of the event.” Participants were encouraged to select a memory that “occurred at one specific time and place in your past (such as one specific afternoon, morning, etc.)” and to “provide as much detail as you can about the event (such as who was there, how you felt at the time, what happened, perceptual detail, etc.).”

Participants in the Semantic Self writing condition were instructed to write about “a description of yourself. You may write a physical description, summarise your personality or character traits, likes, dislikes, idle thoughts, dreams, or fears. You must write enough about yourself to be reasonably detailed.” Participants were encouraged to “not describe events from your past or specific plans for the future. You can choose any

aspect of yourself that you wish, but you must describe yourself as you are right now (not how you used to be or wish to be)” and to “Please provide as much detail as you can about the important aspects of who you are.”

Participants in the Narrative writing condition were instructed to write about a visual scene (taken from the “Affiliation” condition depicted in Fig. 1 of Beadle, Yoon, & Gutchess, 2012) of five middle-aged to older adults sitting together in a loose group in an urban environment. Middle aged targets were selected to avoid having a self-relevant target group, and a group that should be no more relevant to the younger or the older adults. Specifically, they were asked to write “a narrative description of what you believe to be happening in the picture. Please provide as much detail as you can about the events and descriptions in the story (such as who was there, how the characters/items interact, what is happening, etc.).”

Self-reference task. Stimuli for the self-referencing task consisted of 16 positive and 16 negative adjectives taken from the Anderson (1968) norms. Word sets were assigned to two different yes/no judgments: Self (i.e., “Does this word describe yourself?”) or Common (i.e., “Is this word commonly used?”), and trials assigned to each condition were presented in an interspersed, random order that was determined for each participant. There were 8 positive and 8 negative adjectives assigned to each encoding condition, which were all matched on arousal. Each set of positive and negative adjectives (i.e., the set of positive items for the self-descriptive judgment, and the set of positive items for the commonness judgment) were further matched on valence. On a given trial, participants were instructed to evaluate via keypress whether the presented adjective was self-descriptive or common. Participants pressed the Y key to indicate an

affirmative response and the N key to indicate a negative response. Each item was presented for 6 s, followed by a 150 ms intertrial interval. Items were counterbalanced between participants and writing conditions such that all stimuli appeared equally in the self-descriptiveness and commonness encoding conditions. Stimuli were centered in the display and appeared in white against a black background in 35-pt Helvetica Bold font, via LCD monitors. Computer stimuli for both the writing and self-reference portions of the experiment was controlled using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA).

Procedure. Participants were randomly assigned to one of the three writing conditions, and instructed to write a response to the presented prompt for the entirety of a 10-minute interval. The experimenter left the testing room while participants completed their written responses. After the ten minutes had elapsed, a 2 s pure tone sounded and written instructions appeared on the monitor and informed the participants to stop writing. The experimenter then re-entered the testing room.

Following the writing task, participants were told that they had completed the writing portion, and to set their written responses aside in order to prepare for the next, ostensibly unrelated task. They were then given instructions about the self-reference task, and incidentally encoded 32 adjectives. After the incidental encoding phase, participants counted backwards by 7s from 107 for 90 s to clear short-term memory. Following this interval, a 2 s pure tone sounded and participants were provided instructions to stop counting. Finally, participants completed a self-paced, surprise free recall task by writing down all of the adjectives they had encoded during the self-reference task.

Results

Analytical approach. The primary measure of interest was free recall performance from the surprise self-reference memory task as a function of one of two encoding conditions (i.e., self-descriptiveness or commonness of an item), administered within participant. This within-subjects performance was compared among the three writing conditions, using a 2 (Younger / Older Adult) \times 3 (Episodic Self / Semantic Self / Narrative) \times 2 (Self-Referential / Commonness) mixed-model ANOVA.

All results are presented after testing for unequal variance between groups using Mauchly's test of sphericity for analyses of variance. An alpha of .05 was set to indicate significance.

Manipulation check – writing condition

Given the novel design of the current study, a manipulation check was conducted to confirm whether participants were able to follow task instructions in the writing conditions. That is, we wanted to ensure that individuals assigned to the episodic self writing condition used self-referential personal pronouns (e.g., “I”), and a clear temporal focus. Comparably, the semantic self writing condition might also use self-referential personal pronouns, but should not make use of a temporal focus. Finally, the narrative writing condition should not use personal pronouns, but may include a temporal focus. Participants' texts were transcribed and analyzed using the Linguistic Inquiry and Word Count (LIWC2007) text analysis software (Pennebaker Conglomerates, Inc., Austin, TX). LIWC software parses written text for dozens of content characteristics, such as use of personal pronouns and temporal focus. Word usage, as captured through LIWC, is argued to be sensitive to changes in attention (e.g., to self or other), difference in individuals experience and express emotions, and social dynamics (Tausczik & Pennebaker, 2010).

Selected variables are expressed as a percentage of total words in the text sample. Data are summarized in Table 2.

Use of personal pronouns. The personal pronoun *I* was used most in the Semantic Self writing condition, followed by the Episodic Self writing condition, and least in the Narrative writing condition (all $ps < .001$). Younger adults were more likely than older adults to use *I* ($p = .04$). The personal pronoun *we* was used most in the Episodic Self writing condition (both $ps < .001$), relative to the Semantic Self and Narrative writing conditions, which did not significantly differ from each other ($p = .436$). Use of the personal pronoun *they* was used most in the Narrative writing condition (both $ps < .001$), relative to the Episodic Self and Semantic Self writing conditions, which did not significantly differ from each other ($p = .423$). No main effects with age were observed with respect to use of personal pronouns *we* and *they* (all $ps > .09$), nor were any interactions between writing condition and age observed (all $ps > .10$).

Use of temporally oriented language. Past-oriented language was used most in the Episodic Self writing condition ($p < .001$), relative to the Semantic Self writing condition, which in turn used more past-oriented language compared to the Narrative writing condition ($p = .020$). Younger adults also used more past-oriented language relative to older adults ($p = .008$). Temporally present-oriented language was used most in the Semantic Self writing condition relative to the Narrative writing condition ($p = .001$), which also differed significantly from the Episodic Self writing condition ($p < .001$). Future-oriented language did not differ as a function of writing condition (all $ps > .442$) or age ($p = .923$). As with personal pronouns, no main effects with age were

observed with respect to use of present or future-oriented language (both $ps > .55$), nor were any interactions observed between writing condition and age (all $ps > .07$).

Memory performance

Recall. Full results are reported in Table 3 and primary findings are displayed in Figure 1. There was a main effect of encoding condition, $F(1, 143) = 23.04, p < .001, \eta_p^2 = .14$, such that more items judged for self-descriptiveness were recalled than items judged for commonness. Younger adults also recalled more items than older adults, $F(1, 143) = 38.35, p < .001, \eta_p^2 = .21$. Although there was no main effect of writing condition ($F < 1$), the results yielded a reliable interaction between writing condition and encoding condition, $F(2, 143) = 3.15, p = .046, \eta_p^2 = .04$. Planned post-hoc comparisons revealed that the encoding advantage for items judged for self-descriptiveness compared to items judged for commonness was preserved in the narrative writing condition, $F(1, 47) = 22.48, p < .001, \eta_p^2 = .32$, marginally significant in the semantic self-referential writing condition, $F(1, 49) = 4.04, p = .050, \eta_p^2 = .08$, and further reduced in the episodic self-referential writing condition, $F(1, 47) = 2.35, p = .13$. No other effects or interactions were significant, all $Fs < 1$. Compared to the narrative condition, both the episodic, $F(1, 94) = 4.85, p = .03, \eta_p^2 = .05$, and the semantic, $F(1, 96) = 4.57, p = .04, \eta_p^2 = .05$, self-writing conditions had smaller differences between memory performance for self-referential compared to common trials. Although these interactions tended to reflect differences in memory for the self-referential trials, $F(2, 146) = 2.30, p = .10, \eta_p^2 = .03$ (commonness condition: $F(2, 146) = .73, p = .49, \eta_p^2 = .01$), this condition alone did not entirely account for the effects, suggesting that the relative difference between performance on the self and common trials is important to consider.

Intrusions. Intrusions were coded as words generated during recall that were not studied. Older adults committed more intrusions than younger adults $F(1, 143) = 61.66, p < .001, \eta_p^2 = .30$. No differences in intrusion rate were observed as a function of or interaction with writing condition, $F_s < 1$.

Discussion

The primary goal of the present study was to induce and sustain a self-referencing encoding effect (SRE) beyond the level of individual stimuli, through the use of an unrelated self-referential writing task. Results suggest that although we succeeded in inducing a self-referential mode of thought, the manipulation actually worked to *limit* the classic SRE across younger and older adults. The findings also have implications for understanding the different mechanisms through which thinking about oneself can influence memory. We will discuss each of these effects in turn.

The writing manipulation was successful, based on the results from manipulation checks using the LIWC analysis software. The Autobiographical writing condition tended to be past-oriented and use personal pronouns such as “I” and “we”, potentially indicating the socially-relevant and repeated nature of the memories described during the task. The Self-descriptive writing condition made use of these same pronouns but was temporally present, and the Narrative condition primarily invoked third-person pronouns and was not temporally distinct. These patterns emerged across younger and older adults. Therefore, it appears that the self-referential modes of thinking may be associated at least partly with the writing task.

Critically, we observed an interaction between writing condition and encoding condition on the subsequent self-referencing task. Although we replicated the well-

documented self-reference effect for participants in the narrative writing condition, the encoding benefit was weakly present for the semantic self-reference writing condition, and was further reduced in the episodic self-reference writing condition. That is, the writing conditions focused on the self, particularly the episodic self, *reduced* the SRE, which was in contrast to our predictions. Interestingly, there was no observed main effect of writing condition, which indicates that total recall across self-descriptive and common-encoded items was similar among all three writing conditions. Rather than simply reflecting effects of the writing condition on memory for self-referenced items, the findings reflect shifting proportions of memory for self-referenced relative to common items for both younger and older adults. Moreover, although we had predicted that semantic, but not episodic, self writing conditions would operate similarly across younger and older adults due to greater preservation of the semantic self with age, we found that the writing conditions operated similarly across the age groups. Ultimately, this may mean that while a strong SRE can be evoked on the item level in our control condition, the Narrative writing task, the Self writing conditions limit the extent to which SRE occur compared to a control task. We will speculate below on what this unexpected finding suggests about underlying processes.

To our knowledge, we believe no other studies have manipulated the SRE using an ostensibly unrelated task. Although several studies have manipulated the SRE using valenced information (e.g., D'Argembeau, Comblain, & Van der Linden, 2005; Fossati et al., 2004, Herbert, Pauli, & Herbert, 2010), in subclinical and clinical depression (Bargh & Tota, 1988; Derry & Kuiper, 1981; Lemogne et al., 2009; Watson, Dritschel, Jentsch, & Obonsawin, 2008; Wisco, 2009), mindfulness meditation (Berkovich-Ohana,

Glicksohn, & Goldstein, 2012; Farb et al., 2007) or by manipulation of retrieval conditions (D'Argembeau et al., 2005; see Symons & Johnson, 1997, for a review), very few studies have manipulated the effect beyond the item level, and none using a separate task. Philippi and colleagues (2012) observed an elimination of the SRE with damage to medial prefrontal cortex. However, these studies directly manipulated the classic SRE paradigm to obtain reversals and eliminations of the encoding effect. The current study simply introduced a writing task prior to the onset of a typical SRE task to obtain the reported effects. As far as we are aware, no study has modulated the SRE while maintaining the essential SRE task paradigm. The theoretical implications for this are discussed further below.

One aspect of our results suggests that activation of the self may occur via a limited-capacity cognitive resource (e.g, Klein, 2012; Prebble et al., 2013; Symons & Johnson, 1997). Namely, the reduction of the SRE in the Episodic and Semantic Self writing conditions was presumably driven through changes in the recall of both self-reference-encoded and commonness-encoded items, as suggested by equivalent total recall across all three writing conditions. The lack of SRE additivity between the classic SRE and the self-oriented writing conditions suggests that self-reference, activated via a writing task, does not enhance the magnitude of the SRE in the classic paradigm. The inclusion of episodic and semantic SRE writing conditions seems to further support this claim. Therefore, self-reference may be activated through either semantic or episodic means. It is also possible, though less parsimonious, that self-reference may be similarly induced across the two kinds of self-referential writing conditions. In addition, our findings indicate that this limited-capacity cognitive resource does not differ with age.

This may suggest that self-reference effects draw on mechanisms that are not impacted by aging, unlike many other cognitive and memory tasks that are impaired with age. Thus, our findings are in line with many of the SRE studies using classic trial-by-trial paradigms in which benefits from self-referencing emerge to a similar extent for younger and older adults (e.g., Mueller et al., 1986; Gutchess, Kensinger, Yoon, & Schacter, 2007).

Because our initial predictions were not supported, particularly with respect to how the writing-induced SRE interacted with the classic SRE, the specific mechanisms underlying the changes in processing are unclear. To further speculate on relevant processes, it is important to note that the primary pattern indicates a reduction in the benefit for the trials judged for self-reference compared to those judged for commonness. That is, it does not appear to be the case that the self writing conditions enhanced memory for words judged for commonness by infusing a self benefit into these trials, as the level of memory performance for common words is fairly consistent across conditions (although we note in the results section that the combination of common and self trials is necessary to explain the interaction). Thus, it appears that the benefit from self-referencing during encoding tends to be *reduced* in the self writing conditions, relative to the narrative writing condition. According to Conway's (2005) model of the self-memory system, autobiographical memory, invoked by our self writing conditions, is linked to a number of processes. Goals can be activated in the working self, guiding access to information or limiting the potential for incoming information to be perceived as self-relevant. That is, under typical conditions, perhaps there is more flexibility in the types of information that can be associated with the self or retrieved from memory. But after

recalling autobiographical memories, perhaps only information most relevant to one's goals can be associated with oneself or be accessible for memory retrieval. Given the degree of self-initiation required for recall of information from memory, as used in the current task, accessibility of information may be limited. If the self writing condition heightens a focus on goals relevant to oneself, items endorsed as self-relevant at encoding should be disproportionately better encoded than items judged as non-self relevant, and in comparison to the narrative condition. The present data are not ideal for such comparisons, due to the low number of recalled words, which would be even further divided across "yes" and "no" responses. Future work with a recognition task would allow for the comparison of robust numbers of remember items judged as either self-relevant or not. In addition, fluency of information should be increased at retrieval for self-relevance due to the presence of word cues, which would allow for a test of the role of accessibility. In addition, it is worth noting that the pattern of results is generally similar in our episodic and semantic self writing conditions, which could suggest that it is the content of the self, encompassing the present and temporally extended selves, according to the model of Prebble and colleagues (2013), that contributes to this pattern of findings.

Future work would also benefit from using different types of pictures as controls in the narrative condition. We selected a target picture of middle aged adults to be equally relevant, and not self relevant, to younger and older adults. However, it is possible that the older group identified more with the group, having been that age, compared to the younger adults. As the manipulation check measures did not differ across younger and older adults, we do not think this is confounded, but it would be illustrative to manipulate

the nature of the narrative condition, including the use of a non-social prompt to compare the effects on memory.

Our finding of reductions in the SRE in the two self-oriented writing conditions suggests that a sustained state of self-reference may persist beyond the boundary conditions of the intended task for both younger and older adults. However, there are several aspects of the data that should be further explored in future work. For one, the level of recall performance was low, even for younger adults; this may, in part, reflect the long (90 sec) delay before retrieval. Extending the pattern of findings to higher levels of performance would help to address the possibility that the relatively larger difference in the narrative condition does not simply reflect the lack of power to detect effects in the conditions with the lower levels of performance. As the effects appear to be somewhat variable, future work can determine which variables make one more or less likely to benefit from self-referential modes of thought. Emotion could be one variable that is important to consider in terms of how it interacts with self-referencing effects, as previous work has revealed associations between well-being and the valence of semantic self-images (but not episodic autobiographical memories) (Rathbone, Holmes, Murphy, & Ellis, 2015). It is possible that valence could influence effects in our task either through the relative positivity or negativity induced by the writing manipulation or through the effects on memory for positively vs. negatively valenced information. Future work, particularly with measures that invoke higher levels of memory, may help to disentangle whether effects are exaggerated under emotional conditions.

In addition, scoring autobiographical interviews, an approach used in a large body of research on autobiographical memory, may be useful as a manipulation check or in

identifying which aspects of the autobiographical memories and narratives affect memory outcomes. In this technique, individuals are prompted to relay rich episodic details of their autobiographical memories, and the content of these memories is then coded for whether each aspect reflects a specific episodic detail (e.g., the place the event occurred) or more general semantic aspect (e.g., facts about the place that are not tied to the specific episodic) (Levine et al., 2002). Compared to the scores resulting from autobiographical interviews, LIWC has some advantages in terms of using an objective measure that does not rely on labor-intensive coding and agreement of multiple scorers. Furthermore, recent data suggest that both measures can converge, such that the linguistic features extracted by LIWC can predict autobiographical detail summary scores (Peters, Wiehler, & Bromberg, 2017). In future work, however, it may be fruitful to apply the autobiographical interview approach to research investigating self-referencing modes of thought. It is also possible that separating specific episodic details from general semantic aspects would allow for greater sensitivity to detect effects of aging, as aging is typically associated with a selective reduction in episodic details (Levine et al., 2002).

The lack of age differences was somewhat surprising. Although age-invariant findings with regard to the SRE have been well-documented (Glisky & Marquine, 2009; Gutchess, Kensinger, & Schacter, 2010; Gutchess, Kensinger, Yoon, & Schacter, 2007; Gutchess et al., 2015; Hamami et al., 2011; Lalanne et al., 2013; Leshikar, Park, & Gutchess, 2015), it is possible that a stronger manipulation, induced via a longer self-oriented writing task, study of a more constrained range of ages for older adults, or considering emotion may allow for some differentiation between the Episodic or Semantic Self writing conditions (see, e.g., Trelle, Simons, & Henson, 2015; Rathbone et

al., 2015). In the current study, the differences between these components of self-referencing appear to be negligible.

In summary, in the current study we found that encouraging younger and older adults to write about themselves, via induction of episodic and semantic self-reference, reduced the classic SRE at the level of the individual trial. Much work remains to be done to understand and contextualize the boundaries of extending a self-referential mode in memory encoding. Such an extended self-referential mode has the potential to influence performance on subsequent tasks that do not directly reference the self.

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Disclosure of Interest

The authors report no conflicts of interest.

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Table 1
Demographic Data (SDs) as a Function of Age and Writing Task

Measure	Episodic Self		Semantic Self		Narrative	
	Younger	Older	Younger	Older	Younger	Older
<i>N</i> (female)	31 (19)	19 (18)	31 (25)	21 (14)	31 (22)	20 (9)
Age	19.1 (1.0) ^a	76.1 (7.4)	19.0 (1.3)	76.8 (10.1)	19.0 (1.4)	78.8 (8.1)
Years of education	12.4 (0.8)	15.7 (2.5)	12.6 (1.0)	14.9 (3.0)	12.5 (1.0)	15.6 (2.7)
Mini Mental State Exam		29.3 (1.2)		28.9 (1.2)		28.9 (1.6)

^aSD in parentheses for this and all subsequent cells.

Table 2

Linguistic Inquiry Word Count Data (SDs) as a Function of Age and Writing Task

Measure	Episodic Self		Semantic Self		Narrative	
	Younger	Older	Younger	Older	Younger	Older
Personal Pronouns						
<i>I</i> ^{a,b}	8.6 (4.0)	4.0 (0.6)	12.4 (1.9)	10.1 (2.2)	0.2 (0.7)	0.7 (0.9)
<i>We</i> ^a	1.8 (1.9)	2.5 (2.6)	0.2 (0.5)	1.3 (1.8)	0	0
<i>They</i> ^a	0.8 (1.2)	0	0.5 (0.6)	0.2 (0.2)	3.4 (2.0)	1.8 (0.6)
Temporal Orientation						
<i>Past</i> ^{a,b}	9.1 (1.9)	5.0 (1.0)	0.8 (0.9)	1.1 (0.2)	2.4 (2.7)	0
<i>Present</i> ^a	2.5 (1.9)	2.4 (0.7)	11.2 (1.8)	10.6 (1.5)	9.0 (3.0)	8.2 (2.9)
<i>Future</i>	0.4 (0.8)	0.6 (0.9)	0.4 (0.6)	0	0.3 (0.5)	0.6 (0.6)

^aIndicates a significant main effect of writing condition.^bIndicates a significant main effect of age group.

Table 3.

Recall (SD) as a Function of Stimulus Encoding, Writing Condition, and Age

Encoding condition	Episodic Self		Semantic Self		Narrative	
	Younger	Older	Younger	Older	Younger	Older
Self-descriptive	4.1 (2.0)	2.2 (1.4)	3.5 (1.5)	2.3 (1.5)	4.3 (2.1)	3.1 (1.7)
Commonness	3.6 (2.2)	1.7 (1.4)	3.0 (1.8)	1.7 (2.2)	3.2 (2.0)	1.2 (0.7)

Figure Captions

Figure 1. Recall as a function of stimulus encoding and writing condition. Data are collapsed across age to illustrate the significant interaction between writing condition (x-axis) and encoding condition (solid vs. striped bars). Follow-up tests indicate that more words judged for self-descriptiveness are recalled than words judged for commonness in the narrative writing condition, with the difference between the conditions marginal in the semantic self writing condition, and non-significant in the episodic self writing condition. Error bars reflect the standard error of the mean.

Figure 1.

