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Self-Reference Effect and Self-Reference Recollection Effect for Trait Adjectives in Amnestic Mild Cognitive Impairment

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Abstract

Objectives: The self-reference effect (SRE), enhanced memory for self-related information, has been studied in healthy young and older adults but has had little investigation in people with age-related memory disorders, such as amnestic mild cognitive impairment (aMCI). Self-referential encoding may help to improve episodic memory in aMCI. Additionally, self-referential processing has been shown to benefit *recollection*, the vivid re-experiencing of past events, a phenomenon that has been termed the *self-reference recollection effect* (SRRE; Conway & Dewhurst, 1995). Furthermore, it remains unclear whether the valence of stimuli influences the appearance of the SRE and SRRE. **Methods:** The current study investigated the SRE and SRRE for trait adjective words in 20 individuals with aMCI and 30 healthy older adult controls. Ninety trait adjective words were allocated to self-reference, semantic, or structural encoding conditions; memory was later tested using a recognition test. **Results:** While healthy older adults showed a SRE, individuals with aMCI did not benefit from self-referential encoding over and above that of semantic encoding (an effect of "deep encoding"). A similar pattern was apparent for the SRRE; healthy controls showed enhanced recollection for words encoded in the self-reference condition, while the aMCI group did not show specific benefit to recollection for self-referenced over semantically encoded items. No effects of valence were found. **Conclusions:** These results indicate that while memory for trait adjective words can be improved in aMCI with deep encoding strategies (whether self-reference or semantic), self-referencing does not provide an additional benefit. (*JINS*, 2018, *24*, 821–832)

Keywords: Self-reference effect, Healthy cognitive aging, Amnestic mild cognitive impairment, Self-reference recollection effect, Episodic memory, Deep encoding

INTRODUCTION

It is well established that episodic memory, memory for items and events tied to a specific time and place, changes with age and age-related neurological disorders. In healthy cognitive aging, episodic memory declines gradually, while in more pathological forms of cognitive aging, such as Alzheimer's disease (AD), episodic memory impairment is a notable aspect of the behavioral manifestation of the disease. Episodic memory decline is also characteristic of amnestic mild cognitive impairment (aMCI), an intermediate stage between healthy cognitive aging and dementia. Notably, other kinds of memory, such as semantic memory for knowledge about the self and the world, remain relatively intact in aMCI (Barnabe, Whitehead, Pilon, Arsenault-Lapierre, & Chertkow, 2012; Gamboz et al., 2010; Murphy, Troyer, Levine, & Moscovitch, 2008; cf. Leyhe et al., 2009 and Irish, Lawlor, O'Mara, & Coen, 2010). Given that individuals with aMCI are at high risk for developing AD (Albert et al., 2011; Petersen et al., 1999; 2001, 2005, 2009), it is crucial to understand whether it is possible to capitalize on spared aspects of memory to benefit other aspects prone to decline.

Self-Reference Effect

The self-reference effect (SRE), enhanced memory for self-related information, is a cognitive phenomenon discovered by Rogers, Kuiper, and Kirker (1977), based on the Levels of

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Processing approach (Craik & Lockhart, 1972; Craik & Tulving, 1975). These authors showed that encoding information in relation to the self involved "deeper" processing than other encoding manipulations (such as those based on semantic knowledge or identification of surface details) and promoted episodic memory to a greater extent than other ways of encoding. Studies of the SRE have since been primarily conducted in young adults, but more recently the effect has been shown for trait adjectives in healthy aging (Carson, Murphy, Moscovitch, & Rosenbaum, 2016; Genon et al., 2014; Glisky & Marquine, 2009; Gutchess, Kensinger, Yoon, & Schacter, 2007; Lalanne, Rozenberg, Grolleau, & Piolino, 2013; Leblond et al., 2016). Given that healthy cognitive aging is associated with a decline in episodic memory, these results are encouraging.

Individuals with aMCI experience episodic memory decline that is more severe than that apparent in healthy cognitive aging. Episodic memory is related to the ability to perform day-to-day complex activities independently (Koehler et al., 2011; Teng, Becker, Woo, Cummings, & Lu, 2010; Tomaszewski Farias et al., 2009; Tuokko, Morris, & Ebert, 2005; Wadley et al., 2007), and the ability to function independently is at the crux of the distinction between aMCI and dementia. Capitalizing on intact memory processes in aMCI, such as semantic memory, may help to slow episodic memory decline or even improve episodic memory, with the possibility of prolonging independent daily function in aMCI. The SRE, which uses knowledge about the self (personal semantic memory) to promote episodic memory, may prove to be a useful strategy for the maintenance and/or improvement of episodic memory in aMCI.

To date, there have been very few studies of the SRE in aMCI. Rosa, Deason, Budson, and Gutchess (2015) found no SRE for trait adjectives in aMCI, whereas a study by Leblond et al. (2016) found a SRE in aMCI that was specific to positively valenced trait adjectives. Another study by Rosa, Deason, Budson, and Gutchess (2016), indicated that individuals with aMCI did not show a benefit to source memory for self-referenced items, although they did show overall better memory for items that were learned through self-related processing.

Despite limited investigation of the SRE in aMCI, the handful of studies conducted in other memory-impaired populations provide insight into whether individuals with impaired episodic memory show the SRE. The few studies of the SRE in AD have demonstrated mixed results, with some finding no SRE (Genon et al., 2014; Hussey, Smolinsky, Piryatinski, Budson, & Ally, 2012; Lalanne et al., 2013; Wong et al., 2017) and others showing that self-referential processing improves memory in AD (Kalenzaga, Bugaïska, & Clarys, 2013; Kalenzaga & Clarys, 2013). Studies of individuals with acquired brain injury have been more consistent, finding enhanced memory when participants imagined material from a self-referential perspective (Grilli & Glisky, 2010, 2011, 2013; Grilli & McFarland, 2011). Research indicating the successful application of the SRE in memory-disordered populations supports the potential effective use of the strategy in aMCI.

Self-Reference Recollection Effect

Previous research has indicated that self-referential processing promotes episodic memory by enhancing "recollection," the process of re-experiencing contextual details of an episode (Tulving, 1985). The improvement in recollection with self-referential encoding has been termed the *self-reference recollection effect* (SRRE; Conway & Dewhurst, 1995; Conway, Dewhurst, Pearson, & Sapute, 2001). Recollection is known to be vulnerable to changes in healthy aging (Bastin & Van der Linden, 2003; Java, 1996; Light, Prull, La Voie, & Healy, 2000; Mäntylä, 1993) and these changes are even more notable in aMCI.

In contrast, "familiarity," the feeling of prior exposure without specific context (Tulving, 1985), remains relatively preserved in aMCI (e.g., Anderson et al., 2008; Hudon, Belleville, & Gauthier, 2009; Irish et al., 2010; Serra et al., 2010; Westerberg et al., 2006; cf. Ally, Gold, & Budson, 2009; Koen & Yonelinas, 2014; Wolk, Signoff, & DeKosky, 2008). The SRRE has been found in younger adults (Conway & Dewhurst, 1995; Conway et al., 2001; Leshikar & Duarte, 2012; van den Bos, Cunningham, Conway, & Turk, 2010) and healthy older adults (Carson et al., 2016; Genon et al., 2014; Leshikar, Dulas, & Duarte, 2015); however, it has not been investigated in aMCI. It is possible that as in studies of the SRRE in healthy aging, self-referential processing leads to improved recollection in aMCI.

Although the SRRE in aMCI has yet to be studied, other studies of memory-impaired populations provide indication of the potential of self-referential processing to enhance recollection in individuals with episodic memory difficulties. Three of four studies to date that have examined the SRRE in AD found that self-referential processing improved recollection, although Lalanne et al. (2013) found an SRRE in AD only for positive trait adjectives and Kalenzaga and Clarys (2013) and Kalenzaga et al. (2013) found an SRRE exclusively for negative trait adjective words. The AD group in Genon et al. (2014) did not show the SRRE; instead results indicated similarly low recollection scores for material encoded in both self-reference and other-reference conditions. Given that self-referential encoding has been shown to promote recollection in healthy aging and in some studies of AD, it seems likely that those with aMCI would likewise benefit, potentially less than healthy older adults and more than individuals with AD. As indicated in the studies mentioned above, it is also important to consider the influence of stimulus valence on the SRE and SRRE.

Influence of Valence on the SRE and SRRE

Previous studies of the SRE and SRRE in older adults have made predictions consistent with *socioemotional selectivity theory*, which posits that older adults are biased toward memory for positive versus negative information (Carstensen & Mikels, 2005; Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2005). Not all studies of cognitive aging, however, support an age-related positivity bias

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(e.g., Denburg, Buchanan, Tranel, & Adolphs, 2003; Grühn, Smith, & Baltes, 2005; Fernandes, Ross, Wiegand, & Schryer, 2008; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Murphy & Isaacowitz, 2008). There have likewise been mixed results regarding the influence of valence on the SRE and SRRE across the lifespan. One study of the SRE for trait adjectives in healthy aging showed the expected positivity bias specific to older adults (Carson et al., 2016, Experiment 1), whereas another showed enhanced memory in younger adults for negative items and no effect of valence in older adults (Glisky & Marquine, 2009). A third study found similar negative valence preferences across the lifespan (Gutchess, Kensinger, & Schacter, 2007, Experiment 2). Additionally, Leshikar et al. (2015) studied the SRRE in young and older adults and found that recollection was higher for positive versus negative information in both age groups.

The only study of the SRE in aMCI to investigate valence (Leblond et al., 2016) indicated that while healthy controls showed no valence preferences, individuals with aMCI exhibited the SRE specifically for positive trait adjectives. This finding is consistent with other research that has shown a positivity bias in aMCI (Brueckner & Moritz, 2009; Callahan et al., 2016 [immediate recall]; Werheid et al., 2010) but inconsistent with other studies indicating a negativity bias (Mah, Anderson, Verhoeff, & Pollack, 2017) or no difference for positive and negative material over neutral stimuli in aMCI (Callahan, Laforce, Dugas, & Hudon, 2017).

Study Aims and Predictions

The present study aimed to augment the limited research that has explored self-referencing as a strategy for enhancing episodic memory in aMCI and, for the first time, to investigate whether self-referential processing promotes recollection in this population (i.e., the SRRE). It was predicted that individuals with aMCI would show the SRE for trait adjectives, with potentially lower ability to capitalize on the strategy than their healthy counterparts. Based on the work of Leblond et al. (2016), we predicted that if individuals with aMCI showed a valence preference, it would be in the direction of a positivity effect. Lastly, based on previous studies showing the SRRE in healthy older adults and in individuals with AD, we predicted that individuals with aMCI would show enhanced recollection for self-referenced material, however, likely to a lesser extent than their healthy counterparts.

METHODS

Participants

Twenty older adults with single domain aMCI (age: $M = 72.7$; $SD = 5.7$) and 30 healthy older adult controls (age: $M = 70.1$; $SD = 5.5$) participated in the study. All participants completed cognitive testing with a standard battery of neuropsychological tests (described below). Participants were recruited through the Department of Neuropsychology and Cognitive Health at Baycrest Health Sciences and through the Rotman Research Institute and York University research volunteer databases. Single domain aMCI was classified according to diagnostic criteria put forth by Peterson (2004) and updated by the National Institute on Aging-Alzheimer's Association (Albert et al., 2011). These included (1) cognitive concern reflecting a change in cognition reported by patient, informant, or clinician; (2) objective evidence of impairment, most frequently for episodic memory; (3) preservation of independence in functional abilities; and (4) absence of dementia. All participants received monetary compensation for their participation. Exclusion criteria included the presence of neurological, cardiovascular, or psychiatric disorders known to affect cognition. Informed consent was obtained from all participants in accordance with the procedures of Research Ethics Boards at Baycrest Health Sciences and York University.

Neuropsychological Measures

A brief battery of targeted neuropsychological tests was administered to participants with aMCI and healthy older controls. See Table 1 for a list of neuropsychological measures included in the test battery.

Trait Adjective Paradigm

Materials

Stimuli were personality trait adjectives rated according to "likeability" (Anderson, 1968). Ninety words with the most positive rankings and 90 with the most negative rankings were randomly assigned to either the study lists or the distractor list that was presented in the recognition task. Nine study lists were created, each comprised of 10 words (5 positive, 5 negative). For the recognition test, the same list of 90 distractor items was presented to all participants, with an equal number of positive and negative words. The target and distractor lists were matched in terms of likeability ratings, word length ($M = 8.7$ letters), and word frequency ($M = 22.96$; Brysbaert & New, 2009).

Procedure

The procedure was based on previous studies of the SRE for trait adjective words by Fossati et al. (2003, 2004). Participants made yes/no judgments about trait adjective words under three blocked study conditions: self-reference ("Does this word describe me?"), semantic ("Does this word describe a desirable personality trait?"), and structural ("Does this word contain the letter 'e'?"). Trait adjectives were presented on a computer screen using E-Prime software (Psychology Tools). Three of the study lists were assigned to each of the encoding conditions, and allocation of list to condition was counterbalanced across participants. The blocked study

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conditions were presented in a pseudorandomized order that was unique for each participant and constrained so that the same encoding condition was not presented in two sequential blocks.

Presentation of each block commenced with an instruction screen indicating which of the three decisions (self-reference, semantic, structural) was to be made for the subsequent presentation of 10 trait adjective words. Each individual trial consisted of a fixation cross presented for 500 ms followed by a trait adjective word presented for 4500 ms, during which time participants were prompted to make their yes/no judgment. This was followed by a 5000 ms fixation cross. Presentation order of words within blocks was randomized across participants. A 10-min retention interval followed the study phase (based on Gutchess et al., 2007), during which WAIS-III Digit Span, Digit Symbol Coding, Digit Symbol Incidental Learning, and Digit Symbol Free Recall (Wechsler, 1997) were administered. Following the retention interval, participants were administered a recognition test in which they were asked to distinguish previously studied trait adjectives from distractors (old/new button press).

For the recognition test, all 90 studied trait adjectives and 90 distractors were presented in random order, with the same list of distractor items presented to all participants. When participants indicated that a word had been previously studied ("old"), they were then asked to make an additional remember/know decision with a button press. A "remember" button press indicated that the participant was able to recollect specific episodic details from viewing the trait adjective during the study portion of the paradigm. A "know" button press indicated that a trait adjective elicited a feeling of familiarity for the participant without contextual detail. Participants received a thorough explanation of the remember/know distinction before completing the recognition test and were asked to demonstrate the understanding of the distinction. Participants were also provided with a cue card with a simplified explanation of the remember/know distinction for reference during the recognition test. The recognition test was self-paced and responses were recorded by E-Prime software.

Statistical Analyses

Overall recognition (SRE)

Corrected recognition scores were calculated according to encoding condition and valence, resulting in six scores for each participant: self-reference positive, self-reference negative, semantic positive, semantic negative, structural positive, and structural negative. Each of these scores was calculated by subtracting the proportion of false alarms from the proportion of hits (e.g., self-reference positive score = proportion self-reference positive hits – proportion positive false alarms). Each participant had two false alarm scores, one for positive items and one for negative items. Overall recognition was analyzed using mixed $3 \times 2 \times 3$ ANOVAs, with participant group (healthy control/aMCI) as the between-subjects variable and encoding condition (self-reference/semantic/structural) and item valence (positive/negative) as within-subjects factors. In addition, false alarms were analyzed in a 2×2 mixed ANOVA, with participant group (healthy control/aMCI) as the between-subjects factor and valence (positive/negative) as the within-subjects variable.

Recollection and familiarity

Experiences of recollection and familiarity during the recognition test were measured using a remember (recollection)/know (familiarity) button press. Scores were then calculated with the Independence Remember Know (IRK) method, which holds that recollection and familiarity are independent processes and, therefore, familiarity should not simply reflect an absence of recollection (Jacoby, Yonelinas, & Jennings, 1997; Yonelinas & Jacoby, 1995). Recollection scores were calculated for each study condition according to corrected recognition [proportion remember hits – proportion remember false alarms]. Familiarity was calculated for each study condition as [proportion of know hits/1-proportion of remember hits] – [proportion know false alarms/1-proportion remember false alarms]. Recollection and familiarity were analyzed separately in mixed $2 \times 3 \times 2$ ANOVAs, with participant group (healthy control/aMCI) as the between-groups variable and encoding condition (self-reference/semantic/structural) and valence (positive/negative) as within-group variables.

Influence of self-descriptiveness on memory

Previous studies have shown that endorsing a trait as self-descriptive is associated with better memory for that trait (Rogers et al., 1977). We investigated whether this pattern extends to individuals with aMCI in a 2×2 mixed ANOVA, with participant group (healthy control/aMCI) as the between-subjects variable and initial endorsement of correctly recognized words in the self-reference condition (proportion words endorsed as self-descriptive and subsequently recognized/proportion words denied as self-descriptive and subsequently recognized) as the within-subjects variable. We also analyzed whether there was a difference in proportion of traits and valence of traits endorsed as self-descriptive between the healthy control and aMCI groups using a 2×2 mixed ANOVA, with participant group (healthy control/aMCI) as the between-subjects factor and valence of endorsed traits (proportion positive traits endorsed/proportion negative traits endorsed) as the within-subjects factor.

Association between standard neuropsychological and experimental measures

Correlational analyses were performed between self-reference, semantic, and structural corrected recognition scores and neuropsychological measures listed in Table 1.

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RESULTS

See Table 1 for demographic information and performance on neuropsychological measures. The aMCI and healthy older adult control groups did not differ significantly in terms of age, $t(48) = -1.62$, $p = .11$, or formal years of education, $t(48) = -.16$, $p = .87$.

Trait Adjective Recognition (SRE)

Raw scores are presented in Table 2 and corrected recognition results in Figure 1.[1] A main effect of condition, $F(2,94) = 80.42$, $p < .001$, $\eta_p^2 = .63$, with planned contrasts, indicated enhanced memory for trait adjectives encoded in the self-reference condition over the semantic condition, $F(1,47) = 5.44$, $p = .02$, $\eta_p^2 = .10$, and enhanced memory for trait adjectives encoded in the semantic condition over the structural condition, $F(1,47) = 82.56$, $p < .001$, $\eta_p^2 = .64$. However, a significant group by condition interaction, $F(2,94) = 5.98$, $p = .004$, $\eta_p^2 = .11$ and follow-up pairwise comparisons revealed that, while the healthy older adult group showed enhanced memory for self-referenced trait adjectives over those encoded in the semantic condition ($p < .001$), the aMCI group did not receive extra benefit from engaging in self-referential encoding over semantic encoding ($p = .9$).

Both groups showed a benefit of semantic over structural encoding ($ps < .001$). A main effect of group indicated that the healthy group showed overall higher corrected recognition than the aMCI group, $F(1,47) = 15.22$, $p < .001$, $\eta_p^2 = .25$. There was no main effect of valence, $F(1,47) = 1.23$, $p = .27$, $\eta_p^2 = .03$, nor a significant valence by group interaction, $F(1,47) = 1.1$, $p = .3$, $\eta_p^2 = .02$.

False alarms

Proportion of false alarms are presented in Table 2. Analyses revealed a main effect of group, $F(1,47) = 8.99$, $p < .001$, $\eta_p^2 = .85$ with the aMCI group making significantly more false alarms than the healthy older group. Additionally, a main effect of valence, $F(1,47) = 132.24$, $p < .001$, $\eta_p^2 = .74$ showed that across both aMCI and healthy control groups, significantly more false alarms were made for positive versus negative trait adjectives. Furthermore, a significant group by valence interaction, $F(1,47) = 5.27$, $p = .03$, $\eta_p^2 = .10$ indicated a greater difference between positive and negative false alarm scores in the aMCI group ($p = .003$) than in the healthy control group ($p = .03$).

Trait Adjective Recollection and Familiarity (SRRE)

See Table 2 for raw scores. A main effect of condition was revealed, $F(2,94) = 60.99$, $p < .001$, $\eta_p^2 = .57$, with self-referential encoding enhancing recollection over semantic processing, $F(1,47) = 11.46$, $p = .001$, $\eta_p^2 = .20$, and semantic processing improving recollection over structural encoding, $F(1,47) = 55.19$, $p < .001$, $\eta_p^2 = .54$. However, a marginally significant interaction between group and condition, $F(2,94) = 2.83$, $p = .06$, $\eta_p^2 = .06$, and a closer analysis of the data through pairwise comparisons, indicated that while the healthy older group benefitted from self-referential processing and showed a SRRE ($p < .001$), the aMCI group did not show a difference in recollection between self-reference and semantic encoding conditions ($p = .9$). Both groups showed a significant difference in recollection between the semantic and structural encoding conditions ($ps < .001$), as depicted in Figure 2. There was no significant effect of group, $F(1,47) = 2.04$, $p = .16$, $\eta_p^2 = .04$, nor were the effects of valence, $F(1,47) = .03$, $p = .86$, $\eta_p^2 = .001$, or group by valence interaction significant, $F(1,47) = .97$, $p = .33$, $\eta_p^2 = .02$.

Table 1. Demographic information and performance on neuropsychological measures

	HC ($n = 30$)	aMCI ($n = 20$)	Effect size (d)
Age	70.1 (5.5)	72.7 (5.7)	0.46
Education (years)	15.7 (2.8)	15.8 (2.8)	0.04
% female	60	55	
HVLT-R total	28.1 (3.5)	21.6 (3.1)***	1.96
HVLT-R delayed recall	10.1 (1.6)	6.0 (2.5)***	1.95
HVLT-R recog disc.	11.4 (.9)	8.7 (2.2)***	1.60
BVMT-R total	25.2 (5.4)	14.8 (6.4)***	1.76
BVMT-R delayed recall	10.0 (1.6)	5.4 (2.5)***	2.19
BVMT-R recog disc.	5.9 (.3)	5.6 (.6)	0.63
Digit Symbol Coding	62.0 (12.6)	61.2 (10.9)	0.07
Incidental Learning	12.3 (4.6)	6.1 (4.0)***	1.44
Free Recall	7.6 (1.1)	6.2 (1.9)**	0.90
Digit Span Forward	7.0 (1.2)	6.7 (1.2)	0.25
Digit Span Backward	5.23 (1.6)	5.4 (1.3)	0.12
Phonemic Fluency (COWAT)	48.2 (10.5)	44.4 (12.0)	0.35
Semantic Fluency (Animals)	20.1 (5.1)	16.1 (5.5)*	0.75
Boston Naming Test	56.6 (2.8)	52.2 (6.5)**	0.88
TMT A (secs)	34.7 (9.8)	37.3 (9.7)	0.27
TMT B (secs)	77.7 (31.4)	90.1 (28.5)	0.41
HADS-A	4.2 (2.8)	5.1 (3.5)	0.28
HADS-D	2.6 (2.6)	2.5 (2.8)	0.04
MoCA	27.7 (2.1)	25.5 (2.4)***	0.98
NART-R (FSIQ)	116.4 (6.9)	116.0 (4.4)	0.07

Note. Values represent means (standard deviations). HC=healthy controls; aMCI=amnestic Mild Cognitive Impairment; HVLT-R=Hopkins Verbal Learning Test- Revised (Brandt & Benedict, 2001); recog disc.= recognition discrimination; BVMT-R=Brief Visuospatial Memory Test-Revised (Benedict, 1997); WAIS-III Digit Symbol Coding with subtests Incidental Learning and Free Recall and Digit Span (Wechsler, 1997); Phonemic Fluency (COWAT; Benton, Hamsher, & Sivan, 1983); Semantic Fluency (Animals; Rosen, 1980); TMT=Trail Making Test (Reitan & Wolfson, 1993); HADS=Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983); HADS-A=Anxiety score; HADS-D=Depression score; MoCA=Montreal Cognitive Assessment (Nasreddine et al., 2005); NART-R=National Adult Reading Test-Revisd (Nelson & Willison, 1991); FSIQ=Full Scale Intelligence Quotient. HC significantly higher score than aMCI ***$p < .001$, **$p < .01$, *$p < .05$. Each aMCI participant was individually classified according to established clinical criteria for single domain aMCI.

[1] The scores of one healthy control participant could not be analyzed due to technical issues during testing.

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Table 2. Overall recognition and recollection "remember" scores

	Proportion Hits						Proportion False Alarms	
	Self-Reference		Semantic		Structural			
	Pos	Neg	Pos	Neg	Pos	Neg	Pos	Neg
Overall Recognition								
HC	.85 (.13)	.73 (.19)	.74 (.18)	.62 (.17)	.48 (.22)	.36 (.20)	.35 (.17)	.19 (.10)
aMCI	.83 (.16)	.52 (.26)	.76 (.16)	.59 (.23)	.59 (.23)	.34 (.17)	.51 (.17)	.27 (.15)
Recollection "Remember" responses								
HC	.60 (.31)	.45 (.27)	.47 (.27)	.33 (.23)	.26 (.18)	.20 (.16)	.19 (.17)	.09 (.09)
aMCI	.68 (.31)	.43 (.28)	.62 (.27)	.46 (.28)	.44 (.27)	.25 (.20)	.39 (.22)	.18 (.17)

Note. Values represent means (standard deviations). HC = healthy controls; aMCI = amnestic Mild Cognitive Impairment; Pos = positive; Neg = negative.

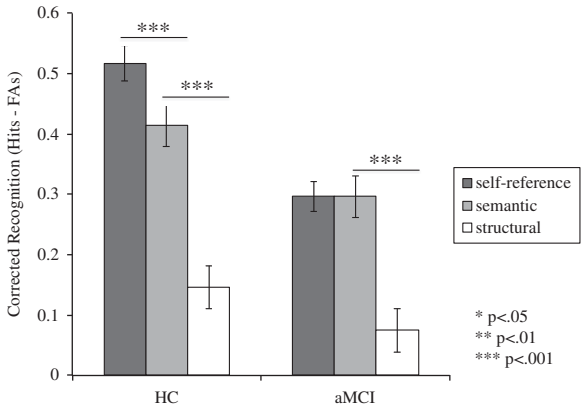


Fig. 1. Trait adjective corrected recognition scores indicating recognition memory accuracy, as a function of participant group and encoding condition. Bars represent standard error.

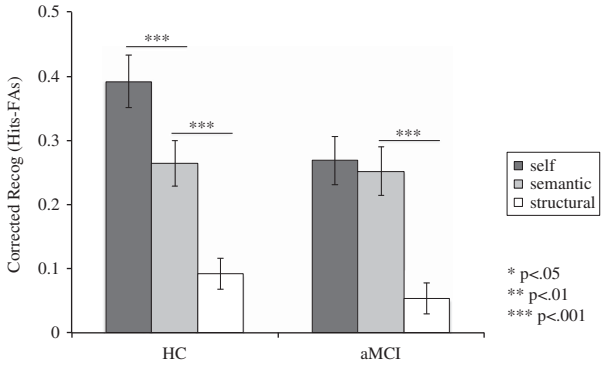


Fig. 2. Trait adjective corrected recognition indicating recollection "remember" scores, as a function of participant group and encoding condition. Bars represent standard error.

The analysis of familiarity scores was limited to a subset of the study participants (12 aMCI and 24 healthy control) as the other participants provided too few "know" button presses to be included in relevant analyses. Average scores from the remaining sample are shown in Figure 3. Analysis of familiarity scores revealed a main effect of group, with healthy controls making more "know" responses for studied material (indicating familiarity) than their aMCI counterparts,

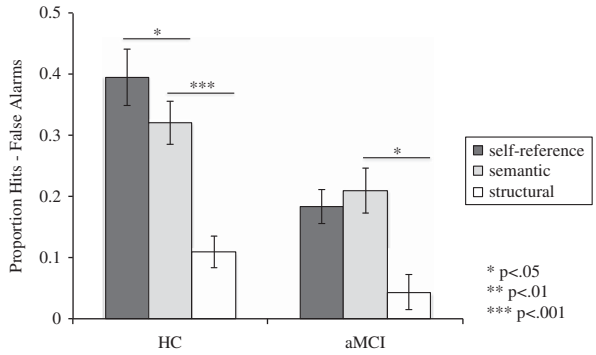


Fig. 3. Trait adjective familiarity "know" scores, as a function of participant group and encoding condition. Bars represent standard error.

$F(1,34) = 12.19$, $p = .001$, $\eta_p^2 = .26$. There was also a main effect of encoding condition, $F(2,68) = 23.57$, $p < .001$, $\eta_p^2 = .41$; planned contrasts indicated no difference between familiarity scores in the self-reference and semantic conditions, $F(1,34) = .87$, $p = .36$, $\eta_p^2 = .03$, but significantly higher familiarity scores in these conditions compared to the structural condition, $F(1,34) = 29.71$, $p < .001$, $\eta_p^2 = .47$.

However, the group by encoding condition interaction approached significance, $F(2,68) = 2.67$, $p = .08$, $\eta_p^2 = .07$, with pairwise comparisons indicating a marginally significant difference between self-reference and semantic familiarity scores for the healthy control group ($p = .049$) but not for the aMCI group ($p = .77$). There was no effect of valence on familiarity scores, $F(2,68) = .81$, $p = .38$, $\eta_p^2 = .02$, nor was there a significant group by valence interaction, $F(2,68) = .001$, $p = .97$, $\eta_p^2 = .001$.

Self-Descriptiveness and Memory[2]

There was no significant difference between the proportion of traits endorsed in the self-reference condition between healthy

[2] The analyses examining self-descriptiveness included data from 20 individuals with aMCI and 25 healthy controls. Due to technical issues, accessing the data necessary for these analyses was not possible for four of the healthy control participants.

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controls ($M = .48$; $SD = .06$) and the aMCI group ($M = .49$; $SD = .06$), $F(1,43) = .80$, $p = .38$, $\eta_p^2 = .02$. Both groups endorsed significantly more positive traits (healthy control: $M = 12.4$; $SD = 2.0$; aMCI: $M = 13.4$; $SD = 1.87$) than negative traits (healthy control: $M = 1.0$; $SD = 1.61$; aMCI: $M = .07$; $SD = 1.08$) as self-descriptive, $F(1,43) = 788.33$, $p < .001$, $\eta_p^2 = .95$. A main effect of self-descriptiveness was found, $F(1,43) = 9.4$, $p = .004$, $\eta_p^2 = .18$; however, a significant interaction, $F(1,43) = 4.35$, $p = .04$, $\eta_p^2 = .09$, and subsequent pairwise comparisons indicated that individuals with aMCI showed an effect of self-descriptiveness on memory ($p = .001$), whereas healthy controls did not ($p = .47$).

Association Between Standard Neuropsychological and Experimental Measures

Correlation analyses indicated that self-reference corrected recognition scores were significantly associated with measures of verbal and non-verbal episodic memory, including: HVLT-R delayed recall $r = .42$, $p = .003$, HVLT-R recognition discrimination $r = .45$, $p = .001$, BVMT-R delayed recall $r = .51$, $p = .001$, and WAIS-III Digit Symbol Coding Free Recall $r = .38$, $p = .007$. The HVLT-R recognition discrimination score and Digit Symbol Coding Free Recall scores were also significantly correlated with the semantic corrected recognition scores, although to a smaller magnitude to that of the self-reference scores ($r = .30$; $p = .04$ for both tests).

DISCUSSION

The present study is one of the few to investigate the SRE in aMCI and the first to examine the SRRE in this population. The influence of material valence was further considered.

SRE for Trait Adjectives in aMCI

To date, two published studies have examined the SRE for trait adjectives in aMCI specifically. Leblond et al. (2016) found that individuals with aMCI showed an SRE for positively valenced trait adjective words, while a study by Rosa et al. (2015) did not find that self-referential processing enhanced memory in aMCI over semantic encoding (this study did not investigate material valence). The results of the current study were more consistent with the findings of the latter of the two studies. Individuals with aMCI did not show a specific benefit to memory for self-referenced words, regardless of word valence. Instead, the present study indicated a general effect of "deep encoding" in aMCI with a comparable benefit of self-referential processing and semantic processing on recognition memory relative to structural processing (shallow encoding). Consistent with prior studies (Carson et al., 2016; Genon et al., 2014; Glisky & Marquine, 2009; Gutchess et al., 2007; Leblond et al., 2016; Rosa et al., 2015), a SRE for trait adjectives was found in the healthy control participants.

The current results were inconsistent with those found by Leblond et al. (2016), despite our studies having the same number of individuals with single-domain aMCI ($n = 20$), using similar stringent criteria for classifying aMCI, and administering trait adjective SRE paradigms with very similar self-reference and semantic encoding conditions. The trait adjective paradigms used in these two studies were much more similar to one another than to the paradigm used in the Rosa et al. (2015) study. Overall memory accuracy (calculated by corrected recognition) for the self-reference and semantic encoding conditions appears to be higher in the aMCI group in the present study (see Leblond et al., 2016 Figure 2 for comparison).

However, even with better overall memory, the SRE pattern did not emerge for the aMCI group in the present study. There were methodological differences between the studies that may have resulted in the absence of a SRE for the aMCI group in our study. First, participants in Leblond et al. encoded 48 trait adjective words in each encoding condition (self-reference, other-reference, semantic) and, therefore, may have had more of an opportunity to engage in self-referential processing than the participants in the present study, who encoded 30 trait adjective words in each encoding condition (self-reference, semantic, structural).

Additionally, during the recognition test of the study by Leblond et al., only a portion of the studied trait adjectives (84/144) were presented, intermixed with 30 distractors. The recognition test used in the present study was likely more overwhelming, as it included all 90 of the studied trait adjectives intermixed with 90 distractors. The present study also included a 10-min retention interval between encoding and recognition, during which participants completed distraction tasks, whereas Leblond et al. tested recognition immediately following encoding. This procedural difference raises the possibility that the aMCI group tested in the present study was unable to maintain benefits from self-referential processing after being presented with distracting information over a 10-min interval.

It is also possible that individuals with aMCI do not generally benefit from self-referential processing over and above that of semantic processing. Although some studies show that personal semantic memory remains relatively intact in MCI (Barnabe et al., 2012; Gamboz et al., 2010; Murphy et al., 2008), others indicate a decline in this ability (Irish et al., 2010; Leyhe et al., 2009). Perhaps the inability of participants with aMCI in the present study to benefit from self-referential processing over and above that of general semantic processing provides support for the decline of personal semantic memory in aMCI. The self-reference component of the trait adjective paradigm relies on self-knowledge, which is perhaps not as easily accessible in aMCI as it is in healthy cognitive aging.

Although the current study found that individuals with aMCI endorsed a similar proportion of traits as self-descriptive as their healthy counterparts, they correctly recognized more traits that were initially endorsed as

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self-descriptive than those that were not, whereas healthy controls did not show a significant difference between recognition of self-descriptive and non–self-descriptive traits. This is in contrast to studies that have shown a self-descriptiveness effect (better memory for self-descriptive information) in healthy aging (e.g., Gutchess et al., 2007). Perhaps unlike healthy controls, individuals with aMCI are unable to flexibly use their self-knowledge to elaborate on information that is considered "not me". Healthy older adults may also be better able than individuals with aMCI to elaborate on traits that are not central to their core identities or are no longer self-descriptive.

Rosa et al. (2015) showed that the degree of trait self-descriptiveness was associated with hit rate in healthy older controls but not in individuals with aMCI. We did not ask participants to rate the degree of trait self-descriptiveness in our study (they were only required to decide whether it was self-descriptive or not), so perhaps for healthy controls, some of the endorsed traits were low or moderately self-descriptive and, therefore, did not promote memory more than traits that were not self-descriptive. Further research is necessary to elucidate the impact of self-descriptiveness on memory and its contribution to the appearance of the SRE in healthy aging and aMCI.

Limited research on structural and functional changes to brain regions that are critical for self-related thinking in aMCI add to the difficulty in interpreting the absence of SRE in our study. Neuroimaging studies on the SRE in healthy individuals have identified cortical midline structures, particularly the medial prefrontal cortex and posterior cingulate cortex, as being integral to self-related processing and memory (e.g., Amodio & Frith, 2006; Benoit, Gilbert, Volle, & Burgess, 2010; Gutchess et al., 2007, 2010; Kelley et al., 2002; Leshikar & Duarte, 2014; Northoff et al., 2006). A study by Ries et al. (2007) found that cortical midline activity was subtly attenuated for self-appraisal in MCI when compared to healthy controls.

Additionally, studies specifically examining posterior cingulate function in MCI show functional changes in this brain region (Anchisi et al., 2005; Nestor, Fryer, Ikeda, & Hodges, 2003). A recent study by Wong et al. (2017) indicated that the magnitude of benefit from self-referential processing in AD was related to the integrity of cortical midline posterior brain regions, including the posterior cingulate and precuneus. Based on these results, the authors concluded that the ability to integrate self-relevant information into autobiographical memory relies on the integrity of cortical midline posterior brain regions, and that atrophy in these regions is an underlying cause of attenuated SRE in AD. This study verified the importance of posterior cortical midline regions for the appearance of the SRE, and the effects of posterior atrophy and disease burden that progressively worsen as an individual progresses from aMCI to AD. The neuroimaging literature on the SRE in aMCI is sparse and further research is needed to delineate neuroanatomical underpinnings of the ability/inability to benefit from self-referential processing in this population.

Influence of Valence

While individuals with aMCI in the Leblond et al. (2016) study showed the SRE, the effect was specific to positively valenced trait adjectives. The aMCI group in the present study showed no influence of valence on memory for trait adjective words. The healthy control group likewise showed no influence of item valence on memory, consistent with many of the studies that have investigated the SRE in healthy older adults (Carson et al., 2016, Experiment 2; Glisky & Marquine, 2009; Gutchess et al., 2007, Experiment 3; Leblond et al., 2016). One area where a notable positivity bias was indeed found for both the healthy control group and aMCI group in the present study was in terms of false alarms made on the recognition test. Participants across both groups were more prone to make false alarms for positively valenced words, and this finding is consistent with other studies of the SRE in healthy aging and aMCI (Glisky & Marquine, 2009; Gutchess et al., 2007; Leblond et al., 2016).

SRRE in aMCI

The present study is the first to investigate the SRRE in aMCI. The results indicated that self-referential processing did not provide an additional benefit to recollection in aMCI over and above that gained from semantic processing. By contrast, healthy older adult controls showed a unique benefit to recollection for self-referenced trait adjectives. Interestingly, the aMCI group and healthy controls showed similar overall levels of recollection, although the healthy controls benefited from self-referential processing. Given that aMCI is a transition state between healthy cognitive aging and AD, and populations on both sides of the spectrum have been shown to exhibit the SRRE (Carson et al., 2016; Genon et al., 2014; Kalenzaga & Clarys, 2013; Kalenzaga et al., 2013; Lalanne et al., 2013; Leshikar et al., 2015), it was surprising not to find a SRRE in our aMCI group. Furthermore, where studies of the SRRE in AD indicated an interaction between the SRRE and valence of material (SRRE for negative material in Kalenzaga & Clarys, 2013 and Kalenzaga et al., 2013; SRRE for positive material in Lalanne et al., 2013), the present study showed no significant effect of valence.

Methodological differences may underlie the disparate results found in our study compared to those of others, particularly studies of the SRRE in AD. One potentially important difference is the way in which "remember" scores indexing recollection were determined in the studies. For example, while the present study allowed participants to determine whether each "old" response was indicative of recollection or familiarity, Lalanne et al. (2013) considered a response indicative of recollection only if the participant could correctly identify the condition in which the word was initially encoded (showcasing source memory). In Kalenzaga and Clarys (2013) and Kalenzaga et al. (2013), "remember" responses were accepted only when a participant could detail the same contextual memory at retrieval that was expressed at encoding. Furthermore, false alarms were not taken into

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account in calculating "remember" scores in Kalenzaga et al. (2013), which may be an additional source of inconsistent results across studies.

Although familiarity scores could only be analyzed for a subset of participants in the present study, results indicated deep encoding effects on familiarity in both healthy aging and aMCI groups, with self-referential processing promoting familiarity to a similar extent to semantic processing, and both of these enhancing familiarity more than structural processing. Self-referential processing did not enhance familiarity over and above that of semantic processing, consistent with the SRRE (which posits that recollection and not familiarity is improved with self-referential processing).

However, a marginally significant interaction indicated that with greater statistical power, self-referential processing may have promoted familiarity more than semantic processing in healthy controls but not in individuals with aMCI. The promotion of familiarity due to deep encoding is consistent with research that has shown that meaningful processing of material increases familiarity (Yonelinas, 2002). In fact, the current study is distinct in the sense that few other studies investigating the effects of self-referential processing on recollection and familiarity in aging have included a structural condition. Consequently, there typically is no "shallow" encoding condition against which to judge deep encoding effects.

That only a subset of the participants in our study made enough "know" responses to be included in the familiarity analysis indicates that these results should be considered with caution. The remember/know distinction was thoroughly explained to participants, participants were given a cue card with a simplified description to which to refer during the recognition test, and the recognition test did not begin until participants could explain the remember/know distinction to the investigator. However, it is possible that "know" button presses were made inappropriately during the recognition test.

Familiarity processes have generally been shown to be less affected in aMCI than recollection (Anderson et al., 2008; Hudon et al., 2009; Irish et al., 2010; Serra et al., 2010; Westerberg et al., 2006), although some studies have produced contradictory results, such that familiarity also declines (Ally et al., 2009; Koen & Yonelinas, 2014; Wolk et al., 2008). It is encouraging that the current study found evidence that deep encoding enhances familiarity processes in aMCI. Both recollection and familiarity processes appear to improve with deep encoding in aMCI, although not specifically with self-referential encoding.

CONCLUSIONS

To our knowledge, the present study is the first to investigate the contributions of recollection and familiarity to memory for self-related material (i.e., the SRRE) in aMCI and one of the few to examine the SRE in this population. Results indicate that, while episodic memory in healthy older adults benefits from self-referential processing, there is a more general effect of deep encoding on memory in aMCI, with a similar effect of self-referential and semantic processing. Furthermore, there was no influence of valence on the SRE. The present study also demonstrates that both recollection and familiarity are enhanced in aMCI by deep encoding: both processes improved to a similar extent with self-referential and semantic encoding over and above shallow, structural encoding. This finding suggests that, unlike their healthy counterparts, individuals with aMCI do not show an SRRE for trait adjectives. It is nonetheless encouraging that episodic memory and recollection, both known to decline in aMCI, can be improved with deep encoding strategies generally. These findings are especially important to consider in the design of memory intervention programs for aMCI.

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