MEMORY, 2007, 15 (8), 822–837

Psychology Press
Taylor & Francis Group

Ageing and the self-reference effect in memory

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The present study investigates potential age differences in the self-reference effect. Young and older adults incidentally encoded adjectives by deciding whether the adjective described them, described another person (Experiments 1 & 2), was a trait they found desirable (Experiment 3), or was presented in upper case. Like young adults, older adults exhibited superior recognition for self-referenced items relative to the items encoded with the alternate orienting tasks, but self-referencing did not restore their memory to the level of young adults. Furthermore, the self-reference effect was more limited for older adults. Amount of cognitive resource influenced how much older adults benefit from self-referencing, and older adults appeared to extend the strategy less flexibly than young adults. Self-referencing improves older adults' memory, but its benefits are circumscribed despite the social and personally relevant nature of the task.

Studies of young adults demonstrate that relating information to oneself is a successful encoding strategy. Self-reference judgements are associated with increased levels of memory compared to making semantic judgements or relating the information to another person such as one's mother or Johnny Carson (e.g., Rogers, Kuiper, & Kirker, 1977; see Symons & Johnson, 1997, for a review). Although there has been debate over the mechanisms of self-referencing and whether the self is a "special" construct that engages unique organisational and elaborative processes (e.g., Greenwald & Banaji, 1989), functional neuroimaging evidence suggests the self engages a unique module and specialised elaborative processes that are not shared by other "deep", or semantically meaningful, judgements (Kelley et al., 2002).

Because self-referencing benefits memory and operates above and beyond depth of processing manipulations (Craik & Lockhart, 1972; Craik & Tulving, 1975), it is surprising that self-referencing has not been extensively investigated in older adults, who sometimes do not benefit as much as

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Support for the research was provided by the National Institutes of Health grants R01 AG008441 (to D.L.S.), F32 AG026920 (to A.H.G.), and MH 070199 (to E.A.K.), University of Michigan UROP Supplementary Research Funding, and the Ross School of Business. The authors gratefully acknowledge the experimental assistance provided by Nick Gonzalez, Ashley Eason, Nicole Williams, Jess DeBartolo, Linyun Yang, and in particular, Emily Nelson, who also contributed through her insights into this research.

http://www.psypress.com/memory DOI:10.1080/09658210701701394

young from ''deep'' encoding manipulations (Kausler, 1994). At least three areas of research make the self-reference effect of interest to study in older populations: the self is a personally meaningful construct, and therefore may provide an encoding strategy that effectively can support older adults' memory; the self is linked to motivational and social goals, which take on increased importance with ageing; and self-referential encoding could potentially place reduced demands on cognitive resources. Each of these is discussed in turn.

Ageing is marked by cognitive impairments in a number of domains (e.g., Park et al., 2002; Salthouse, 1996), including long-term memory, but older adults' memory performance is malleable. As is the case for young adults, strategies and orientations that engage ''deep'' encoding processes benefit older adults (e.g., Erber, Herman, & Botwinick, 1980; Eysenck, 1974). Self-referential processing shares elaborative and organisational properties with other deep encoding strategies (Klein & Loftus, 1988) but the benefits of self-referencing extend beyond a simple depth of processing manipulation (Kelley et al., 2002). It could be that the rich structure of the self constitutes a familiar and natural encoding strategy. These properties may be particularly important for older adults' encoding success (Castel, 2005) and could mitigate difficulties with self-initiating encoding strategies with age (Hultsch, 1969). For example, older adults exhibit increased recall when using self-generated strategies that rely on personally relevant information (e.g., important birthdates) relative to other mnemonic strategies (Derwinger, Neely, MacDonald, & Bäckman, 2005). The self-concept is relatively stable throughout the lifespan, with adults undergoing modest changes in personality (Terracciano, McCrae, Brant, & Costa, 2005) and there is a large overlap in self-schema across the age groups (Mueller & Johnson, 1990; Mueller, Wonderlich, & Dugan, 1986). Thus, the highly familiar and meaningful structure of the self could support accurate memory.

Because older adults do not always benefit from ''deep'', or semantic, encoding strategies to the same extent as young adults (Kausler, 1994), it is all the more important to consider the additional mnemonic benefits that are offered by self-referencing. Given the inherently social and emotional nature of the self, older adults may benefit disproportionately from self-referential encoding relative to young adults. Socioemotional processing sometimes confers greater benefits to older adults than young adults compared to neutral or negative processes. Older adults may be more motivated than young adults to maintain positive affect and to exercise controlled processing in order to devote attention to positive socioemotional information, which can lead to superior memory for positive information (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2005; Mather & Knight, 2005). Beyond memory improvements for positively valenced information, age-related source memory impairments (e.g., Hashtroudi, Johnson, & Chrosniak, 1989; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991) can be eliminated when source information is situated as relative to one's safety or potential to be deceived (May, Rahhal, Berry, & Leighton, 2005; Rahhal, May, & Hasher, 2002). Although these preserved pockets of source memory have been discussed in terms of the prioritisation of emotional information in memory, the participant him- or herself is incorporated into the framing of the problem and the memorial benefits could stem, at least in part, from self-referencing. Based on these findings, orienting to the self could boost memory to the same level in older adults as in young adults, which would contrast with older adults' poorer memory for words encoded using a shallow or semantic task.

Self-referencing may place minimal demands on cognitive resources, which would make the strategy particularly beneficial for older adults. Neuroimaging data indicate that self-referential encoding differs from other encoding strategies in that it engages different neural regions. Whereas semantic or ''deep'' encoding tasks activate inferior prefrontal regions often associated with controlled processing, self-referencing activates medial prefrontal cortex (Kelley et al., 2002; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004). Medial prefrontal cortex has been implicated in social information processing (Mitchell, Macrae, & Banaji, 2005), but it is unknown to what extent the region contributes to *cognitive* processes. It may be the case that processes that engage medial prefrontal cortex are not as cognitively demanding as processes that draw on other prefrontal regions that contribute to controlled processing. This idea is intriguing because medial prefrontal cortex appears to be less prone to age-related decline, in contrast to many other prefrontal regions that are implicated in cognitively demanding processes. Young and older adults similarly engage medial prefrontal cortex

during self-referencing decisions (Gutchess, Kensinger, & Schacter, 2007) and structural data suggest that medial prefrontal regions show little decline with age (Salat et al., 2004). Literature on early development also suggests that the self-reference effect may not depend on the availability of cognitive resources; the effect emerges by age 5 (Sui & Zhu, 2005) and is unaffected by further cognitive development between the ages of 7 and 11 (Pullyblank, Bisanz, Scott, & Champion, 1985). While it is possible that self-referencing is not heavily cognitively demanding, the wide extent of encoding deficits with age (Kausler, 1994) and the finding that medial prefrontal cortex is implicated in successful encoding (Macrae et al., 2004) make it likely that the availability of cognitive resources plays at least some part in supporting recognition. Older adults are an ideal population with which to explore the role of cognitive resources in self-referencing because resources can be limited and vary widely across individuals.

Although it is unclear to what extent the benefits of self-referencing require cognitive resources, the task employed in the one existing study of self-referencing with an older population suggests it may be particularly cognitively demanding. Mueller et al. (1986) measured memory with recall, which suffers heavy impairments with age relative to recognition (Craik & McDowd, 1987). They found that while the memorial benefit of self-referencing extends to older adults, older adults recalled less information than young adults. However, it is possible that under conditions that are less cognitively demanding, such as recognition, self-referencing could lead to similar levels of memory in young and older adults. Thus, it is necessary to study self-referencing with tasks other than recall, particularly because recall can be driven by pre-existing associations in which case the words recalled could reflect the self-schema more than the episodic memory trace (Ferguson, Rule, & Carlson, 1983).

The present study investigates potential age differences in the self-reference effect using recognition memory. We investigate young and older adults' memory for self-referenced information and explore the extent to which cognitive resources and socioemotional orientation affect the benefits of self-referencing. We predict that the self-reference effect should extend to older adults and perhaps even be enhanced relative to semantic or shallow processing orientations because older adults prioritise socioemotional information and the primary neural region implicated in self-referencing (i.e., medial prefrontal cortex) is relatively preserved with age. However, if cognitive resources contribute substantially to the self-reference effect, older adults could benefit less than young adults from self-referencing. Specifically, we investigate (1) whether the magnitude of the self-reference effect is similar for young and older adults, (2) the role of cognitive resources in self-referencing with age, and (3) the contribution of socioemotional orientation to self-referencing benefits with age.

EXPERIMENT 1

Method

Participants. A total of 24 young adults (age range 18– 20) from the University of Michigan and 24 older adults (age range 60–82) from the surrounding Ann Arbor community participated in the study and were compensated with either course credit or payment. Characteristics of these samples, including age, gender, years of education, speed of processing, and vocabulary scores, are presented in Table 1.[1] Consistent with samples in the majority of cognitive ageing studies, older adults had significantly more years of education than young adults, $t(46) = 4.05$, $p < .001$, and better vocabulary scores, $t(46) = 4.87$, $p < .001$, suggesting preserved crystallised knowledge. Young adults exhibited greater processing capacity, completing significantly more items than older adults on the speed of processing tasks: digit comparison, $t(46) = 3.03$, $p < .005$, and pattern comparison, $t(46) = 4.54$, $p < .001$.

Materials. A set of 288 adjectives were selected from Craik et al. (1999), drawn primarily from Anderson's (1968) adjective norms. The adjectives were divided into subsets with approximately equal numbers of positive and negative adjectives. Word sets were assigned to three different yes/no judgements: Self (i.e., does this word describe me?), Other Person (i.e., does this word describe Albert Einstein?), or Case (i.e., is this word displayed in upper case?). These conditions are alike in that they require orientation to a specific aspect of the word. They also allow for a contrast of deep (i.e., self and other person)

[1] Due to omission of responses, ages are unavailable for one young and one older adult.

TABLE 1
Participant demographics from Experiments 1–3 (means and *SD*)

	Experiment 1		*Experiment 2*		*Experiment 3*	
	Young	*Older*	*Young*	*Older*	*Young*	*Older*
Age	19.50 (.79)	68.50 (5.64)	20.46 (2.51)	71.03 (4.60)	19.61 (2.25)	71.11 (5.80)
N	24	24	30	60	18	18
Gender	13M, 11F	9M, 15F	15M, 15F	25M, 35F	8M, 10F	5M, 13F
Years of education	12.96 (1.06)	15.25 (2.56)	13.35 (1.02)	16.17 (2.61)	13.47 (1.74)	17.42 (2.68)
Digit comparison	74.46 (12.63)	62.54 (14.54)	73.83 (10.11)	58.10 (10.04)	76.35 (11.92)	60.06 (12.58)
Pattern comparison	57.33 (11.11)	44.04 (9.06)	58.80 (9.70)	46.17 (9.42)	N/A	N/A
Shipley vocabulary	31.42 (2.47)	35.75 (3.59)	29.37 (5.25)	35.75 (3.44)	34.39 (3.15)	35.65 (4.54)

with shallow (i.e., case) encoding conditions, and the comparison of self with a comparable social condition, as in previous studies (e.g., Craik et al., 1999; Kelley et al., 2002). Words were presented in Arial 24-point font. Half of the words in each condition, including lures, were randomly selected to appear in all upper case letters, whereas the remaining half of the words appeared in all lower case letters. Case was relevant only for the upper case judgement condition, but varied within each condition to control for perceptual characteristics of the stimuli.

Because the self-concept is complex and generally positive (e.g., people endorse more positive than negative items), it is difficult to match a personally unfamiliar other to the self. Pilot ratings from 25 young and 25 older adults suggested that Albert Einstein was a reasonable choice out of a number of famous people rated on nine-point scales (1 = low, 9 = high) because he was regarded as both positive (young $M = 7.20$, $SD = 1.39$; older adults $M = 7.44$, $SD = 1.47$) and familiar (young $M = 6.80$, $SD = 1.52$; older adults $M = 7.12$, $SD = 1.69$) by young and older adults ($ts < 1$).

Procedures. Participants provided written informed consent for a protocol approved by the University of Michigan Behavioral Sciences Institutional Review Board. After receiving instruction and practice on the adjective judgement task, participants incidentally encoded adjectives by making self, other, and case judgements. Adjectives were presented on the computer screen for 4 seconds, during which time the participants pressed a labelled key on a computer keyboard to provide a ''yes'' (i.e., adjective describes me/Einstein; adjective is displayed in upper case) or ''no'' (i.e., adjective does not describe me/Einstein; adjective is not displayed in upper case) response. A total of 144 adjectives were encoded, with 48 adjectives assigned to each of the three conditions (self, other, and case). Three counterbalanced orderings allowed the adjectives to be assigned to each condition across participants, and trials were presented in a random order, unique to each participant.

During a 10-minute retention interval participants completed measures including a digit comparison task (Hedden, Park, Nisbett, Li, & Jing, 2002) and a pattern comparison task (Salthouse & Babcock, 1991) to assess speed of processing. Participants then received instructions for the surprise recognition test, which was self-paced on the computer. Participants responded by pressing keys labelled ''yes'' to denote a previously studied word or ''no'' to denote a new word. Recognition was tested for all 144 encoded adjectives and 144 lures. Instructions placed equal emphasis on responding with accuracy and speed. Tasks were presented with E-Prime software (Psychology Software Tools, Pittsburgh, PA). Demographics and vocabulary measures (Shipley, 1986) were administered at the beginning and end of the session, respectively.

Results and discussion

To assess performance we calculated three memory scores for each participant, consisting of the hit rate to studied items (for Self, Other, and Case trials) minus the false alarm rate to new items. Because there was only one pool of lure items at recognition, the false alarm rate was constant across the three hit minus false alarm scores, but provided a correction for potential between-group differences in the false alarm rate.

We conducted a 2×3 mixed analysis of variance (ANOVA) on the hit minus false alarm rates, with Age (Young/Older adults) as the between-groups variable and Condition (Self/Other/Case) as the within-group variable. Results are shown in Figure 1a. Importantly, the Age $\times$ Condition interaction did not reach significance, $F(2, 92) = 2.12$, $p = .13$, $\eta_p^2 = .04$. The ANOVA yielded a main effect of Age, with young adults ($M = .34$) exhibiting more accurate recognition of words than older adults ($M = .21$), $F(1, 46) = 14.53$, $p < .001$, $\eta_p^2 = .24$. The main effect of Condition was also significant, $F(2, 92) = 64.67$, $p < .001$, $\eta_p^2 = .58$. Follow-up 2×2 ANOVAs with Age (Young/Older adults) and only two levels of the Condition variable (Self/Other or Other/Case) revealed that words encoded in the self condition were remembered better than those encoded in the other person condition, $F(1, 46) = 24.53$, $p < .001$, $\eta_p^2 = .35$, and that, in turn, the other person condition supported better memory than the case condition $F(1, 46) = 51.26$, $p < .001$, $\eta_p^2 = .53$.

The main effect of age emerged primarily due to the false alarm rates (young $M = .19$, older adults $M = .31$), $t(46) = 3.08$, $p < .01$. In an ANOVA of the hit rates alone, neither the main effect of age ($F < 1$) nor the interaction of age with condition ($F < 2.5$) reached significance. Compared to older adults, young adults had numerically higher hit rates in the self and other conditions and a lower hit rate in the case condition, but none of the hit rates differed significantly across the age groups ($ts < 1$).

The pattern of results suggests that the self-referencing effect benefits older adults' memory, much like it does for young adults. However, older adults exhibit lower levels of memory than young adults across the board, and self-referencing does not reduce age differences in memory relative to other types of encoding strategies.

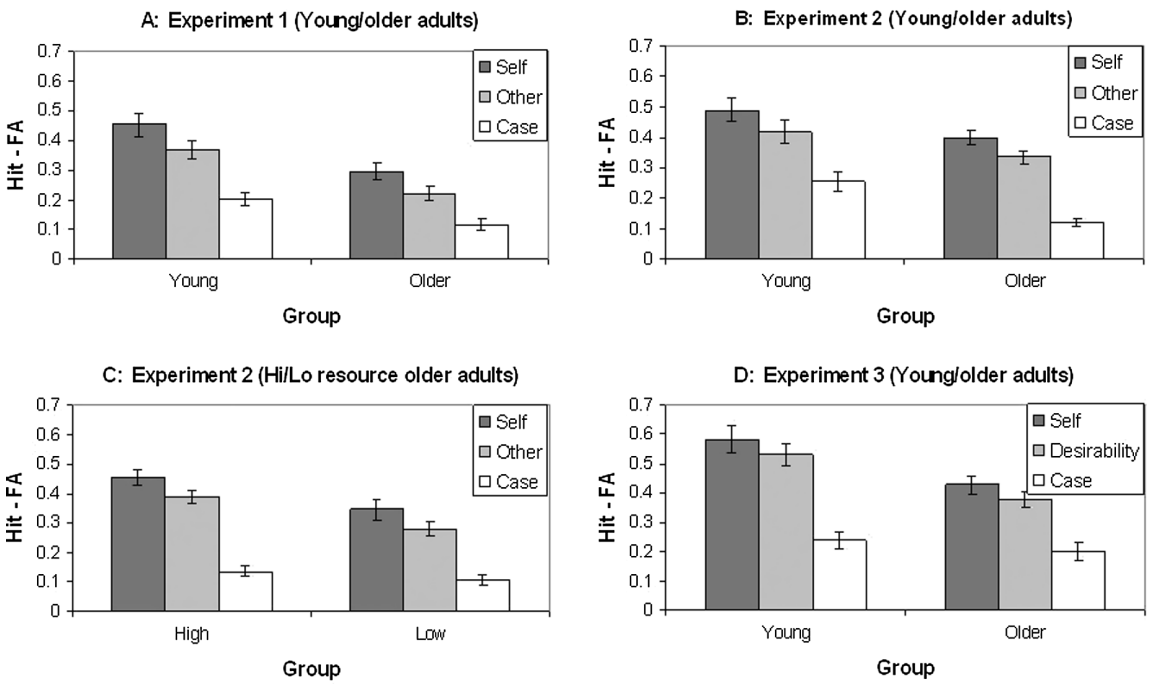

Figure 1. (a) Age comparison for Experiment 1. The graphs display adjective recognition performance for Experiment 1 across the age groups. Although young adults exhibit better memory than the older adults, the pattern is the same across age groups and both samples benefit from self-referencing of information. (b) Age comparison for Experiment 2. The graphs display adjective recognition performance for Experiment 2 across the age groups. Even when judgements are made about a "close other", the findings are identical to those of Experiment 1 with main effects of Age and Condition, but no interaction of Age $\times$ Condition. (c) Comparison of high vs low resource older adults for Experiment 2. The graphs display adjective recognition performance for Experiment 2 across the groups of older adults with high and low amounts of cognitive resource. High resource older adults benefit more than low resource older adults from referencing the self or another person. (d) Age comparison for Experiment 3. The graphs display adjective recognition performance for Experiment 3 across the age groups. When judgements are made about desirability, young adults show enhanced encoding relative to older adults for self and desirability trials compared to case trials.

Influence of emotion on age differences. To explore the extent to which self-referencing depended on age-related differences in emotional processing, we examined the influence of adjective valence (positive/negative) and the participants' ratings responses (yes/no) on recognition performance. Using a median split on adjective valence (Anderson, 1968), we divided the adjectives into positive and negative sets. Based on the findings of a positivity bias in older adults' memories (Mather & Carstensen, 2005), we might expect that older adults' memory performance would approach that of young adults for positive words. In a comparison of hit minus false alarm rates using an ANOVA of Age (Young/Older) × Condition (Self/Other/Case) × Valence (Positive/Negative), we did not find evidence that valence differentially affected memory across the age groups (Fs < 2). However, there was a trend overall for negative words ($M = .29$) to be better remembered than positive words ($M = .26$), $F(1, 46) = 2.84$, $p < .10$, $\eta_p^2 = .06$. Although hit rates were higher for positive than negative words for all conditions (ps < .03), the particularly high false alarm rate for positive compared to negative items ($p < .001$) likely contributes to the overall trend for higher corrected recognition scores for negative items. Valence interacted with condition, $F(2, 92) = 4.73$, $p < .02$, $\eta_p^2 = .09$. While corrected recognition scores were higher for negative than positive items in the case condition, the pattern differed significantly from the self condition, in which memory was more balanced for positive and negative words with a slight tendency for positive items to be remembered more accurately than negative items, $F(1, 46) = 8.75$, $p < .01$, $\eta_p^2 = .16$. The other condition ($F < 1$) did not differ significantly from the case condition. Hit and false alarm rates are displayed in Table 2. Across both age groups, higher levels of memory for positive self-relevant items and negative items in the other and case conditions seem to reflect memory processes rather than differences in initial judgements because young and older adults initially endorse similar proportions of positive and negative items as descriptive of self and other (Gutchess et al., 2007).

Influence of self-relevance ratings on age differences. Age differences in reflecting on the self, or the complexity of the self-concept, could be reflected in the initial ratings judgements and impact recognition memory. Young adults show increased recognition for items that are characteristic of themselves (as in Rogers et al., 1977, but not Rogers, Rogers, & Kuiper, 1979); it could be the case that resource limitations with age cause older adults to prioritise information that is most personally relevant at the expense of information that is not self-relevant. One might predict that even though young and older adults remember more items judged as self-descriptive than items that do not describe the self, this benefit will be exaggerated in older adults. Across all participants, the proportion of items rated "yes" that were subsequently recognised was higher than the proportion for those rated "no", $F(1, 45) = 58.14$, $p < .001$, but none of the interactions involving age reached significance (Fs < 2).[2] In addition, the time needed to make the initial judgement did not vary significantly across the age groups. Although there was a main effect of condition, $F(2, 90) = 39.19$, $p < .001$, with the slowest RTs for the "other" condition and the fastest RTs for the case condition, the pattern was the same across both age groups, and did not vary as a function of response (Yes/No). Reaction times are displayed in Table 2. We did not find any evidence for differences in the diversity of the self-concept across age groups. Young and older adults required similar amounts of time to make judgements of self-descriptiveness, relative to the judgements for other conditions, and remembered similar proportions of items rated as self-descriptive.

For self and other person trials, the amount of time spent making the initial rating judgements was unrelated to later memory performance. The contribution of cognitive resources to self-referencing benefits will be addressed further in Experiment 2, but because the other encoding variables (i.e., response speed and yes/no response) did not differentially affect memory across the age groups, these factors will not be considered in subsequent experiments.

Based on Experiment 1, we conclude that self-referential information may support effective encoding by young and older adults, although it does not reduce age-related declines in episodic memory. Encoding information in relation to oneself is a socially meaningful task, which engages successful encoding strategies for older adults.

[2] Rating and reaction time data during encoding were unavailable for one young participant.

TABLE 2
Reaction times for ratings and the number of hits (out of 24) and false alarms (out of 72) for positive and negative items in Experiment 1 (means and *SD*)

	Self		*Other*		*Case*		*FA*	
Hits & false alarms by valence	*Pos*	*Neg*	*Pos*	*Neg*	*Pos*	*Neg*	*Pos*	*Neg*
Young	16.67 (4.31)	14.38 (4.67)	13.79 (4.20)	12.63 (4.60)	9.13 (3.97)	9.67 (3.73)	17.42 (10.96)	10.92 (8.16)
Older	16.96 (4.49)	12.00 (4.32)	14.46 (5.19)	10.83 (5.03)	12.17 (5.19)	8.13 (4.93)	28.79 (14.14)	15.38 (8.87)
Reaction times								
Young	1788 (406)		1811 (427)		1421 (476)		N/A	
Older	1857 (380)		1944 (445)		1632 (479)		N/A	

EXPERIMENT 2

Based on Experiment 1, we found young and older adults both benefit from self-referencing of information beyond the benefit from other-person referencing. However, additional factors could restrict the self-reference benefit for older compared to young adults. First, judgements about highly familiar, intimate others (Bower & Gilligan, 1979; Ferguson et al., 1983) lead to high levels of recognition. These judgements support more modest benefits for self-referencing compared to other-referencing. It is as if there is an incorporation of information regarding both the self and the close other, such that the self does not remain as distinct an entity. Because older adults should generally have longer-lasting relationships with an intimate other person compared to young adults, this could allow for more incorporation of the close other in older adults' concept of self (Aron, Aron, Tudor, & Nelson, 1991). Were this to occur, older adults should have a less distinct self-representation and should not benefit from self-referencing more than other-referencing. Even if an extended relationship selectively affects the representation of the other person, rather than also influencing the representation for self, a highly differentiated and elaborated other would lead to a reduced self-referencing effect due to a smaller memory enhancement for self over other.

The self-reference effect could also be more limited in older adults if self-referential processing places strong demands on cognitive resources. It is unclear whether there would be such a draw on cognitive resources. On the one hand, the child development literature divulges that the self-reference effect can be stable despite changes in cognitive development (Pullyblank et al., 1985), and thereby suggests that cognitive capacity plays a small role in self-referential encoding. On the other hand, however, cognitive resources likely contribute to the ability to benefit from organisational and elaborative processes engaged by the self (Klein & Kihlstrom, 1986; Klein & Loftus, 1988; McDaniel, Lapsley, & Milstead, 1987), and it would be surprising if older populations were not affected by resource limitations. Older adults often show substantial variability in cognitive resources, and these individual differences can lead to marked differences in performance on a range of cognitive tasks.

Experiment 2 was designed to address potential age-related limitations in the self-reference effect. To examine the extent to which a blending of self and other could reduce the self-reference benefit, we asked young and older adults to make decisions about the self and about a close other person. To address the degree to which the self-reference effect depends on the availability of cognitive resources, we compare older adults with high and low levels of resource using speed of processing measures. Although it is unclear whether speed of processing tasks tap into one fundamental process, such as the speed of neural transmission, or reflect resource availability through the interaction of speed with other higher-order cognitive processes such as working memory, prior research suggests that speed of processing is highly correlated with measures of executive function and memory, and mediates much of the age-related variance in cognitive performance (Park et al., 2002; Salthouse, 1996). We predict that older adults with more cognitive resources available should benefit from self-referencing more than those with limited cognitive capacity.

Method

Participants. A total of 30 young (age range 18–30) and 60 older adults (age range 61–80), drawn from the same samples as Experiment 1, participated in the study. Demographic characteristics and performance on measures of cognitive ability are presented in Table 1.[3] Older adults were significantly more educated than young adults, $t(88) = 5.69$, $p < .001$, slower on the speeded digit comparison, $t(88) = 5.94$, $p < .001$, and pattern comparison, $t(88) = 6.99$, $p < .001$, tasks, and scored higher on the Shipley vocabulary scale, $t(84) = 6.79$, $p < .001$.

Materials and procedures. The experiment was identical to Experiment 1, but participants were cued to make judgements about a ''Close Person'' rather than Albert Einstein. Participants identified a single personally familiar other to reference for all ''Close Person'' judgements, and completed a questionnaire about this individual. Both age groups selected close others who were highly familiar (young $M = 8.67$, $SD = .81$; older adults $M = 8.47$, $SD = 1.48$) and well liked (young $M = 8.86$, $SD = .44$; older adults $M = 8.62$, $SD = .92$) as rated on a 9-point scale where a score of 9 indicates ''extremely familiar'' or ''like very much'', and there were no significant age differences in these ratings ($ts < 1.5$). Not surprisingly, older adults reported knowing their close other significantly longer ($M = 44.11$ years, $SD = 13.13$) than did young adults ($M = 12.18$ years, $SD = 8.11$); $t(81) = 11.75$, $p < .001$. They also reported more frequent contact with their selected target person, with daily contact for 73% of older adults as opposed to only 24% of young adults. The majority of older adults (72%) selected a spouse or romantic partner as their close other, with a friend/best friend (12%) or family member (child 10%, parent 3%, sibling 2%) selected less often. Young adults' selections were more evenly distributed across romantic partner/spouse (28%), best friend (31%), and family members (24% for siblings and 17% for parents). Both age groups selected close others with similar proportions of each gender (young 62% female; older adults 58% female), although older adults' close other was older ($M = 66.75$ years, $SD = 11.98$) than young adults' ($M = 26.86$ years, $SD = 12.81$); $t(87) = 14.39$, $p < .001$. In sum, older adults reported more contact and longer experiences, particularly of a romantic nature, with their close other compared to young adults, although both groups selected individuals they held in high regard and had known for a large proportion of their lives.

Subdivision of older adult group. To investigate the role of cognitive resources in the ability to benefit from self-referencing, we divided older adults into high and low resource groups based on the speed of processing measures. Digit and pattern comparison tasks require participants to make perceptual judgements of two strings of characters. We selected these tasks because they represent both verbal and non-verbal judgements, and because they make fewer motor demands than some other speed tasks (such as digit–symbol substitution). We used the combined total number of items correctly completed (minus errors) on the two speed tasks. Thus, high performers, compared to low performers, were significantly faster on both the pattern comparison, $t(58) = 8.81$, $p < .001$, and digit comparison, $t(58) = 5.90$, $p < .001$. Across both measures, high performers completed an average of 117.43 items ($SD = 8.37$) while low performers completed an average of 91.10 items ($SD = 11.72$). Low performers, in comparison to high performers, were significantly older ($M = 72.62$ vs $M = 69.44$), $t(58) = 2.83$, $p < .01$, less educated ($M = 15.48$ vs $M = 16.85$), $t(58) = 2.09$, $p < .05$, and had poorer vocabularies ($M = 34.70$ vs $M = 36.72$), $t(54) = 2.28$, $p < .05$.

To ensure that older adults with high and low amounts of cognitive resource did not differ in the types of close others selected, we conducted independent-sample *t*-tests on the close person questionnaire responses. The groups did not differ in their ratings of familiarity or liking, or in their length of acquaintance with the target individuals ($ts < 1$). The target individuals did not differ on age ($t < 1.5$), gender (53% female for low resource; 63% for high resource), relationship to the participant (the majority were spouses/romantic partners: 70% low resource; 73% high resource), or frequency of interaction (daily: 73% for both groups).

Results and discussion

Age differences. As in Experiment 1, we calculated hit minus false alarm rates to assess recognition performance for each of the three conditions (Self, Close Other, and Case). We then

[3] Ages are unavailable for two young adults and vocabulary scores are unavailable for four older participants.

conducted a 2×3 mixed ANOVA on the hit minus false alarm rates, with Age (Young/Older adults) as the between-groups variable and Condition (Self/Other/Case) as the within-group variable. Results are displayed in Figure 1b. The ANOVA revealed a main effect of Age: $F(1, 88) = 10.97$, $p < .005$, $\eta_p^2 = .11$. As in Experiment 1, young adults remembered more items relative to their false alarm rate than older adults (young $M = .39$; older adults $M = .29$). The main effect of Condition was significant, $F(2, 176) = 121.08$, $p < .001$, $\eta_p^2 = .58$, with the self condition resulting in higher levels of memory than the other person condition, $F(1, 88) = 34.51$, $p < .001$, $\eta_p^2 = .28$, and the other person condition supported higher levels of memory than did the case condition, $F(1, 88) = 103.88$, $p < .001$, $\eta_p^2 = .54$. The Age $\times$ Condition interaction did not approach significance: $F(2, 176) = 1.30$, $p = .28$, $\eta_p^2 = .02$. Thus, the results converge with those of Experiment 1 to demonstrate that older adults' memory benefits from referencing the self or a familiar person, relative to the case condition. Memory is poorer across all conditions with age; even referencing an intimately close individual with whom older adults have extensive life experience does not afford any advantage relative to young adults. Young and older adults exhibit self-reference effects of a similar magnitude in comparison to a personally familiar close companion.

The main effect of age emerges through the combination of the hit and false alarm rates. Older adults ($M = .27$) make more false alarms than young adults ($M = .23$), but this difference is not significant, $t(88) = 1.04$, $p = .30$. Young adults had significantly more hits in the case condition, $t(88) = 2.56$, $p < .02$, and marginally more in the self, $t(88) = 1.53$, $p = .13$, and other, $t(88) = 1.36$, $p = .18$, conditions. Although a different pattern emerged in Experiment 1, which yielded significant age differences in false alarms rates but not the hit rates, inspection of the means reveals substantial similarity across the two conditions. The patterns of results for the age groups are identical across the two studies, with the sole exception of the hit rate for the case condition.

The results of Experiment 2 converge with those of Experiment 1 to suggest that although recognition performance is impaired for older adults relative to young adults, self- and other-referencing of information at encoding leads to higher levels of memory compared to a shallow condition for both young and older adults. Referencing a close other person did not substantially change the pattern of results compared to the use of a personally unfamiliar other in Experiment 1. This result is in contrast to previous literature (Bower & Gilligan, 1979), which suggests that personally familiar others engage the same elaborative encoding processes as the self. Even though the close other was much more familiar and possibly incorporated into the construct of "self" (Aron et al., 1991) for older more than young adults, the relative differences between the young and older adults were similar across the conditions and similar to the pattern exhibited in Experiment 1. If anything, the poorer performance of older adults was exaggerated for the case condition. Another factor to consider is that the large number of trials in this experiment may have maximised the difference between conditions. A meta-analysis shows that the self-reference effect is larger under conditions of high memory load and distraction during the retention interval (Symons & Johnson, 1997), both of which were present in our design.

Resource-based differences for older adults. To compare the effect of self-referencing across high and low resource groups of older adults,[4] we conducted a 2×3 mixed ANOVA with Group (High/Low resource) as a between-subjects variable and Condition (Self/Other/Case) as a within-subjects variable on the corrected recognition (hit minus false alarm) scores. There was a main effect of Group, $F(1, 58) = 7.44$, $p < .01$, $\eta_p^2 = .11$, such that high resource older adults ($M = .33$) exhibited better memory than low resource older adults ($M = .24$). As in the comparisons of age groups in Experiments 1 and 2, there was also a main effect of Condition, $F(2, 116) = 137.91$, $p < .001$, $\eta_p^2 = .70$, with recognition higher in the self condition than the other person condition, $F(1, 58) = 26.15$, $p < .001$, $\eta_p^2 = .31$, and higher in the other person condition than in the case condition, $F(1, 58) = 140.00$, $p < .001$, $\eta_p^2 = .71$. Unlike the comparisons across age groups, there was a significant interaction of Group $\times$ Condition, $F(2, 116) = 3.42$, $p < .05$, $\eta_p^2 = .06$. Based on 2×2 mixed ANOVAs with Group and only two levels of the Condition variable (Self/Case or Other/Case), high resource older adults exhibited disproportionately higher memory than low

[4] A direct comparison of young and high-performing older adults is available from the authors.

resource older adults for other person trials, $F(1, 58) = 5.00$, $p < .05$, $\eta_p^2 = .08$, and marginally higher memory for self trials, $F(1, 58) = 3.54$, $p = .065$, $\eta_p^2 = .06$, relative to the case condition. Results are shown in Figure 1c, and suggest that the availability of cognitive resource contributes to the ability of older adults to achieve enhanced encoding from referencing the self or another person.[5]

The group differences appear to be driven largely by the hit rates, with high-resource older adults making significantly more hits in the self, $t(58) = 2.07$, $p < .05$, and other, $t(58) = 2.25$, $p < .03$, conditions. The false alarm rates for high ($M = .25$) and low ($M = .28$) resource older adults do not differ, nor do the hits for the case condition ($ts < 1$).

Results of Experiment 2 suggest that the availability of cognitive resources plays an important role in the potential to benefit from self-referencing of information. Older adults with higher amounts of resource (as assessed by speed of processing measures) benefited more from referencing the self or another person compared to those older adults with less cognitive resource. The benefits extend across both deep encoding conditions; hence rather than suggesting a unique benefit from self-referencing, it likely reflects the support that high-resource older adults receive from conditions that promote deep, elaborative encoding (see Kausler, 1994).

The equivalent performance in the case condition for older adults with high and low amounts of cognitive resource argues against the influences of resource-based processes in this condition. The pattern also suggests that potential age differences in the case condition do not reflect a tendency for older adults to more selectively allocate encoding resources to the self and other person conditions compared to young adults.

Influence of emotion on group differences. The trend in Experiment 1 for higher corrected recognition scores for negative words ($M = .35$) than positive words ($M = .32$) reached significance in Experiment 2, $F(1, 88) = 4.98$, $p < .03$, $\eta_p^2 = .05$. However, valence did not interact with age or condition ($Fs < 2$). The availability of cognitive resources across older adults did not affect the magnitude of the positivity bias for older adults. There were no main effect or interactions ($Fs < 2$) involving valence in a comparison of high and low resource elderly.

These data converge with those of Experiment 1 to suggest that negative adjectives are better remembered than positive ones, but in this experiment with a larger sample, the pattern is the same for self-referencing as for the other person or case conditions. Furthermore, we do not find any differences across the high and low resource groups of older adults in the effects of valence. This pattern contrasts Mather and Knight's (2005) findings that the amount of available cognitive resources contributes to the magnitude of the positivity bias for older adults. It may be that our speed of processing measure is less sensitive to these effects than the cognitive control measures used by Mather and Knight (2005), or that our stimuli are not as strongly valenced as the pictures used in their study.

Experiment 2 establishes that the availability of cognitive resources contributes to mnemonic benefits of self-referencing and, to a lesser degree, other person referencing. The finding of reduced benefits for low resource older adults establishes limits to the strategy of referencing self or other.

EXPERIMENT 3

Because Experiment 2 demonstrated limits to the self-referencing effect for subgroups of older adults, we investigated potential age-related limits to the self-reference effect, while also manipulating the socioemotional nature of the judgements. We propose that subjective judgements that do not require judgements about the self per se could also rely on flexibly referencing the self. In Experiment 3 we investigated the ability of young and older adults to extend self-referencing to subjective judgements about desirability. For young adults, evaluative judgements, such as desirability, can elevate memory to the same level as self judgements in between- (Ferguson et al., 1983), but not within- (McCaul & Maki, 1984), subjects designs. Affective judgements may spontaneously reference the self to some degree (i.e., Do I find this desirable? Is this a trait I would want to display?), and participants may capitalise on the overlap between processes to better encode information when making both

[5] This pattern is also present for the smaller samples tested in Experiment 1. The interaction of condition and group is significant, with high resource older adults, but not low resource older adults, exhibiting significantly higher memory for the self-referenced items compared to the other-referenced items. Analyses are available from the authors.

kinds of judgements. Young adults may be more prone than older adults to adopt a strategy that extends self-referencing to evaluative judgements, and socioemotional judgements to self-referencing, which would demonstrate a limit to the self-referencing effect with age.

Method

Participants. A total of 18 young adults (ages 18–26) from Harvard University and 18 older adults (ages 61–79) from the surrounding community participated in the study. Demographic characteristics and performance on measures of cognitive ability are displayed in Table 1.[6] Older adults were significantly more educated than young adults, $t(34) = 5.23$, $p < .001$, but completed fewer items on the speeded digit comparison task, $t(33) = 3.93$, $p < .001$. Although vocabulary scores were in line with those collected from older adult samples in Experiments 1 and 2, older adults did not perform significantly better than young on the vocabulary test ($t < 1$). Older adults scored at least a 27 on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), with an average score of 29.33 ($SD = .98$).[7] The research was approved by the Harvard University Institutional Review Board.

Materials and procedures. The experimental materials and procedures were identical to the previous studies, with two exceptions. The Shipley vocabulary test (Shipley, 1986) was administered during the retention interval in place of the pattern comparison task, which was not administered. The key manipulation change was that participants made desirability judgements instead of judgements about another person. Instructions emphasised the self-referential nature of making desirability judgements, in that they should be based on the participant's personal experience. We verified that the participants' desirability assessments evoked self-referencing through the use of a debriefing questionnaire with a 5-point scale where a rating of "1" denoted "almost all the time", a rating of "3" denoted "about half the time", and a rating of "5" denoted "never". Participants rated that they often thought about the self while making the desirability judgements (young $M = 2.67$, $SD = .77$; older adults $M = 1.71$, $SD = .92$). Even though older adults reported referencing the self more than did young, $t(33) = 3.36$, $p < .005$, both groups similarly claimed ($t < 1.6$) that what they reflected upon to make the self judgements overlapped with that for the desirability judgements (young $M = 3.50$, $SD = .86$; older adults $M = 3.94$, $SD = .83$ where a rating of "3" reflects "sometimes yes, sometimes no" and rating of "4" reflects "fair amount of overlap"). Desirability judgements had little in common with the case judgements (young $M = 1.94$, $SD = .73$; older adults $M = 1.71$, $SD = 1.05$ where a rating of "1" corresponds to "not at all – very different" and a rating of "2" corresponds to "not particularly"), though both groups again responded similarly, $t < 1$.

Results and discussion

Age differences. In a 2×3 mixed ANOVA with Age (Young/Older adults) as the between-groups variable and Condition (Self/Desirability/Case) as the within-subjects variable, multiple effects emerged, as shown in Figure 1d. Young adults ($M = .45$) remembered significantly more words than older adults ($M = .34$), $F(1, 34) = 7.83$, $p < .01$, $\eta_p^2 = .19$. The main effect of Condition was also significant, $F(2, 68) = 83.36$, $p < .001$, $\eta_p^2 = .71$, and follow-up 2×2 ANOVAs suggested that the self condition resulted in higher levels of memory than the desirability condition, $F(1, 34) = 7.42$, $p < .05$, $\eta_p^2 = .18$, and that the desirability condition resulted in greater memory than the case condition, $F(1, 34) = 93.15$, $p < .001$, $\eta_p^2 = .73$. In contrast to Experiments 1 and 2, the interaction of Age × Condition was significant, $F(2, 68) = 4.29$, $p < .05$, $\eta_p^2 = .11$. To interpret the interaction, we conducted a series of 2×2 ANOVAs with only two levels of the Condition variable (Self/Case or Desirability/Case), and results suggest that young benefited disproportionately more than older adults from making self, $F(1, 34) = 4.77$, $p < .05$, $\eta_p^2 = .12$, and desirability judgements, $F(1, 34) = 5.99$, $p < .05$, $\eta_p^2 = .15$, during encoding, relative to making case judgements. Note that in contrast to the previous experiments, young and older adults are matched on performance in the case condition. This provides an equivalent baseline across age groups from which to compare the benefit from

[6] For Experiment 3, one young participant did not complete the digit comparison task, and one older participant did not complete the vocabulary measure. The debriefing questionnaire was also omitted by one older adult.

[7] Current MMSE scores were available for 15 out of 18 older adults.

referencing the self, and thus provides a means of matching performance.

Age influenced both hit and false alarm rates, similar to the pattern that emerged for Experiment 2. Young made significantly more hits for self, $t(34) = 2.09$, $p < .05$, desirability, $t(34) = 2.18$, $p < .05$, but not case trials ($t < 1$), whereas older adults made marginally more false alarms, $t(34) = 1.90$, $p = .07$.

Previous findings in the literature (e.g., May et al., 2005; Rahhal et al., 2002) suggest that attending to socioemotional information can equate memory across young and older adults. In contrast, our results from Experiment 3 show that adding an evaluative social judgement increased the magnitude of age differences, with young adults performing disproportionately better than elderly people in both the self and desirability conditions. Thus, Experiment 3 suggests that the self-reference advantage does not benefit elderly people solely due to the socioemotional nature of the task: When attention is heightened to socioemotional information in this experiment, elderly adults benefit less than young adults and the results diverge from the findings of our initial experiments.

We further argue that our pattern of results suggests that young adults may extend self-referencing to other socioemotional judgements more than older adults. When making desirability judgements, participants were encouraged to reflect on their own personal experiences to make the subjective judgements. Orienting to desirability and self-relevance, in comparison to the case condition, disproportionately improved young adults' memory relative to that of older adults. Perhaps young adults were able to benefit from the overlap between evaluative and self-referential processes and devoted resources to these trials at the expense of case trials. It seems that the desirability condition, rather than the self condition, drove the heightened memory performance of young adults particularly when compared to the pattern for Experiment 2.[8] In contrast to Experiments 1 and 2, desirability judgements required explicit evaluation of the positive or negative connotations of the adjectives. There may be increased awareness of the social desirability of traits when making judgements about oneself, whereas one is less focused on this feature when making judgements about others. When both decisions are jointly presented in one context, desirability judgements may involve consideration of the self to some extent (e.g., ''Do *I* consider 'rude' to be a desirable trait?'') but self-judgements may also involve consideration of desirability (i.e., ''Because it's an undesirable characteristic to exhibit, I'm ashamed to admit that I can be 'rude' sometimes.''). This suggests that the extension of self-referencing to the desirability judgements, and vice versa, disproportionately benefits young adults.

Because Experiment 3 sampled from a different population of young and older adults, we cannot definitively rule out sampling differences. However, it is the young adults, not the older adults, who appear to differ on some neuropsychological measures (see Table 1), but memory does not differ for the comparable conditions across experiments.[9]

It also seems unlikely that the effects involving age in Experiment 3 result from different interpretation of the instructions by each age group. If anything, older adults claimed in the debriefing measure that they reflected on themselves to a greater extent for the desirability condition than did young adults. Even so, introducing desirability judgements did not support successful *encoding* of self or desirable trials for older adults as much as it did for young, which we interpret as a limitation in older adults' ability to extend self-referencing as broadly as young adults. The co-occurrence of the self and desirability conditions may be critical; young adults may not benefit disproportionately in a between-subjects design (see McCaul & Maki, 1984, for a similar argument). Further research is needed on this point.

Notably, the age groups are matched on the case condition in Experiment 3. We do not believe that this explains older adults' reduced benefit in the self and desirability conditions relative to the young. When case performance is matched across groups in Experiments 1, we do not replicate the pattern seen here of reduced benefits for older adults.[10]

Influence of emotion on age differences. In a comparison of hit minus false alarm rates using an ANOVA of Age (Young/Older adults) × Condition (Self/Desirability/Case) × Valence (Positive/Negative), there were no significant main effects

[8] Analyses are available from the authors.

[9] Analyses are available from the authors.

[10] Analyses are available from the authors.

or interactions involving valence (Fs < 2.5). Inclusion of a condition that focuses on the socioemotional aspects of words, as accomplished with the desirability judgements in this experiment, may equate the encoding of positive and negative words.

Even when valence is explicitly referenced in the desirability condition, we do not find a greater enhancement for positive items in the self condition, relative to the other conditions. The pattern of results from Experiment 3 converges with the previous experiments to suggest that the self-reference effect is not attributable solely to the emotional nature of self-judgements. If emotion drove the self-referencing effect, the emphasis on evaluative, emotional encoding processing should lead to equivalent memory enhancement relative to the case condition for both young and older adults. Rather, the pattern of findings suggests that the intact self-reference effect for older adults reported in Experiments 1 and 2 may reflect additional non-emotional properties of the self as a structure that facilitates encoding.

GENERAL DISCUSSION

Over a series of three experiments we demonstrated that under some circumstances, older adults can benefit from self-referencing to the same extent as young adults. Self-referencing similarly enhanced recognition performance for young and older adults relative to familiar others, personally familiar others, and shallow perceptual encoding. Although we predicted that self-referencing could restore older adults' memory to the level of young adults, this finding was not obtained, and the results indicated instead that older adults are more limited in their application of self-referencing. Older adults with fewer cognitive resources benefited less from self-referencing than those with greater cognitive resources. Further, drawing on the self to make desirability judgements did not enhance memory for older adults as much as it did for young adults. Thus, we conclude that older adults may be limited in their application of self-referencing due to its demand on cognitive resources and their diminished ability to apply the strategy flexibly and broadly in other types of evaluative judgements.

In a similar vein, we proposed in the introduction that self-referencing could partially explain effects in the literature that have been attributed to emotion (e.g., May et al., 2005; Rahhal et al., 2002). This possibility seems unlikely because the results of Experiment 3 suggest that self-referencing does not support older adults' memory solely due to its socioemotional features and self-referencing alone does not support equivalent levels of memory performance in young and older adults. Casting information in terms of its emotional significance would likely involve spontaneous extension of self-referencing, which we have demonstrated is difficult for older adults even with explicit instructions. We maintain that it would be a worthwhile venture for future studies to delineate the individual contributions of self and emotion. For example, must an older adult be able to project him or herself into the situation as the target of deception, illness, or risk in order to encode as effectively as young adults?

Our study of self-referencing departs from previous studies of socioemotional processing in a few important ways. The source information presented in previous studies (Rahhal et al., 2002; May et al., 2005) is of a consequential nature, suggesting impending danger or deception. Participants may find the potential outcomes more pertinent to future behaviour, real or imagined, than making simple, quick judgements of the self- or other- relevance of adjectives. Self and other judgements that are more relevant to the future and invoke more deliberative reflection could bolster older adults' memory to the level of the young. A second important departure from prior studies is the presentation of conditions within participants, rather than between. The magnitude of the self-reference effect changes as a function of the other conditions included in the design (McCaul & Maki, 1984). This result could be particularly relevant for our third experiment in which the co-occurrence of self and desirability trials could be critical to the pattern of findings; age differences could be less pronounced in a between-subjects design. The intermixing of trials could be of particular concern in a between-subjects design because it might induce task-switching demands, which impact older adults more than young adults (Kray & Lindenberger, 2000) and could contribute to impoverished encoding with age. In addition, our studies had high memory loads (e.g., 144 items to encode), which may put older adults, particularly those with less cognitive resources, at a disadvantage relative to young adults. Additional empirical investigations, holding all other factors constant, would be necessary to assess the contribution of

each of these factors to the present pattern of results.

Although we identify a role for cognitive resources in determining the magnitude of the benefit from self-referencing, our use of a speed of processing measure does not indicate which specific resources are important. While it is possible that speed of processing measures tap directly into processing constraints, such as the speed of neural transmission (Salthouse, 1996), or inhibitory function (Lustig, Hasher, & Tonev, 2006), it may be that the measure reflects the indirect operation of differences due to age or education (low resource samples are both older and less educated than high resource samples), or the availability of additional time to encode stimuli after making an adjective judgement response. More nuanced approaches to assess cognitive control (Mather & Knight, 2005) or executive function (Marquine, Walther, & Glisky, 2006) may ultimately offer greater specificity regarding the locus of the effects of ageing on the self-reference effect, but our results offer initial evidence that the magnitude of the self-reference effect depends on the availability of cognitive resources. It is important to note that while the adjective judgements themselves are performed quickly and perhaps with low effort, the *encoding* of adjectives places demands on cognitive resources.

The limitations in older adults' ability to use self-referencing have implications for the viability of using self-referencing in everyday situations. Real-world applications necessitate flexible and spontaneous application of the strategy to overcome age-related declines in memory. In our paradigm, participants were explicitly instructed to evaluate desirability based on their own personal experiences—even without demands to spontaneously self-initiate use of self-referencing, older adults were constrained in their ability to apply it successfully. Because these limitations exist even for high-functioning older adults, the strategy does not seem to hold much promise as an intervention for clinical ageing populations, such as those with mild cognitive impairment (MCI) or in the early stages of Alzheimer's disease. These qualifications are not intended to discount the improvements in memory that do occur as a result of self-referencing. Self-referencing does appear to be an effective encoding strategy, even compared to other ''deep'' strategies, and should result in some gains in memory even for cognitively impaired older adults. However, moving the strategy away from sterile laboratory conditions and explicit task instructions would likely pose significant challenges to successful application of the strategy.

Finally, more work is needed to understand what aspects of items are better encoded through self-referencing. Self-referencing may be prone to memory distortion in that it evokes a schematic representation of oneself. Young adults commit more false alarms for items that are self-descriptive than for those that are not (Rogers et al., 1979). This tendency could be exaggerated with age, as is the case for other types of memory distortion (e.g., Koutstaal & Schacter, 1997). Compounding this possibility, schematic support seems to be intact for older adults, and compared to schema-inconsistent or irrelevant information, it can sometimes support memory performance (Castel, 2005), but also be more difficult to inhibit with age (Malmstrom & LaVoie, 2002). In terms of the self-reference effect, an older adult who considers his/her unselfish nature to be a defining feature essential to his/her self-schema would have heightened activation associated with ''unselfish''. This activation could be mistaken for familiarity in the task at hand, leading to a false alarm. Alternatively, for words that resonate with one's self-schema, encoding could emphasise the connotation of the word rather than the precise word used to illustrate the concept. This would lead to heightened familiarity for associated words, such as ''generous'' and perhaps even the antonym, ''selfish''.

In conclusion, we have provided evidence that self-referencing (1) can enhance memory similarly for young and older adults, (2) depends on the availability of cognitive resources and has more limited effectiveness in older adults, and (3) diverges from socioemotional processing.

Manuscript received 26 February 2007
Manuscript accepted 20 September 2007
First published online 13 November 2007

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