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The relationship between prospective memory and episodic future thinking in younger and older adulthood

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Episodic future thinking (EFT), the ability to project into the future to "preexperience" an event, and *prospective memory* (PM), remembering to perform an intended action, are both examples of future-oriented cognition. Recently it has been suggested that EFT might contribute to PM performance but to date few studies have examined the relationship between these two capacities. The aim of the present study was to investigate the nature and specificity of this relationship, as well as whether it varies with age. Participants were 125 younger and 125 older adults who completed measures of EFT and PM. Significant, positive correlations between EFT and PM were identified in both age groups. Furthermore, EFT ability accounted for significant unique variance in the young adults, suggesting that it may make a specific contribution to PM function. Within the older adult group, EFT did not uniquely contribute to PM, possibly indicating a reduced capacity to utilize EFT, or the use of compensatory strategies. This study is the first to provide systematic evidence for an association between variation in EFT and PM abilities in both younger and older adulthood and shows that the nature of this association varies as a function of age.

Keywords: Prospective memory; Episodic future thinking; Autobiographical Interview; Virtual Week

In everyday life, we spend a considerable amount of time thinking about and planning our future. This ability to disengage from the present to contemplate potential future scenarios is highly adaptive as it allows us to act in anticipation of future needs (Hanson & Atance, 2014). There are a number of different types of future-oriented cognitions, two of which will be the focus of the current study: *episodic future thinking* (EFT) and *prospective memory* (PM). While both have individually attracted attention in the literature in terms of, for example, their developmental trajectories (e.g.,

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Busby & Suddendorf, 2005; Mahy, Moses, & Kliegel, 2014) and level of impairment in clinical groups (e.g., Henry et al., 2014; Terrett et al., 2013), little attention has been paid to the nature of the relationship between these constructs. This is a surprising omission, since clarifying this relationship would further extend our understanding of the cognitive mechanisms implicated in PM function and would also provide an important test of the claim that EFT is a key determinant of PM performance (Brewer & Marsh, 2010).

EFT refers to the ability to imagine experiencing future situations (Addis, Wong, & Schacter, 2008; Atance & O'Neill, 2001; Schacter, Addis, & Buckner, 2007). It is a complex process requiring the construction of mental scenes and as such is likely to rely on multiple cognitive processes including executive control (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010), semantic memory (Irish, Addis, Hodges, & Piguet, 2012), and self-projection (Buckner & Carroll, 2007).

Particular attention, however, has been paid to the role of episodic memory. According to the *constructive episodic simulation hypothesis*, episodic future thinking relies heavily on the retrieval of personally relevant memories of the past as these provide basic information that is then flexibly recombined to construct novel future events (Schacter et al., 2007). Evidence of a core neural network underpinning both episodic memory and EFT adds support to the claim that episodic memory and EFT are closely related (Weiler, Suchan, & Daum, 2010; see Schacter et al., 2012, for a review).

PM refers to the ability to remember to carry out a planned action. Successful completion of a PM task involves several sequential stages: (a) forming the intention; (b) retaining the intention in memory while engaged in other ongoing activities; (c) initiating the intended action at the appropriate time; and (d) evaluating the outcome of the action (Einstein & McDaniel, 1996; Ellis, 1996; Ellis & Freeman, 2008). A number of cognitive abilities have been implicated in PM, including executive functioning and retrospective memory (see Kliegel, Altgassen, Hering, & Rose, 2011, for a review). Retrospective memory in particular has been shown to play a key role as PM tasks require retention of the content of the tasks as well as the circumstances in which it is to be executed (Kliegel, McDaniel, & Einstein, 2000; Zöllig et al., 2007).

Recently it has been proposed that EFT might be an important determinant of PM performance (e.g., Schacter, Addis, & Buckner, 2008; Szpunar, 2010). More specifically, it has been suggested that mentally simulating a future intended action strengthens encoding of the content of the PM intention during the intention formation stage (Brewer & Marsh, 2010; Schnitzspahn & Kliegel, 2009), which increases the likelihood that the PM task will be successfully completed. Currently two main lines of evidence support a possible link between EFT and PM. The first comes from research that has found future simulation to be an effective strategy for improving PM performance (e.g., Altgassen et al., 2015; Brewer & Marsh, 2010; Leitz, Morgan, Bisby, Rendell, & Curran, 2009; McFarland & Glisky, 2012; Neroni, Gamboz, & Brandimonte, 2014). For example, in a lab-based study, Paraskevaides et al. (2010) found that imagining performing PM tasks reduced the adverse effects of alcohol consumption. In addition, Brewer and Marsh (2010) found that young adults who were asked to form an implementation intention (i.e., "If X occurs, then I will do Y"; Gollwitzer, 1999) while imagining themselves undertaking a PM task performed better than those who were given standard instructions (i.e., "Please do Y whenever X occurs") with no additional future visualization component. In both studies it was argued that imagining successful completion of the PM task at the appropriate future time-point, a form of episodic foresight, allows participants to preexperience the retrieval cues. By increasing the salience of retrieval cues that indicate the point at which the PM task should be performed, it is suggested that they are detected more efficiently, which in turn increases the likelihood that PM tasks will be successfully completed.

The second source of support for a link between PM and EFT comes from neuroimaging studies. For example, it has been shown that imagining produces similar brain activation to that produced when experiencing a specific situation in real life (e.g., Stokes, Thompson, Cusack, & Duncan, 2009). Given that greater similarity in brain activation at encoding and retrieval is associated with better PM performance (e.g., West & Ross-Munro, 2002), it has therefore been argued that imagining the future cue when forming an intention increases the similarity in brain activity at encoding and retrieval (Gilbert, Armbuster, & Panagiotidi, 2012), thereby supporting successful PM performance. Furthermore, a high degree of overlap has been shown in brain areas, particularly BA10, that are activated during both PM (e.g., Burgess, Scott, & Frith, 2003) and EFT (Addis, Wong, & Schacter, 2007; Weiler et al., 2010), additionally supporting the claim that the two processes are related. However, it should be noted that this common neural network, as previously noted, is also activated during episodic memory (Addis et al., 2007; Weiler et al., 2010), raising the possibility that any association between EFT and PM may be a reflection of a common reliance, at least to some degree, on episodic memory.

Nevertheless, these two research areas have been used to support the argument that EFT plays a key role in PM. The first critical test of this hypothesis, however, is showing that there is a direct, positive association between these two constructs. Investigations using this approach are, however, surprisingly limited. To the best of our knowledge there have been only two such studies (Atance & Jackson, 2009; Nigro, Brandimonte, Cicogna, & Cosenza, 2013), and both involved young children. While these studies did not find a relationship between EFT and PM in children under the age of 5 years, Nigro et al. (2013) did report a significant, albeit moderate, correlation between EFT and PM amongst an additional group of older children (7-year-olds), suggesting that this relationship may not emerge until middle childhood. However, this association has not been directly investigated in adulthood. A further important test of this hypothesis is showing that EFT contributes to PM over and above the contribution of other variables previously shown to be associated with PM, in particular retrospective memory.

The aim of the current study was therefore to advance our understanding of the relationship between EFT and PM, as well as the contribution of EFT to PM, by conducting a large-scale assessment of these abilities in two distinct adult populations. Specifically, because of considerable prior evidence showing that the capacity for future-oriented cognition may be reduced for older relative to younger adults (Addis, Musicaro, Pan, & Schacter, 2010; Addis et al., 2008; Lyons, Henry, Rendell, Corballis, & Suddendorf, 2014; see Henry, MacLeod, Phillips, & Crawford, 2004, for a review), and because age is known to disrupt many of the cognitive abilities likely to be important to engage in both types of prospective thought (e.g., Prull, Gabrieli, & Bunge, 2000; Salthouse, 2000), we tested younger and older adulthood separately. First, we assessed the association between the two constructs and hypothesized that EFT and PM would be positively related in young adults. We also expected this to be the case for older adults, based on the assumption that the positive relationship between EFT and PM would be retained despite an anticipated reduction in both of these abilities in this group. Second, we investigated whether EFT ability would contribute to PM over and above individual differences in age, general cognitive ability, and retrospective memory for both young and older adults.

EXPERIMENTAL STUDY

Method

Participants

Participants were 125 young adults (18–30 years) and 125 older adults (65–85 years). Both groups were approximately 70% female. Participant characteristics for the two age groups are shown in Table 1. Both groups were recruited from the community and received $30 Australian, for participating in a two- to three-hour testing session. Older adults were screened for possible dementia using the Addenbrooke's Cognitive Examination Revised (ACE–R; Mathuranath, Nestor, Berrios,

Table 1. *Characteristics of the sample*

	Young adults (age range 18–30 years) n = 125		Older adults (age range 65–85 years) n = 125		t test[a] (df = 248)	
Characteristic	M	SD	M	SD	t	p
Number of women	89 (71.2)		87 (69.6)			
Age (in years)	22.90	3.45	73.80	5.57		
Education (in years)	13.94	2.16	13.30	3.61	1.72	.086
Self-rated health[b]	2.11	0.84	2.21	0.94	0.85	.395
Self-rated sleep	2.56	0.93	2.66	1.00	0.79	.432
Geriatric Depression Scale	7.21	4.75	4.04	3.84	5.80	<.001
NART Verbal IQ[c]	98.20	8.13	110.17	8.44	11.42	<.001
Verbal Fluency[d]	57.37	13.07	56.32	14.14	0.61	.543
ACE–R[e]			92.70	3.76		
MMSE[f]			29.37	0.86		

Note: Percentages in parentheses.
[a]Age groups were compared on each measure with separate independent-groups *t* tests. [b]Self-rated health on day of test and sleep over past month were rated on a 5-point scale: 1 = excellent; 2 = very good, 3 = good; 4 = not very good; 5 = poor. [c]Verbal IQ score as predicted from the number of errors made on the NART (National Adult Reading Test). [d]Verbal fluency was total number of words generated for P, R, W, and animals. [e]ACE–R refers to the Addenbrooke's Cognitive Examination Revised—range of scores was 84–100. [f]MMSE refers to the Mini-Mental State Examination—range of scores was 27–30.

Rakowics, & Hodges, 2000). All older adults had normal mental status as indexed by scores greater than 83 (out of a possible 100) on the ACE–R and scores greater than 26 (out of a possible 30) for the Mini-Mental State Examination (MMSE; Mathuranath et al., 2000). The age groups did not differ in years of education, verbal fluency, self-ratings of sleep, or self-ratings of health on day of testing. The older adults had higher mean predicted verbal IQ, based on the National Adult Reading Test (NART) vocabulary test, and had lower levels of depression than the young adults (see Table 1).

Materials and procedure

Episodic future thinking. The Autobiographical Interview (AI) procedure originally developed by Levine, Svoboda, Hay, and Winocur (2002) and adapted by Addis et al. (2008) was used to assess participants' ability to generate episodic content when describing past and future events. This is an interview format procedure during which participants are presented with a set of cue words. They are required to generate details about either a past or a future event in response to each word. In the current study, each participant was asked to describe six events: three in each of two conditions (past three years and next three years). All three events relating to one temporal direction, past or future, were completed before commencing the further three events relating to the other temporal direction, and temporal direction was counterbalanced across participants. A total of six cue words were administered to participants. We followed a two-stage randomizing process to assign the words to the past and future conditions. First, for each participant, the six words were randomly selected from a list of 20 possible cue words (e.g., apple, letter, baby). These words were nouns that were all rated high on frequency, imageability, and concreteness (Clark & Paivio, 2004). Second, these six words were then randomly allocated to past and future conditions for each participant.

AI testing sessions. First, the interviewers were trained in the procedures outlined by Addis et al. (2008) and were given an interview administration manual.[1] Several pilot interviews conducted by the interviewers were then audiotaped and analysed for consistency with the procedures used by Addis et al. (2008). Feedback was provided. Following completion of this training, testing of participants began. Testing sessions commenced with participants receiving instructions about the task, including a demonstration of a cue word and sample response. In the interview that followed, for each of the three trials relating to a particular temporal direction (past or future), participants were given a cue word (e.g., baby) and had three minutes to generate as many details as possible about an event that they either experienced in the past or could imagine experiencing in the future. The event did not have to relate directly to the cue word, and participants were encouraged to freely associate. They were told that the event had to refer to a specific time and place, it had to be less than one day in duration, and future events had to be realistic and not previously experienced. Participants were also directed to describe the event from their own perspective rather than that of an observer. During the three minutes, the relevant cue word was displayed on a card along with the task instruction ("recall past event" or "imagine future event"). If necessary, the experimenter gave general probes in line with protocols set out by Addis et al. (2008) such as asking general questions to clarify instructions and facilitate further description of event details. Responses were recorded using a digital audio recorder and were sent to a professional transcriber who was independent of the study, and who was blind to participants' group membership and study hypotheses.

AI scoring. Standardized AI scoring procedures outlined by Addis et al. (2008) were applied. The following scoring procedure was applied. A central event was first identified in the transcription for each cue word trial, and this was then sectioned into key details, or unique chunks of information. These details were categorized as either *internal* (episodic information related to central event) or *external* (nonepisodic details, including semantic information, information of other events not specific in time and place to the central event, and repetitions). The total number of internal details generated across all three future events was the primary measure of EFT.

Four scorers, independent from the study, blind to group membership, and blind to the experimental hypotheses, scored the transcripts. Prior to commencing, the scorers completed the training procedures set out by Addis et al. (2008) using the manual and training events provided by Donna Addis (see Footnote 1). Their scores during training were assessed for consistency with four experienced scorers from Donna Addis's lab (see Footnote 1). Inter-rater reliability for our four scorers was then assessed on the basis of a two-way mixed-design analysis of variance (ANOVA) intraclass correlation analysis of their scores on the first 12 participants' responses. The Cronbach alphas obtained for our scorers were .90 for internal details and .89 for external details.

Prospective memory. Virtual Week is a laboratory measure designed to represent PM in daily life (original version, Rendell & Craik, 2000; and for recent review, Rendell & Henry, 2009). It uses a computerized board game format in which participants move their token around the board by rolling a die and moving their token the number of squares indicated by the die. Each circuit of the board represents a day from 8 a.m. to 11 p.m., thus capturing the hours that participants are typically awake. As participants move their token around the board and pass each event "E" square, they must pick up an "event card". There are 10 event cards per virtual day, with each card presenting participants with a plausible event to pretend to be engaged in and three options for activities to participate in during the event. Based on the activity that the participant selects, a dice roll consequence is revealed,

[1]We thank Donna Addis for providing advice and detailed manuals for Autobiographical Interview administration and scoring procedures consistent with Addis et al. (2008), and for data and information allowing inter-rater reliabilities to be calculated between the scorer in the current study and those from her lab.

such as “roll an even number”, or “roll a 6”, which must be achieved before the participant can move their token and continue on with the game. In addition to selecting activities, rolling the die, and moving the token, participants are to remember to carry out several PM tasks. Thus, the PM tasks are embedded in the ongoing activity of simulating participation in the Virtual Week.

Each day of the Virtual Week includes 10 PM tasks (four regular, four irregular, and two time-check). The four regular PM tasks are the same each day and simulate the kinds of regular tasks that occur as one undertakes normal duties (such as taking medication every day at the same time); two of the regular PM tasks are event based (triggered by specific event cards: breakfast and dinner event cards), and two are time based (triggered by specific virtual times of the day: 11 a.m. and 9 p.m.). The four irregular PM tasks (also two event and two time based) are different each day and simulate the kinds of *occasional* tasks that can occur in daily life. These tasks thus place greater demands on retrospective memory than regular tasks that recur each day (Kliegel, Martin, McDaniel, & Einstein, 2002). In the original version of Virtual Week, which was used in prior studies (e.g., Rose et al., 2010), time of day was cued by having consecutive hours of the day marked on the squares on the board. A recent innovative feature of Virtual Week, which was used in the current study, is that both the regular and irregular time-based tasks require monitoring a virtual clock calibrated to the token position on the board (see Rendell et al., 2011). The two time-check tasks are the same each day but require the participant to disengage from the activities of the game to monitor real time on the stop-clock that is displayed on the board and indicate when a specified period of time had passed: 2 min 30 s and 4 min 15 s from the start of each virtual day. In this study, all participants completed the practice day and four virtual days. In order to maximize the reliability of PM measurement and variability in the samples, overall PM performance (i.e., a composite score of proportion correct across all types of PM tasks in Virtual Week) was the dependent measure under consideration in this study.[2]

As in recent computerized versions of Virtual Week, a standardized set of instructions with help messages and prompts were presented throughout the practice day. Participants were tested one at a time, and an experimenter sat with them throughout the practice day, highlighting the help messages and ensuring that the participants understood all procedures before starting their first virtual day. Just prior to starting the first virtual day, the experimenter informed the participant that there would be no more help messages on the screen or assistance provided by the experimenter.

Retrospective memory. Upon completion of each virtual day, participants were immediately asked to write down the PM tasks they remembered being required to carry out during the virtual days. Participants were instructed that they did not need to recall the target cue that prompted the task, only the content of the task. This recall task (scored as mean proportion of PM tasks correctly recalled) provides an index of the retrospective memory component of the PM tasks. As in Rendell et al. (2011), only recall of irregular PM tasks was used to measure retrospective memory because, as in previous studies using Virtual Week in adults (e.g., Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010), postexperimental retrospective memory of regular PM tasks was at ceiling.

Verbal intelligence. Verbal intelligence was estimated using the National Adult Reading Test (NART; Nelson, 1982). Participants are required to read aloud 50 English words with phonetically atypical pronunciation (e.g., *cellist*). Standardized IQ scores

[2]As part of another study, participants were directed to use different encoding strategies when performing some of the PM tasks. Analyses of the overall PM score (the index of PM ability used in this study) revealed that there was no interaction between age and encoding condition, and, furthermore, a similar pattern of results to those reported below was obtained when encoding condition was controlled for in the multiple regression analyses. In the interests of parsimony, therefore, the analyses reported in this paper do not include effects of the encoding condition manipulation.

are calculated, with higher scores indicating better performance. The NART is a strong predictor of intellectual function in the normal population (Bright, Jaldow, & Kopelman, 2002). Reliability estimates for the NART range from .90 to .93, and it has been well documented as a valid and reliable estimate of verbal intelligence (Crawford, Henry, Crombie, & Taylor, 2001; Crawford, Parker, Stewart, Besson, & De Lacey, 1989).

Procedure. All participants were tested individually at the university. Testing was completed in one session of approximately two to three hours duration, with breaks provided as needed. Administration of cognitive assessments was counterbalanced.

Results

Initial analyses were undertaken to establish whether the older adults displayed the anticipated deficits in EFT and PM, as well as retrospective memory. In relation to EFT, an independent-samples *t*-test showed that older adults produced fewer internal details on the AI ($M = 32.98$, $SD = 19.39$) than young adults ($M = 52.59$, $SD = 19.71$), $t(244) = 7.87$, $p < .001$, $d = 1.00$, reflecting poorer EFT ability. In relation to overall PM score, an independent-samples *t*-test similarly showed that older adults ($M = .42$, $SD = .15$) scored significantly lower than young adults ($M = .72$, $SD = .17$), $t(248) = 14.74$, $p < .001$, $d = 1.87$. Older adults ($M = .25$, $SD = .16$) also scored significantly lower than young adults ($M = .52$, $SD = .18$), $t(248) = 12.41$, $p < .001$, $d = 1.58$, on retrospective memory.

To investigate the relationship between EFT and PM within each age band, we computed the Pearson product–moment correlations for the two groups separately (see Figure 1 for scatterplot of these relationships). These correlations were computed using overall PM scores in order to maximize the reliability of PM measurement and variability in the samples, and because we had no a priori prediction regarding differences in the relationship between EFT and PM for different PM task types. The correlation between overall PM score and EFT was .274, $p = .002$, for the young adults, and .278, $p = .002$, for the older adults. Thus, there were significant, modest correlations between EFT ability and overall PM score, indicating that better episodic future thinking was associated with better PM performance for both young and older adults. (For the interested reader, correlations between EFT and each separate PM task type are reported in the Appendix, generally showing similar modest correlations for most task types for each group.)

Table 2 shows intercorrelations between all variables. To test whether the EFT–PM associations reflect a unique contribution of EFT to PM, hierarchical multiple regression analyses were conducted. The regression analyses were run for the young and older adult groups separately (see Table 3). Age and verbal intelligence were entered at Step 1 in the analyses, retrospective memory at Step 2, and EFT at Step 3.

The results of the regression analysis for the young adults showed that EFT accounted for a significant amount of variance (4%) in overall PM score, over and above that accounted for by the other predictors. Retrospective memory was the only other significant contributor, with better retrospective memory associated with better PM performance. It accounted for a larger proportion of the variance in PM (32%) than EFT. The predictors together accounted for a substantial amount of variance (37%). In the regression analysis for the older adults, age and retrospective memory were significant predictors, with increasing age and poorer retrospective memory associated with poorer PM performance. These variables uniquely accounted for 13% and 12% of the variance, respectively, in overall PM score. EFT, however, did not contribute any additional variance. For the older adults, the predictors together also accounted for substantial variance (28%) in PM.[3]

[3]To test for a nonlinear relation between EFT and PM, regression analyses were re-run to include both linear and quadratic EFT terms. The nonlinear effect did not account for a significant amount of unique variance in PM beyond the linear effect for either group: R^2 change young, $F(1, 119) = 3.05$, $p = .083$; old, $F(1, 119) = 3.05$, $p < .001$.

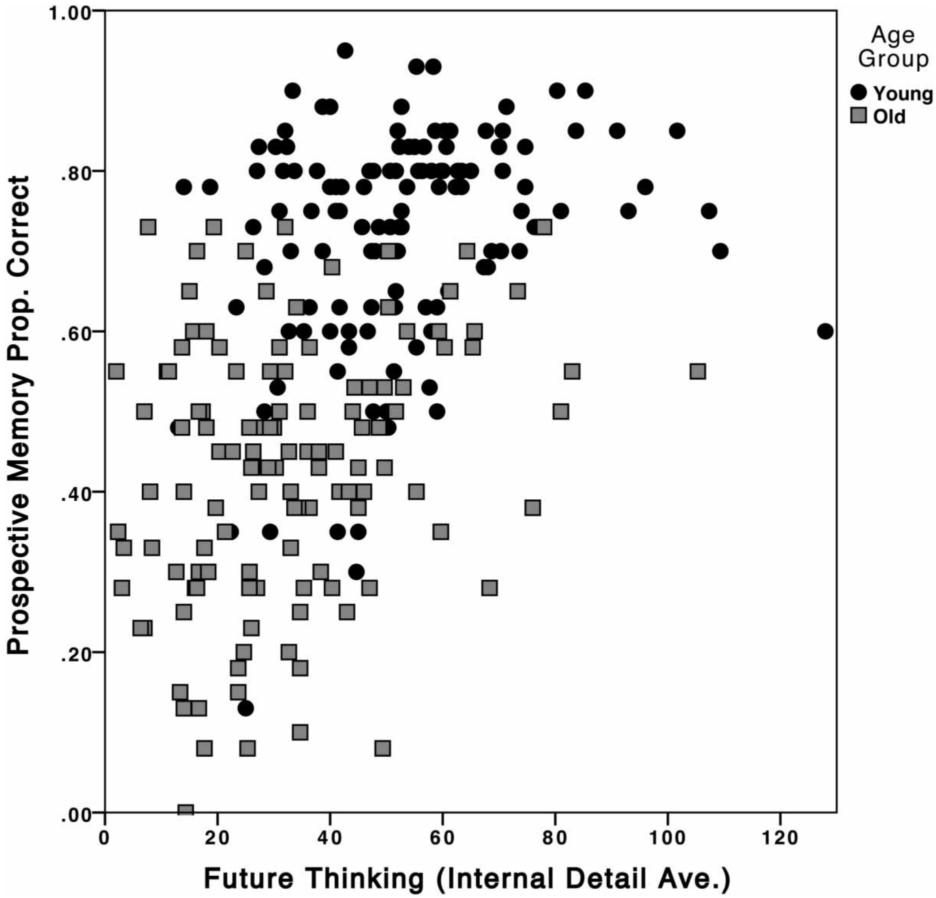

Figure 1. *Scatterplot of the relationship between episodic future thinking (EFT) and prospective memory (PM) for young and older adults.*

Table 2. *Pearson product–moment correlations for the two groups*

Measure	*1*	*2*	*3*	*4*	*5*	*6*
1. PM (Total)	—	.14	−.36***	.35***	.44***	.28**
2. IQ (Verbal)	.13	—	.05	.41***	.44***	.06
3. Age	.04	.33***	—	−.10	−.20*	−.28**
4. ACE–R (total)				—	.40***	.24**
5. Post VW recall	.57***	.10	−.03		—	.30**
6. EFT	.27**	−.02	−.05		.16	—

Note: EFT = episodic future thinking; PM = prospective memory; ACE–R = Addenbrooke's Cognitive Examination Revised; VW = Virtual Week. Intercorrelations for the older adult group ($n = 125$) are presented above the diagonal, and intercorrelations for younger adult group ($n = 125$) are presented below the diagonal. EFT: $n = 121$ for older adult group. ACE–R test was not administered to the younger adult group.
*$p < .05$. **$p < .01$. ***$p < .001$.

It should be noted that the retrospective memory variable in these analyses was the score on the recall task in Virtual Week (VW). Past internal details on the AI was another option as a measure of retrospective memory, but given that the regression analyses focused on the prediction of PM performance, memory for the content of the PM tasks provided a more methodologically rigorous test of the extent to which retrospective memory contributes to PM. Nevertheless, we did re-run the regression analyses substituting the past internal details score for the VW retrospective memory score. The pattern of results for the two age groups in relation to all other predictors in their respective models remained unchanged, including the continued significant contribution of EFT to PM for the young adults ($p = .010$) but not for the older adults ($p = .345$). Past internal details, however, did not account for significant variance in PM for either group. This is in contrast to the significant variance accounted for by the VW retrospective memory variable in the original regression analyses for both groups. We also re-ran the regression analyses adding past internal details to the original set of predictors (i.e., including VW retrospective memory). Again, the pattern of results did not change, and past internal details did not account for a significant amount of variance in PM for either young or older adults ($p = .640$, $p = .421$, respectively).

Discussion

The current study represents the first empirical assessment of the relationship between EFT and PM in an adult cohort. As predicted, a significant positive relationship was found between EFT and PM in both young and older adults. However, of particular importance here was the finding that EFT remained a significant contributor to young adults' PM even after accounting for the variance attributable to individual differences in age, general cognitive ability, and, of particular note, retrospective memory, which was the only other significant predictor in the regression model for the younger age group. The present results are consistent with the findings of Nigro et al. (2013), who reported a positive correlation between EFT and PM in middle childhood, and indeed extends them by showing that this relationship is not simply a reflection of shared variance with other variables, in particular retrospective memory. Although meaningful comparisons between these two studies are somewhat limited by the use of different developmental cohorts, measures, and methods, the findings of the current study are important in providing additional evidence that level of EFT ability predicts PM performance. While conclusions about the exact nature of the relationship between EFT and PM are beyond the scope of the current study, there are a number of possibilities that may be considered. For example, these findings support the claim that EFT might support encoding of the content of the PM intention during the intention formation stage (e.g., Brewer & Marsh, 2010; Schnitzspahn & Kliegel, 2009). In particular, EFT may contribute to PM performance by introducing a *preinstatement* of the context that will be encountered at the moment at which the intended action is to be retrieved and performed. These findings are also consistent with studies highlighting the effectiveness of encoding strategies such as implementation intentions, which involve episodic future simulation, in improving PM (e.g., Brewer & Marsh, 2010). The significant contributions of retrospective memory and EFT to PM also fit with evidence of shared neural substrates supporting all three of these cognitive processes (Addis et al., 2007).

The results for the older adults revealed the expected age-related reduction in both EFT and PM, as well as the hypothesized positive relationship between these two constructs. However, we also investigated whether EFT would make a unique contribution to PM in this age group. Interestingly, despite the significant bivariate correlation between them, the regression model showed that EFT did not explain unique variance in PM over and above that attributable to individual differences in age, general cognitive ability, and retrospective memory. More specifically, while for older adults PM was significantly associated with increasing age and poorer retrospective memory, individual differences in EFT did not additionally

Table 3. *Hierarchical multiple regression analyses predicting prospective memory from episodic future thinking, after controlling for age, verbal IQ, and retrospective memory, for young and older adults separately*

	Young (n = *125)*			*Old* (n = *121*[a])		
Predictor	ΔR^2	B	β	ΔR^2	B	β
Step 1	.02			.15***		
Age		0.00	.04		−0.01	−.26**
Verbal IQ		0.00	.07		0.00	−.02
Step 2	.32***			.12***		
Retrospective memory		0.21	.53***		0.20	.37***
Step 3	.04*			.01		
Episodic future thinking		0.00	.19*		0.00	.10
Total R^2	.37			.28		

Note: Adjusted R^2 for young = .35, old = .25.

[a]Four older adult participants did not perform the episodic future thinking (EFT) task.

*$p < .05$. **$p < .01$. ***$p < .001$.

explain PM performance. Thus it appears that the determinants of PM performance may change as we move into older adulthood. One possible explanation for this pattern of results may be that the well-established age-related reduction in attentional resources (see Craik & Rose, 2012, for a review) reduces the capacity of older adults to efficiently utilize both EFT and retrospective memory when performing PM tasks. Alternatively, it may be that the age-related deficits in both of these abilities lead older adults to use other strategies (possibly more externally based "bottom-up strategies" rather than "top-down", self-initiated cognitive strategies) to support their PM task performance. In both scenarios, the end result would be a weakening of the relationship between retrospective memory and PM and between EFT and PM. While these possibilities are of course speculative and await further empirical investigation, they are conceptually consistent with the literature addressing age-related changes in memory encoding, which not only highlights the deterioration with age in the neurological underpinnings of a range of cognitive processes resulting in a reduction in available processing resources, but also reports evidence of compensatory mechanisms occurring at both the neural and behavioural level in older adults when performing memory tasks (see Craik & Rose, 2012, for a review).

Strengths, limitations, and future directions

The current study used well-validated measures (AI and Virtual Week) to comprehensively assess two types of future-oriented cognition, EFT and PM, respectively. Furthermore, the sample size was substantial and allowed for analyses to address the relationship between individual differences in EFT and PM. However, the measure of EFT assessed only the phenomenological quality of future-directed thoughts. Given that PM involves remembering to carry out future intentions, one possible avenue for future research may be to consider behaviourally based measures of episodic future thinking such as the recently developed episodic foresight version of Virtual Week (Lyons et al., 2014), which taps the capacity to imagine the future and take steps in the present in anticipation of future needs. Conceptualizing EFT in this way in future studies may reveal even closer links to PM as a result of its contribution to the development of episodic plans (Atance & O'Neil, 2001), which impact how we initially choose, or develop, a mnemonic (a rehearsed, script-like plan) that will allow us to remember our intended action in the future. Furthermore, the inclusion of a measure of semantic future thinking would also be beneficial in future studies assessing the contribution of EFT to PM in order to tease out the extent to which an individual's ability to preexperience the future (EFT) contributes to PM over and above their ability to simply imagine some future state of the world. While the current study did have a measure of external details generated on the AI, which includes semantic details, it is severely limited as a measure of semantic future thinking. This is because participants are explicitly instructed and prompted to provide episodic rather than semantic details when completing the AI. Furthermore, in addition to semantic details, external details also include repetitions and information about events that are not specific in time and place (Addis et al., 2008). Finally, while the measure of PM used in the current study reflected a range of common PM tasks, assessing PM in everyday life where older adults can compensate for PM decline would also be valuable. Given the current findings for young adults, in addition to the initial positive correlation between EFT and PM among older adults, it is possible that EFT might account for unique variance in the PM performance of older adults in their everyday lives.

Conclusion

Overall, these data add to growing evidence for links between EFT and PM but, importantly, the results highlight that this relationship may vary with age across adulthood. As this is the first study assessing the contribution of EFT to PM in young and older adults, these findings require replication, but, nevertheless, they provide important information to help understand how the processes underlying PM may change as we age.

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APPENDIX

Pearson product–moment correlations between EFT and PM task types for the two groups

	PM task type			
Group	*Regular event*	*Irregular event*	*Regular time*	*Irregular time*
Young adults				
EFT	.24**	.20*	.10	.31**
Older adults				
EFT	.29**	.07	.17†	.21*

Note: EFT = episodic future thinking; PM = prospective memory. Young adult group, $n = 125$; older adult group, $n = 121$.
*$p < .05$. **$p < .01$. †$p = .062$.