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The Effects of Aging on Remembering Intentions: Performance on a Simulated Shopping Task

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SUMMARY

Three studies are described in which age differences on a task measuring memory for delayed intentions using naturalistic stimuli were examined. A simulated street scene was constructed from a network of photographs and sounds that participants could move through using a touch screen while completing a series of event-based shopping errand instructions. The objective of the research was to identify the cognitive processes involved in the task that were vulnerable to the effects of ageing. Memory search but not cue detection was specifically affected in older persons when participants were given fewer trials to learn the instructions. There was no age specific effect on cue detection or memory search in either an unfamiliar street or one with increased levels of irrelevant visual and auditory noise. Cue detection but not memory search was disproportionately affected in older persons after filled interruptions, suggesting that the capacity for self-initiated reinstatement of working memory is reduced in old age. In general, using a computer-based simulation of a real-life task was found to be a practical means of examining the effects on behaviour and cognition of task parameters that are significant in assessing everyday memory abilities. Copyright © 2006 John Wiley & Sons, Ltd.

In everyday life, it is often necessary to call to mind delayed intentions. One such situation is remembering to complete a task such as 'buying bread on the way home when you pass the grocery' (McDaniel & Einstein, 2000, p. S128), often referred to as prospective memory. This task has some interesting features. It requires that an intention is generated or an instruction encoded, and that while completing an ongoing task (driving home), the grocery store is noticed, the drive interrupted, and the bread purchased. It is, however, a common experience to arrive home without the bread. Of interest are the conditions under which such forgetting is most likely to occur and reasons for individual differences in performance, for example, personality factors or, as in the present study, the effects of ageing (Huppert, Johnson, & Nickerson, 2000).

One of the attractions of studying memory for future intentions is its direct relevance to the activities of everyday life. For example, deficits in the ability to complete future intentions as a result of traumatic brain injury or disease have serious implications for continued independent functioning (Alderman, Burgess, Knight, & Henman, 2003; Cockburn, 1995; Knight, Harnett, & Titov, 2005; McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999; Shallice & Burgess, 1991). Studying the recall of intentions in the real

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world is challenging for a variety of practical reasons, however, including the manifold problems involved in standardising procedures outside the laboratory or the clinic. Driving home, for example, is more or less demanding depending on the time of day, the weather, and the day of the week. For this reason most of the research into how delayed intentions are recalled has been conducted in the laboratory setting, using computer-based tasks and a high level of experimental control. Many such laboratory tasks, however, have limited ecological validity and as a consequence, the findings are difficult to apply to real-life situations. An important objective of the present research was to determine if it is possible to bridge the gap between behavioural tests conducted in the real world and experimental memory tasks, by employing a laboratory-based procedure that simulated a real-life task.

One area where the use of practical tasks with enhanced ecological validity is likely to be of interest is in the study of the effects of old age on memory. There are several significant differences between laboratory-based and everyday memory tasks, some of which may serve to ameliorate the effects of ageing on memory for delayed intentions, while others may accentuate any decline in abilities. Most obviously the semantic stimuli often used in laboratory tasks lack the naturalistic visual and auditory complexity of the real world. Furthermore, many computer-based laboratory tasks require the participant to focus their attention on a computer screen and there are none of the unpredictable distractions that would occur in the real world, which may impair the older person's performance. On the other hand, many everyday memory tasks have a spatial or physical dimension that links the stimuli in a meaningful way, which may aid recall. That is, rather than the stimuli being presented in a series of random occurrences, the natural environment is often a familiar and ordered setting, making it possible to anticipate the occurrence of a particular target event and to plan ahead. Thus the familiarity of naturalistic stimuli and tasks may minimize the difference between older and younger participants, and explain why one situation where older persons typically outperform their younger counterparts is on naturalistic tasks attempted outside the laboratory (e.g. Rendell & Craik, 2002; Rendell & Thomson, 1999). In addition, in everyday life it is possible to compensate for difficulty in remembering by slowing the rate at which stimuli occur, that is, to trade off speed against improved accuracy. Older persons may well use the strategy of adjusting the speed of occurrence of input to a level where they feel comfortable to enhance recall.

The effect of old age on memory for intentions has been studied extensively using prospective memory paradigms. A recent meta-analytic review (Henry, McLeod, Phillips, & Crawford, 2004) comparing the performance of older and younger persons has confirmed that prospective remembering is impaired in old age and that this is particularly evident on tasks that required effortful or strategic processing. In their review of prospective memory studies, Henry, MacLeod, Phillips, & Crawford (2004) found that tasks with high strategic and effortful processing demands produced an average age-related effect size of -0.40, whereas the effect size was -0.14 for those tasks that were relatively more automatic. This is consistent with findings that older persons are specifically impaired on memory and attentional tasks that rely on effortful, conscious or controlled processing (Craik, 1986; Jennings & Jacoby, 1993, 1997; Light, Prull, La Voie, & Healey, 2000; Titov & Knight, 1997), relative to their performance on tasks dependant on relatively automatic abilities. Interestingly, however, Henry et al. (2004), found that older groups were superior to younger groups on naturalistic time-based tasks (Effect size $= 0.52$), despite showing a decline (Effect size $= -0.39$) on laboratory-based tasks. This result implies that although younger persons may have superior memory skills, older persons can do better on

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naturalistic tasks where they may be more motivated to succeed and have more time to focus on the intention to be remembered.

Accordingly, we were interested in how older participants would perform on a memory task using naturalistic stimuli and the familiar activity of completing shopping errands, which they could perform at their own pace. The shopping scenario was chosen because both older and younger participants are likely to have substantial experience with shopping and the task lends itself to administration under controlled laboratory conditions. Our task involved recall of a number of distinct intentions ('Buy a belt at K-Mart') in a situation where the completion of the errands provided by the experimenter was the only task given to the participants. In this case, we would not argue that our paradigm necessarily lies in the domain of prospective memory research. In a prospective remembering task the targets are embedded in a sequence of stimuli that, because of their relevance to an ongoing task, cannot be ignored (Einstein & McDaniel, 1996; Kvavilashvili, 1987; McDaniel, Robinson-Riegler, & Einstein, 1998). Although it could be argued that the distractions and interruptions that occur on a shopping trip, such as moving in and out of shops and interacting with shop assistants while ignoring irrelevant stimuli, constitute an ongoing task, the task of initially identifying shops as cues is better described as requiring vigilance and recognition in the face of distraction.

It should be noted that classifying a practical task in a way that allows connections with experimental research is not always simple. Part of the problem is that many everyday tasks do not fit neatly into a laboratory paradigm, and vice versa. It is possible to render a shopping trip into an unequivocal prospective remembering task, for example, by having participants make a rating of the aesthetic qualities of each shop as they pass (the ongoing task), and have the shopping errands (the prospective component) designated as secondary to this task. This is, however, a way of making a real life situation conform to a laboratory procedure. It may therefore be more informative to examine age differences in forgetting intentions on a shopping trip by constructing a task that has the features of what really happens.

The computer-presented environment for the shopping trip used in the present investigation was created by networking a series of photographs, taken in a shopping precinct, in a way that allowed participants to move about and complete errands at appropriate locations, using a touchscreen. This procedure allows the standardisation and manipulation of the conditions under which the task is completed; for example, the amount of distraction can be increased by attaching sound or moving figures to the photographs, or the environment reshaped to make it more or less familiar. The construction of a computer-based street was an attempt to blend laboratory and real world paradigms, and to create a task that would engage the interest of both older and younger participants. At the outset it must be acknowledged that this novel method of assessing memory for intentions has limitations. In particular the presentation on a touch screen concentrates focus on relevant stimuli in ways that differ from real life and moving about by touching buttons on a navigation bar is quite a different ongoing task from the physical activity of walking in a crowded street. Another limitation is that the task occupies a relatively short time frame whereas for many real-life tasks, the intention to act is delayed over hours or days. Nonetheless the street environment offers an interesting opportunity to study real life behaviour in an analogue situation and to determine whether experimental findings generalise to more naturalistic settings.

In the studies reported in this article, we examined three aspects of this task that we hypothesised to be sensitive to age, the opportunity to learn the instructions, the familiarity

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of the shopping environment, and the presence of distractions. In each study we assumed a basic distinction between the process of recognising a cue, which relies on attentional and recognition processes, and recalling the associated action, which relies on self-initiated memory search (Einstein & McDaniel, 1996; McDaniel & Einstein, 2000). In doing so we were expecting that some manipulations would impact on the cue detection component (e.g. recognising cues in an unfamiliar environment), while others (e.g. strength of initial learning) would impact on the memory search processes. This distinction between the processes involved in cue recognition and task recall has been supported by electrophysiological and behavioural data from studies by West and colleagues (Cohen, West, & Craik, 2001; West, Herdon, & Covell, 2003). Throughout the research, we sought to keep the procedure within a range where older persons would not be daunted by the experimental expectations. For this reason, the number of instructions and the length of testing sessions were kept at a reasonable level; although this was likely to produce ceiling effects for younger participants, it ensured the motivation of the older groups, and made it more likely that they would perform in a manner similar to the way they would respond in everyday life.

STUDY 1

One reason why older persons have difficulty on delayed intention tasks is that they have reduced capacity to make effortful searches through memory (Einstein, Smith, McDaniel, & Shaw, 1997; Light et al., 2000; McDermott & Knight, 2004). This parallels the common experience of everyday memory failure that older persons report of going to another room to do something, but forgetting what it was. Although the ability to recognise a cue may be relatively preserved, retrieval of the associated action is impaired. Cue detection in a shopping environment is typically experienced as a relatively automatic activity; the salient cue stands out as familiar as soon as it is seen. For example, participants in our experiments sometimes report that they do not move along the street actively rehearsing instructions because years of experience with shopping tasks has taught them that if they see the cue, its significance will come to mind automatically. In contrast, recall of the action under some (but not all) circumstances requires more effortful processing. As noted previously, however, categorisation of memory search as controlled processing and contrasting it with noticing, a more automatic process, is overly simplistic. Because some cues and actions are highly associated, memory search is sometimes relatively automatic (Buy a coffee at Starbucks); others are less strongly associated (Buy a street map at Barnes and Noble) and necessitate conscious recollection. The same situation applies to cue detection. Sometimes a cue is identified without conscious awareness; on other occasions it can only be detected by a process of strategic search.

In the present study we were interested to determine whether the typical finding that the more effortful retrospective recall process is more greatly affected by age than recognition of cues (e.g. Henry et al., 2004), applies to a situation where naturalistic stimuli were used and movement along the street was under the participants' control. It is possible that when older persons are able to move at their own pace, and to enter shops and to use any other available cues to prompt recall, as would happen in real life, their memory performance may be comparable to that of the younger group. This possibility is consistent with the findings of Smith (2003) and Smith & Bayen (2004) that the combination of prospective remembering and ongoing tasks in a prospective memory procedure is analogous to a

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dual-task paradigm, where each task affects the other. The ability to control the ongoing activity, in this case being able to move more slowly down the street, may compensate for the reduced ability of the older group to complete prospective tasks. In order to examine the relative effortfulness of the cue detection and memory search components of the task, the opportunity to learn the list of cues and associated actions was manipulated by having either one or three learning trials. In this situation the greater opportunity to rehearse the instructions makes it more likely that the intention associated with the cue will be recalled (Guynn, McDaniel, & Einstein, 2001). It was hypothesised that when the performance of younger and older participants was compared, the reduced opportunity to encode the association between cue and action in the 1-Trial condition would have a disproportionate negative effect for the older participants on the more effortful process of recalling actions relative to their ability to recognise cues.

Method

Participants
Forty older persons (25 females and 15 males) took part in this study. All were members of the Otago Memory Research Volunteer panel, a group of around 100 persons aged between 61 and 80 years, recruited through local media and University Bulletins, to take part in studies of cognition in the elderly. All of the older group were living independently in the community, were leading active social lives, were able to travel independently to the testing session, and reported no history of psychiatric or neurological impairment at the time of the panel intake interview. Participants on the panel were selected to have comparable social and economic backgrounds to the students comprising the younger group. The 40 younger participants (20 male and 20 female) were undergraduate students enrolled at the University of Otago, who responded to advertisements to take part in the study in return for course credit or a modest payment ($10).

For the purposes of the study, participants were assigned to two groups ($n = 20$). Details of the age and years of education are given as part of Table 1. The adequacy of matching the

Table 1. Performance of the older and younger participants after one or three learning trials

	Older				Younger			
	3-Trials		1-Trial		3-Trials		1-Trial	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	66.65	4.80	66.00	4.81	21.60	2.98	21.70	2.62
SILS vocab	37.65	3.39	35.10	3.97	31.25	5.33	30.25	4.76
Years education	13.80	3.74	11.95	2.10	15.90	2.25	15.45	1.67
Correct								
P (Location)	0.87	0.10	0.79	0.11	0.92	0.09	0.84	0.10
P (Task | location)	0.55	0.15	0.30	0.17	0.67	0.15	0.53	0.13
Performance								
Time/page (secs)	4.76	0.76	5.39	1.14	3.67	0.48	3.72	0.57
Pages/location	13.63	1.07	14.64	1.12	13.42	0.85	14.04	0.76
Male: female	7: 13		8: 12		10: 10		10: 10	

Note: SILS = Shipley Institute of Living Scale.

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older and younger groups was assessed using the 40-item Vocabulary test from the Shipley Institute of Living Scale (SILS; Shipley, 1940). Scores on the SILS have been shown to increase with age (Harnish, Beatty, Nixon, & Parsons, 1994), therefore older participants were expected to obtain higher vocabulary scores than the younger group. As is apparent in Table 1, for each of the experimental conditions, the older groups had significantly higher SILS scores than the younger group (for the 1-Trial condition, $t(38) = 3.50$, $p < 0.005$ and for the 3-Trial condition, $t(38) = 5.33$, $p < 0.001$). There were no significant differences between the two older, and two younger groups in average age or years of education. All participants were residents of Dunedin and familiar with the shopping area used in the study.

Materials

Virtual street

The Virtual street computer procedure was designed to simulate the experience of walking along a shopping precinct and was created using a commercially available web-design package (Microsoft® FrontPage 2002). The programme is run through Internet Explorer®, and operated by an Apache web-server. The Virtual street is comprised of approximately 1500 photographs of the inside and outside of shops in the city of Dunedin (New Zealand), each of which may be linked to one of 50 different sounds to make a 'Page' (for further details see Titov & Knight, 2005). The sounds are appropriate to a street scene and include vehicle noises, music and snatches of conversation. The photographs were recorded using a digital camera and the sounds recorded using Goldwave computer audio recording software. A laptop with a 1000 MHz processor was used to project photographs on to a TFT LCD (Model number 710A) touch screen monitor (300 mm × 225 mm). Each Page appears on the touch screen as a photograph above a navigation bar, part of which contains left and right arrows, and a 'Forward' button, which participants use to 'walk along' the street. By touching the left arrow, for example, the Page that is displayed fades and is replaced by a Page showing the view approximately 30 degrees to the left. Similarly, the participant can move further along the street by pressing the Forward button, which accesses a Page showing a visual image taken approximately 2 m further ahead. By fading the photographs into each other with a 2-second delay, the illusion of 'walking' along the street is enhanced, and using discrete Pages makes it possible to monitor accurately the stimuli that participants see. Further, the speed with which they move along the street is under their control and can be recorded.

The section of street along which participants move contains 26 shop or business fronts, most but not all (it is not possible take photographs inside a bank) of which can be entered. The journey from one end of the street to the other directly requires pressing the Forward button 59 times (thus accessing 59 different pages). To turn 180 degrees the participant must press the same arrow button seven times thus accessing seven different pages, which seen in serial order provide the range of visual field observed when turning right around in real life. By touching the 'Enter Shop' button on the navigation bar, participants are able to enter and move about inside a shop. Once inside, the 'Enter Shop' changes to 'Exit Shop' and an 'Approach Counter' button appears on the navigation bar. Thus, memory for intentions can be tested by instructing participants to complete a task such as 'purchase a coffee at Subway'. Once they correctly enter Subway, they can press the 'Approach Counter' button to access a Page that includes a visual image of a shop assistant, who greets

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them and asks what they would like. In response to this auditory cue, participants are expected to recall the instruction aloud and the experimenter records their response. They can then leave the shop using the Exit Shop button. Moving from the door of the shop to the counter directly requires accessing five Pages and exiting the shop requires accessing two Pages. Once the test is completed, data are extracted from the web-server to provide a detailed record of the participants' activities, including the number of Pages accessed and time taken to complete each errand.

Memory for intentions task. Participants were asked to complete 14 event-based instructions, each of which consisted of two components, the action (e.g. 'Buy a bottle of wine') and the location where the task was to be completed (e.g. . . . at the B. Bottle Store). In order to vary the nature of the actions to be completed, different types of instructions were used. Some required the participant to remember to make a purchase ('Buy' items), while others required some other interaction with the shop assistant (e.g. 'Enquire about the price of . . .'). A list of instructions is provided in the Appendix (DN version, List A).

Procedure

After providing informed consent, participants learned how to use the navigation bar on a segment of the street not used in the experiment. The training involved learning first to move down the street, and then to manoeuvre within a shop. The participants' competence was then tested by instructing them to complete three practice errands. All participants completed the training successfully within 10 minutes. They then completed the experimental procedure in one of two experimental conditions. In each case they were told they would have a list of 14 instructions to remember to carry out in a street like the one they had practiced in. They were instructed that they were only to enter those businesses or shops where they had a task to complete. In the first condition, participants were given the list of errands and asked to read them aloud three times. The list was presented in a different random order for each participant. In the second condition the same procedure was used, but participants read the list through only once. All participants were then placed at the northern end of the street, facing south. They were instructed that they were to complete as many of the instructions as they could remember while walking to the southern end. They were told that they should only move forward and could not retrace their steps.

Participants completed the experiment sitting a comfortable distance from the touch screen, with the experimenter positioned alongside monitoring the task from another computer display. The experimenter recorded all the participants' verbal responses. On occasion, participant became disoriented (e.g. turning the wrong way when coming out of a shop); when this happened they were assisted by the experimenter to continue the task. The experimental phase lasted no more than 20 minutes and ended when participants reached the southern end of the street. They then completed the SILS and were thanked for their participation.

Results

For each participant, the probability of correctly identifying a cue for action was expressed as the proportion of the total number of cues to be detected ($n = 14$). It should be noted that it is possible to obtain a perfect score on this variable by indiscriminately entering every

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shop. Participants were instructed not to do this and no person in any of the studies adopted this strategy. Although shops were occasionally entered that were not designated in the instructions, these confusions were typically understandable (e.g. entering the wrong travel shop to purchase airline tickets). Task recall was counted as correct if the participant entered the correct shop and correctly reported the action (e.g. 'Buy') and the object (e.g. 'Hamburger'). The number of tasks correct was then determined and expressed as a proportion of the number of cues noticed. This procedure was adopted because recognition of a cue is a necessary precursor of correct recollection of the action. Means and standard deviations for the probability correct data are given in Table 1. These data were analysed with a 3-factor analysis of variance (ANOVA) where Age (Younger vs. Older) and Learning Trial (1 vs. 3) were the between-subjects factors, and task component (Cues vs. Tasks) was a repeated measure. There were significant main effects for Age, $F(1,76) = 21.87$, $MSE = 0.02$, $p < 0.001$, Learning Trial, $F(1,76) = 37.34$, $MSE = 0.02$, $p < 0.001$, and Component, $F(1,76) = 442.66$, $MSE = 0.01$, $p < 0.001$. The Learning trial × Component interaction was also significant, $F(1,76) = 12.15$, $MSE = 0.01$, $p < 0.001$. This interaction is apparent in Table 1, where the proportion of correct task recall was significantly more affected by the reduction in opportunity to learn than the probability of detecting cues. The Component × Age interaction was also significant, $F(1,76) = 14.58$, $MSE = 0.01$, $p < 0.001$. As can be seen in Table 1, under both Learning Trial conditions, although the Older and Younger groups did not differ in cues noticed, they did differ in proportion of tasks recalled. The means in Table 1 suggest this effect was greater in the 1-Trial than in the 3-Trial condition, and this is reflected in the Age × Learning Trial × Component interaction, which approached significance, $F(1,76) = 2.93$, $MSE = 0.01$, $p < 0.09$.

The 3-way interaction was explored further by conducting separate 2-factor (Age × Component) ANOVAs for the 1-Trial and 3-Trial data. For both analyses, as expected, the Age and Component main effects were significant. Of more interest, however, were the Age × Component interactions. This interaction was not significant for the 3-Trial condition, $F(1,38) = 2.14$, $MSE = 0.01$, $p = 0.15$, but was significant for the 1-Trial condition, $F(1,38) = 15.89$, $MSE = 0.01$, $p < 0.001$. Overall, these findings suggest that on the virtual street task, the older participants have disproportionately more difficulty recollecting tasks than detecting cues, relative to the younger group. Furthermore, if the opportunity to learn the instructions is reduced, recollection is more affected in the older than in the younger group.

The mean time to walk down the street averaged across conditions was 13.78 minutes ($SD = 2.81$) for the older group and 10.37 minutes ($SD = 1.72$) for the younger group. For each participant, time/Page was computed by dividing the total time by the number of Pages accessed (Table 1). A 2-factor ANOVA (Learning Trial × Age) ANOVA was conducted on the data in Table 1. The only significant effect was for Age, where the older persons spent longer viewing each page ($M = 5.07$, $SD = 1.00$) than the younger group ($M = 3.70$, $SD = 0.52$), $F(1,76) = 62.69$, $MSE = 0.06$, $p < 0.001$. Participants were not slower in the 3-Trial condition, $F(1,76) = 3.76$, $MSE = 0.06$, and there was no significant Age × Learning Trial interaction, $F(1,76) = 2.68$, $MSE = 0.06$. The number of Pages accessed averaged across conditions was comparable for the older ($M = 163.25$, $SD = 14.27$) and younger ($M = 168.25$, $SD = 13.34$) groups. Because this measure was likely to be affected by the number of correct locations detected and shops entered, Page/correct location was computed for each participant. These data (Table 1) were also analysed with a 2-factor Learning trial × Age ANOVA. There was a significant difference

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between the 1-Trial ($M = 14.34$, $SD = 0.99$) and the 3-Trial ($M = 13.52$, $SD = 0.96$) conditions, $F(1,76) = 14.47$, $MSE = 0.93$, $p < 0.001$. Overall, both groups were more efficient when they had three learning trials. No other effects were significant.

Discussion

The most significant finding in the present task was the dissociation between detecting cues and self-initiating recall as a function of age. The older and younger groups did not differ in their ability to detect cues in the two learning conditions but the older group were less likely than the younger group to recall the correct action associated with the location cue. Furthermore, the older participants were significantly more affected than the younger group when they had only one opportunity to learn the list. In the 1-Trial condition, the association between cue and action was weaker than in the 3-Trial condition because of the reduced opportunity for encoding, making self-initiated memory search more difficult. Under those circumstances the specific difficulty that older people have in correctly remembering the action that follows detecting the cue was exacerbated. The between-group differences are consistent with the view that recognising a cue in the street is a relatively automatic task, whereas bringing the correct action to mind is a more effortful process, especially when the memory traces are weak (Einstein & McDaniel, 1996).

The equivalence of the probability of correct task recall for the older group after three trials ($M = 0.55$) with that of the younger group after one trial ($M = 0.53$) provides an index of the superiority of memory recall in younger persons, and also suggests that with an enhanced opportunity to learn the instructions, older persons can perform as well as the younger group. It should be noted that this finding pertains to a list of 14 instructions, which was sufficient to reveal individual differences between participants, but was probably a larger number than would normally be attempted in real life. In general the number of Pages the older and younger groups accessed were similar but the older persons tended to be about 3 or 4 minutes slower moving along the street. The older persons spent more time per Page but this was not affected by the experimental manipulation, that is they did not slow more in the 1-Trial condition, to compensate for the greater difficulty recalling tasks.

STUDY 2

The aim of the second study was to determine whether recognising cues in an unfamiliar environment is more difficult for older than younger persons. There is little in the way of previous research to guide the formulation of hypotheses about how aging effects vigilance and remembering in unfamiliar naturalistic environments. Familiarity with a cue, or the environment within which the cue is set, however, may have an impact on the processes used in cue detection. Two consequences of being instructed to recognise cues in an unfamiliar environment are possible. One is that an unfamiliar cue may be more difficult to detect because the stimulus features are unknown or difficult to encode precisely and so the process of monitoring the environment is more effortful. For example, a person living in England, expecting post boxes to be red might be able to detect the familiar sight of a red pillar-box in London automatically. The same person searching for a place to post a letter in the United States, where the colour of the box is an unfamiliar blue, may need to more

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consciously monitor the street environment. Further, it is possible that the familiar order in which shops appear in a street scene will facilitate the automatic detection of cues. If we expect a shop to appear after a particular cue has appeared this may enhance the automatic switching of attention to a relevant cue. It is therefore possible that instructions based on a location in the virtual street that are unfamiliar or located in a different order to that in a familiar environment will be more difficult to detect without a more controlled search process. An alternative possibility is that an unfamiliar target will be easier to detect than a familiar one because the only salient association the participant has with cue is the instruction they have been given before they entered the street. In an unfamiliar environment the instruction given is the only reason for a target to stand out as significant in the testing context. In line with this explanation, unfamiliar words have been found to produce more reliable prospective remembering than familiar ones (Einstein & McDaniel, 1990; McDaniel & Einstein, 1993).

The primary aim of Study 2 was to determine whether operating in an unfamiliar environment would disproportionately either reduce the number cues detected by the older group or slow their movement down the street. To this end, two versions of the street were constructed, one based on a familiar main street in the participants' city of residence, the other a similar street from an unfamiliar city. The street in the unfamiliar city was different from the familiar street primarily in the order in which different types of businesses and shops along the street appeared, and the names and signage of many of the shops. In other respects the two locations were chosen to be similar in that the density and mix of shops and other businesses was the same and some chains of stores were represented in both streets (e.g. banks). The two cities from which the streets were chosen are of approximately the same size and have similar downtown shopping precincts.

We were also interested in comparing older and younger persons' estimation of the number of instructions they were likely to remember. The issue of self-awareness of memory capacity has not been systematically examined in relation to memory for delayed intentions, although the ability to judge what it is possible to remember has been studied in retrospective recall (the feeling-of-knowing phenomenon; Nelson, 1984). In everyday life the accurate perception of cognitive abilities is important in determining the approach that is taken to planning to remember. There is a point when shopping, for example, where it is no longer possible to rely on unaided memory, and it is necessary to make a list. In a similar study using naturalistic videotaped stimuli, persons with traumatic brain injury were found to overestimate how many instructions they would be able to recall relative to a group of matched controls (Knight et al., 2005). The implication of this is that part of the rehabilitative process in adjusting to an acute injury is learning new limits of performance. It would be expected that older persons, who have experienced a slow and gradual decline in cognitive ability unlike persons with brain injury, would have a more realistic appreciation of what they are likely to remember.

Method

Participants

The older group was composed of 30 persons recruited from the participant panel as in Study 1. No participants took part in both studies. The younger group comprised 30 undergraduates who participated either for course credit or a modest payment ($10). Data

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from one older participant were excluded when it was learned she had lived in close proximity to the unfamiliar city, and from one younger participant due to a computer malfunction. The older group (19 females, 10 males) had an average age of 68.83 ($SD = 5.50$) years, and had a mean score of 37.72 ($SD = 2.15$) correct on the SILS vocabulary scale. The younger group had an average age of 21.62 ($SD = 3.51$) and mean vocabulary score of 31.48 ($SD = 3.51$) correct. The older groups' vocabulary scores were significantly higher, $t(56) = 8.16$, $p < 0.001$, than those of the younger group. All participants were residents of Dunedin and rated their familiarity with the central shopping area between 1 and 4 on a 9-point familiarity scale (1 = very familiar). No participant reported being familiar with the city of Palmerston North.

Measures

Virtual street. In this study performance on the two versions of the virtual street were compared. The first was the version used in Study 1, which was set in the main street of Dunedin (DN). The second was set in a main shopping street in central Palmerston North (PN), a city located 1000 km to the north, on the other main island of New Zealand. Both cities are comparable in size and population, and have similar downtown shopping precincts. As with the DN version, about 1500 photographs were taken inside and outside the PN shops, linked with sounds, and networked together. The new version used the same navigation bar and general procedure for moving about the street as was described in Study 1. The lengths of the two streets in terms of the number of Pages linking one end of the street with the other were equivalent (i.e. it was possible to move one end to the other by pressing the Forward button 59 times). Approximately the same number and types of shops were seen on each version.

Memory for intentions test. To allow for the repeated testing of participants on the two versions of the test, two different lists of instructions (A and B) were constructed, which were designed to be of comparable difficulty. Extensive pilot testing of the groups of items was conducted to ensure equivalence. Because each version of street contained different shops, a DN and PN version of each list was constructed using the shops in each setting. The DN versions of the test are given in the Appendix.

Procedure

Participants were tested individually in two sessions spaced between 7 and 10 days apart. The general procedure was similar to Study 1. The participants first completed a practice session during which they learned to move around a separate segment of the street and demonstrated their competence in using the touch screen by completing the list of three practice errands. The method of administering the study list of errands, however, changed from Study 1. A modified selective reminding procedure was used in order to equalize learning for the two groups. On Trial 1 of the learning procedure, the experimenter read aloud each instruction on a written list, and then gave the list to the participants and asked them to read each instruction aloud. After they read each item, they were asked to say how likely they were to remember the instruction in the virtual street, using a 4-point scale (1 = very likely, 2 = likely, 3 = unlikely, 4 = very unlikely). To assist them to do this, a written version of the rating scale was placed in front of them. When this was completed, the experimenter took back the written list, and administered a cued recall test, using the

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location as the cue for each item, to test memory for the action. Each instruction was tested by asking 'What were you asked to do at . . .?'. On Trial 2, each of the instructions that participants could not correctly recall in response to the cue on Trial 1 were read aloud by the experimenter, who then tested these items using the same cued recall method as for the preceding trial. On Trial 3, any instructions not recalled on Trial 2 were repeated and learning tested.

Participants in each age group were alternately assigned to either the familiar or unfamiliar version of the street in the first session. Administration of List A or B was counterbalanced within each group. They then returned 7 to 10 days later to complete the alternative version of the test. The procedure used was the same as in the first session, except that there was no practice session.

Results

Means and standard deviations for the proportions of cues and tasks correct, calculated as for Study 1, are given in Table 2. A 3-factor ANOVA, with Age (Younger vs. Older) as a between subjects factor, and Familiarity (Unfamiliar vs. Familiar cities) and Component (Cues vs. Tasks) as repeated measures, was conducted on these data. There were significant Age, $F(1,56) = 39.21$, $MSE = 0.01$, $p < 0.001$, and Component $F(1,56) = 59.87$, $MSE = 0.46$, $p < 0.001$, main effects, but no effect of Familiarity, $F(1,56) = 0.21$, $MSE = 0.51$, $p = 0.65$. There was a significant Component $\times$ Group interaction, $F(1,56) = 10.56$, $MSE = 0.01$, $p < 0.002$, replicating the finding in Study 1 that older persons have more difficulty recalling actions than cues, relative to the younger group. No other interactions were significant.

The time/Page and Page/location data (Table 2) were analysed with separate 2-factor Age $\times$ Familiarity ANOVAs. There was a significant Age effect for time/Page, $F(1,56) = 19.11$, $MSE = 0.46$, $p < 0.001$, but no Familiarity effect, $F(1,56) < 1.00$, $MSE = 0.18$, and no interaction, $F(1,56) = 1.59$, $MSE = 0.18$. For Page/location, there was no Age effect, $F(1,56) < 1.00$, $MSE = 0.84$, and no significant interaction, $F(1,56) = 1.33$, $MSE = 0.43$. There was a trend towards a significant familiarity main

Table 2. Performance of the older and younger participants in the familiar and unfamiliar streets

	Older				Younger			
	Familiar		Unfamiliar		Familiar		Unfamiliar	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Correct Recall								
P (Location)	0.91	0.06	0.88	0.07	0.95	0.06	0.95	0.06
P (Task | location)	0.77	0.14	0.76	0.13	0.90	0.09	0.90	0.10
Performance								
Time/page (secs)	4.92	0.59	4.82	0.73	3.63	0.45	3.73	0.45
Page/location	13.72	0.55	14.12	1.02	13.79	0.77	13.89	0.79
Likeliness analysis								
Predicted recall	9.17	2.71	8.17	3.26	9.75	2.32	9.10	1.86
Actual recall	9.75	1.99	9.55	2.03	12.00	1.53	12.01	1.81

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effect, $F(1,56) = 3.94$, $MSE = 0.43$, $p = 0.052$, suggesting participants tended to be less efficient in their movements around the unfamiliar street.

The 4-point ratings of the predictions of recall of instructions were converted to a dichotomous (1 = Likely, 0 = Unlikely) scale, and for each participant the sum of the item rated 1, was aggregated (maximum = 14). The actual number of instructions recalled correctly (maximum = 14) was also calculated. Means and standard deviations for these variables are given in Table 2. These variables were entered into a 3-factor ANOVA with Age as the between subjects factor, and Familiarity and Recall (Predicted vs. Actual) as repeated measures. The Age effect was significant $F(1,56) = 17.17$, $MSE = 8.13$, $p < 0.001$, as was the Recall effect, $F(1,56) = 27.87$, $MSE = 6.56$, $p < 0.001$, and the Recall × Group interaction, $F(1,56) = 5.56$, $MSE = 6.56$, $p < 0.05$. The participants in both groups underestimated how much they would remember, but the younger groups' underestimation was greater than the older group (Table 2). There was a trend towards the participants predicting a poorer performance in the unfamiliar street, $F(1,56) = 3.12$, $MSE = 2.43$, $p = 0.08$.

Discussion

The primary outcome of Study 2 was that older persons were not affected by the unfamiliarity of the environment in which they were required to search. Neither their speed of movement nor their accuracy cue detection was adversely influenced by the novelty of the shopping environment. As in the previous study, the older group displayed poorer recall abilities and were disproportionately less accurate in memory search than in cue recognition, relative to the younger group. There was no evidence that either group was significantly disadvantaged when asked to carry out instructions in an unfamiliar environment. This may be because the magnitude of the differences between the two street settings was not sufficient to influence the ability to notice cues. In order to make the two environments as equivalent as possible on all other dimensions except the actual shop frontages and the order in which shops appeared, the environment might not have been sufficiently alien to cause differences in attentional strategies.

The analysis of the predicted recall data revealed that both groups on average expected to remember about 8 or 9 of the 14 instructions and neither group expected to have much more difficulty in the unfamiliar street. Although both groups underestimated their actual performance, the younger group was significantly more conservative in their estimates of what they would actually achieve than the older adults. This is interesting because it suggests that expectations of remembering shopping instructions do not decline with age even though success on the actual task does. One explanation for this is that due to their longer life experience, older people have a more accurate perception of how many of the list of instructions they are likely to recall. Alternatively, it may be that the older persons are not making an accommodation in the awareness of their capacity to remember with advancing age. The estimation that participants are being asked to make in the situation where a naturalistic stimuli are being used is one where it is difficult to be accurate. It is not possible to know in advance how easy it will be to see the target shop and whether there will be any visible cues to aid memory recall. For that reason when the likelihood estimates are made in the present study, they represent an expression of general

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confidence in memory capacity rather than an accurate prediction of an individual item. It may be that the older persons when asked on an item-by-item basis to estimate recall are expressing an implicit but unrealistic belief that their memory for intentions has not changed.

STUDY 3

Movement along the street with distracting sights and sounds represents the ongoing task in most real life shopping scenarios. If there is only one intention to complete (e.g. to post a letter), and this is forgotten, it is unlikely to be because the memory of the intention has dissipated; it is more likely to be because the post box was not noticed. This could be because the post box is an unfamiliar location (Study 2) or because attention was engaged elsewhere when the post box was passed. In the third study we examined the effect of distractions on the shopping errands task. In one condition, the amount of noise and movement associated with the Pages in the street was enhanced. In the other, lengthy interruptions were introduced to disrupt movement down the street. The focus on distraction was prompted by numerous findings that older persons are more affected by irrelevant stimuli than younger persons in complex visual search environments (Carlson, Hasher, Connelly, & Zacks, 1995; Morrow, Leirer, & Altieri, 1992; Plude & Hoyer, 1986; Rabbitt, 1965), possibly as a consequence of an inability to inhibit irrelevant inputs (Hasher & Zacks, 1988).

In the first condition, a noisy environment was created, which required participants to ignore the features of the street that were irrelevant to them, in order to recognise targets efficiently. West & Craik (1999) have attributed with the increased likelihood of failures on prospective memory tasks by older adults to momentary lapses of intention. In two experiments using a category judgement task in which speed of category assignment and detection of prospective cues were analysed, they concluded that failures in prospective memory were a consequence of brief lapses in vigilance rather than an inability to remember the task instructions. We hypothesised that the effect of operating a noisy environment would be to increase the likelihood of momentary lapses of attention, resulting in failures of cue detection.

McDaniel, Einstein, Stout, & Morgan (2003) found that brief delays in the opportunity to execute an intention caused deficits in the performance of older adults, suggesting problems of maintaining information in working memory. We experimented with incorporating similar brief delays by having participants ‘wait’ in queues before reaching the counter to recall their errands. In this situation, however, the delayed-execute manipulation had little effect, possibly because the naturalistic surroundings were a constant reminder of the task in hand. Accordingly, a longer filled interruption was introduced in the second condition. Our aim was to create an analogue of the situation where shopping is interrupted by having a conversation with another person in the street by introducing four verbal fluency tasks during the movement down the street. In this case, participants must disengage from the shopping task and engage in a new cognitive activity. Because working memory load has been shown to affect memory for intentions in older persons (e.g. Kidder, Park, Hertzog, & Morrell, 1997; Marsh & Hicks, 1998), we hypothesised that older persons would display a deficit in the reinstatement of working memory for the shopping task.

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Method

Participants

For the older group, the data for the control (no distraction) condition came from the 20 participants in Study 2 who best matched the older groups in the two distraction conditions. The older participants in the two distraction conditions had also previously completed the DN version of the test either in Study 1, or in other studies conducted during the development of the procedure. Hence all the older participants had previously completed the DN version of the street and all had equal familiarity with the procedures to be used in this study. The data presented in this study came from PN versions of the street. Three groups of younger participants were recruited from undergraduate classes. Although the older persons had more experience with the general testing procedure than the younger groups, this was a conservative bias in terms of the hypotheses, and likely to be compensated for by the greater experience of younger participants with computers. Age, SILS vocabulary scores, and years education data for the groups tested are presented in Table 3. There was no significant difference in age between the three older groups, $F(2,57) = 1.01$, or between the younger groups, $F(2,57) < 1.0$. A 3-factor ANOVA revealed a significant age effect on the SILS vocabulary scales, $F(1,114) = 69.31$, $MSE = 14.10$, but no Condition effect or Age × Condition interaction.

Materials and procedure

Two versions of the PN street were constructed that incorporated additional levels of distraction. In the first, labelled the Distraction version, moving pictures of persons and loud distracting sounds were added. In the second, labelled the Interruption condition, four 1-minute interruptions were introduced into the Distraction version of the street. Each interruption was placed at an equal distance apart along the street. The interruption was signalled by words appearing on the screen that instructed the participant to complete a verbal or semantic fluency exercise. There were four interruptions, two in which they were asked to generate as many words starting with a letter (S,L) and two where the task was to generate words in a particular category (Fruits and Vegetables, Animals). In each case the

Table 3. Prospective remembering as a function of noise distractions and task interruptions

	Older						Younger					
	Distraction		Interruption		Control		Distraction		Interruption		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	65.35	4.46	67.33	4.73	66.55	3.82	20.85	2.32	21.50	3.24	20.65	2.28
SILS vocabulary	37.10	2.73	36.17	4.45	37.45	1.82	32.10	3.54	31.40	3.75	29.95	5.40
Years education	14.00	2.56	14.48	2.56	14.47	2.84	15.15	1.46	15.00	1.75	15.70	2.08
Correct												
P (Location)	0.92	0.09	0.77	0.15	0.89	0.07	0.96	0.04	0.96	0.05	0.95	0.05
P (Task | location)	0.74	0.15	0.70	0.23	0.76	0.11	0.86	0.10	0.85	0.10	0.93	0.07
Performance												
Time/page (secs)	4.48	0.78	6.34	1.03	4.73	0.65	3.44	0.31	5.21	0.41	3.74	0.48
Pages/location	13.57	0.69	14.54	1.23	14.13	0.73	13.10	0.33	13.15	0.44	13.94	0.87
Male: female	9:11		9:11		8:12		10:10		10:10		10:10	

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generation task lasted 60 seconds, after which the experimenter instructed the participant to continue with their tasks on the street. The PN versions of the List A and B instructions were used alternately with the older and younger participants in each condition. The administration of the two distraction conditions used the same practice and learning procedures as for Study 2. Equal numbers in each group were administered PN List A and B.

Results

The results for the probability of correct detection of cues and tasks, calculated as in the two previous studies, are given in Table 3. The hypothesis that there would be a specific age-related decrement on the cues correct but not the tasks correct data as a consequence of distraction was tested in two separate ANOVAs. A 2-factor, Condition (Distraction, Interruption, Control) by Age group ANOVA was first conducted on the probability of correct location results. There were significant Age, $F(1,114) = 41.32$, $MSE = 0.007$, $p < 0.001$, and Condition, $F(2,114) = 9.81$, $MSE = 0.007$, $p < 0.001$, effects, and a significant Condition × Age interaction, $F(2,114) = 6.37$, $MSE = 0.007$, $p < 0.002$. This is illustrated in Table 3, where the ability of the older group to detect cues in the interruption condition was significantly reduced, relative to their performance in the other two conditions. *Post hoc* testing, using Tukey's Honestly Significant Difference (HSD) procedure, ($MSE = 0.007$, $df = 114$) revealed that the only significant differences were for the older group, between the control and interruption conditions ($p < 0.001$) and the distraction and interruption conditions ($p < 0.001$). A similar ANOVA was conducted for the probability of recalling the tasks correctly. The only significant effect was for Age, $F(1,114) = 33.89$, $MSE = 0.02$, $p < 0.001$; neither the Condition $F(2,114) = 2.49$, nor the interaction of Age and Condition, $F(2,114) < 1.0$, were significant.

The time/Page data in Table 3 were analysed using a 2-factor (Condition, Age) ANOVA. Age was significant, $F(1,114) = 77.06$, $MSE = 0.43$, $p < 0.001$. It should be noted that since the time taken to complete the task included the interruptions, the mean time/Page data for that condition are not accurate. Since the condition by age interaction, was not significant, $F(2,114) < 1.0$, $p = 0.85$, no action was taken to correct these means. There was no evidence that the older group slowed their time of inspection per page to compensate for the presence of any additional distraction. A similar 2-factor ANOVA for the Page/location data, revealed an Age effect $F(1,114) = 23.45$, $MSE = 0.60$, $p < 0.001$ and an Age by Condition interaction, $F(2,114) = 6.52$, $MSE = 0.60$, $p < 0.005$. Using Tukey's HSD ($MSE = 0.60$, df = 114), for the younger participants, the control group accessed more pages for each location correct than either the distraction ($p < 0.01$) or interruption ($p < 0.02$) groups. The means, however, were similar in magnitude. For the older participants, the older group in the interruption condition differed from the group in the distraction condition ($p < 0.005$), but not the control condition ($p = 0.22$).

Discussion

The objective of this study was to determine whether older persons are significantly affected by distraction when completing a task with naturalistic stimuli. The results were clear. Simply adding irrelevant visual and auditory distractions to the situation had little effect. The older persons were well able to focus their attention on the aspects of the environment that were relevant to the task and to block out those that were not. Our

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hypothesis that increased noise in the environment would produce momentary lapses of attention (West & Craik, 1999) in the older group was not supported. It is important to add a caveat at this point. It is possible that the ability to restrict attention is dependent on the nature of the present task, remembering errands in a simulated street. For example, much of the distraction was provided by auditory noise, and it is relatively easy for participants to inhibit this modality, since it is clearly not relevant to the shopping task, which relies on visual cues. Furthermore, in this case shopping in a noisy environment is a familiar experience and locating the features of the street that are relevant to the execution of the errand-based task is a well-practiced skill. The ability to exclude irrelevant noise is likely to be more difficult in circumstances where the environment is less familiar and the distinction between relevant targets and noise stimuli is less pronounced.

When the older person is interrupted in the execution of a task by being redirected to a new task, however, accuracy of cue perception is affected. Asking participants to engage in a verbal fluency task was intended to simulate the situation where an ongoing shopping task is interrupted by a conversation with another person that completely engages the participant's attention and prevents rehearsal. In this situation, working memory capacity is diverted from the cognitive activities relating to the shopping task to a new and demanding task. When switching back to the old task, it is necessary to self-initiate working memory processes to reconstruct the situation that pertained prior to the interruption. The effect of doing this for older people was that they are subsequently less likely to notice cues in the street. The interruption and the delay, however, had no condition-specific impact on recall; if the cue was noticed then the probability of remembering the associated action was unchanged. This result suggests, as was apparent in Study 1, that the capacity for accurate memory search is fixed to a large extent at the time instructions are delivered or intentions formed. Recognising cues on the other hand is dependent on conditions that arise in the environment. These results have some parallels with the findings of McDaniel et al. (2003) and Einstein, McDaniel, Manzi, Cochran, & Baker (2000) that brief delays between cue recognition and the opportunity to act impair older persons' performance. There are a number of possible explanations for this. In the present context it is likely that the difficulty reflects a reduced ability to reinstate information or strategies in working memory. This may be a consequence of a decline in the resources necessary to switch between tasks or it may be that reduced working memory capacity interferes with the ability to keep the features of one task in mind while completing another. The results do confirm the common experience that older persons report of difficulty remembering what they were doing before they were interrupted.

GENERAL DISCUSSION

The present research was focused on determining whether the decline in accuracy of memory for intentions in old age demonstrated in the laboratory would generalise to a familiar task using naturalistic stimuli. Overall, the present investigation demonstrated that older persons have difficulty remembering intentions, even when the environment and tasks are familiar and they can move at their own pace. This confirms numerous previous reports of a decline in accurately remembering future intentions in older persons on both laboratory-based and real world tasks (e.g. Cherry & LeCompte, 1999; Henry et al., 2004; Huppert et al., 2000; McDaniel et al., 2003). In this investigation we used a relatively small number of items to ensure that the older participants were not discouraged by the demands

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placed on them. Even in situations where the younger persons' performance was near ceiling, the older group were still less accurate in their completion of errands. In addition, their performance tended to be slower and they spent more time inspecting each scene before moving on.

Although establishing a generalised reduction in performance is significant; identifying circumstances where older persons have a disproportionate impairment in performance relative to younger participants is of more interest. A specific deficit provides information about the aspects of cognition most vulnerable to aging and contributes to understanding the more general issue of the extent to which different cognitive processes are involved in remembering. In the first study, older persons were specifically impaired in the memory search component of the task relative to detecting cues, implying that recall is more effortful than attentional processing in this situation. Given a list of 14 instructions, older persons were just as likely to recognise the location cues as the younger persons, but more likely to forget the reason for which the cue is relevant. This finding is consistent with studies that have shown that self-initiated memory search is impaired in old age (e.g. Einstein et al., 1997; McDermott & Knight, 2004), and that recall is more affected by aging than recognition (Light et al., 2000). When the task was rendered more difficult by administering only one learning trial, the older participants' probability of correct recall was more severely affected than that of the younger group. The presence of naturalistic stimuli and a task that might have facilitated recall because of the presence of relevant visual cues did not compensate for the weakened normal memory in the older participants.

In the two subsequent studies, the focus was on the vigilance aspect of the memory for intentions task, and the difficulty of memory search was minimised by using a 3-trial reminding procedure to administer the list of instructions. In Study 2, the familiarity of the environment was manipulated by having participants search either in a street that was highly familiar or in a street that was similar in many respects, but in a completely different city. Before the study was conducted it was unclear whether cue recognition in the unfamiliar environment would be more difficult for the older persons because locations would be harder to encode, or easier, because in an unfamiliar environment locations mentioned in the instructions stand have an enhanced salience relative to the background (McDaniel & Einstein, 1993). In the event, familiarity had no effect on the accuracy or speed of movement in the street of either younger or older participants. It is not possible to determine from the data whether cue recognition in an unfamiliar environment is generally easier, since both groups performed at a ceiling level of around 90% in the correct detection of locations. Our conclusions are therefore limited to stating that older persons are not specifically disadvantaged when asked to recognise a relatively small number of distinct cues in an environment that, although unfamiliar, is within their range of experience. It is possible that older participants might be more adversely affected if the environment was totally outside their experience, for example, set in a foreign country.

One of the reasons why recognising cues in an unfamiliar environment is more difficult is the presence of new and distracting sights and sounds. The inability to inhibit distraction by allowing irrelevant thoughts or contemplation of irrelevant stimuli to intrude on working memory while completing an ongoing task has been cited as a reason for less effective processing in old age (e.g. Hasher & Zacks, 1988). In the final study the effect of introducing visual and auditory distraction was investigated. By adding moving people and loud noises to the static photographic images, the street scene became noisier. It was

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hypothesised that older persons would have problems inhibiting attention to irrelevant stimuli and fail to notice the target cues; this did not happen, the older persons responded by blocking out the distractions. Whether it is possible for them to do so in a high-density real-world urban environment with multiple distractions is not clear. In this case, however, it was obvious that they kept in mind the fundamental objective of walking down the street completing errands and did not allow irrelevancies to intrude.

When they were put in a situation where the distraction could not be ignored, however, the ability of older persons to notice cues was significantly disrupted. Having to disengage working memory from one task and work on another for a short period of time did have an impact on the probability that they would recognise relevant cues. Although they might have had no difficulty remembering why they were in the street (the meta-strategy was intact), reinstating the details of the monitoring processes and the memories of the tasks they had completed is likely to be strategic and effortful, and therefore vulnerable to the effects of ageing. The interruption procedure made explicit one of the central features of prospective remembering tasks, the need to turn aside from one task to execute another. This had the effect of disrupting the prospective vigilance or monitoring component of the task, while having no specific effect on the memory search component. The results of Study 3 suggest that one of the central features of a task that causes failure in the recall of delayed intentions is the total displacement in working memory of one task by another. When introducing the present investigation we took the research outside the domain of prospective remembering and characterised our investigation as one focusing the effects of ageing on the processes involved in recalling intentions in a familiar shopping task. Many researchers would concur with the view of Ellis & Kvavilashvili (2000) that a significant feature of a prospective memory task is that it necessitates an interruption to 'one's activity in order to carry out the intention' (p. S2). In Study 3, we interrupted the prospective vigilance (intention) component with an ongoing task (activity), which reorders the priority of the tasks, to create a more realistic scenario in a shopping situation. The conclusion implicit in the findings of Study 3 is that ignoring irrelevant distractions in a task using naturalistic stimuli has less effect than an interruption that requires the effortful reinstatement of an ongoing memory task.

One of the dilemmas involved in studying remembering in the laboratory is that in order to study individual differences, it is necessary for participants to make errors. In everyday life, however, when remembering is important, we do not adopt a strategy where memory failure is likely. Hence an initial stage when engaging in any task involving future recall is deciding how much it is possible to remember and, if necessary, acting to compensate by preparing a list or instituting some external cue. Creating experimental situations for older adults where memory failure is certain moves the procedure outside the normal range of their experience; asking participants to do something where they will fail at least in part, makes the task less realistic and impacts on motivation. For example, giving participants in Study 1 a single trial to learn 14 instructions was clearly not something they would attempt in everyday life. Obviously the reason for doing this was to allow a meaningful test of the hypothesis that there would be an interaction between age and proportion of cues or tasks recalled. A significant part of Study 2 was asking participants on an item-by-item basis how likely they were to remember each instruction, in a manner analogous to the procedure used to assessing feeling-of-knowing in a retrospective recall test. Interestingly, both older and younger participants predicted they would remember on average between about 9 and 10 instructions. We have previously found (Knight et al., 2005) that accuracy of estimating recall of individual instructions in a shopping context is highly inaccurate because

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participants cannot know the context in which the cue will appear. The visibility of a cue has an impact on its likelihood of detection; this is another important feature of naturalistic stimuli. So accuracy was not examined, but it was significant that even though the actual probability of remembering the intentions declined with age, the expectation of accuracy did not. This raises interesting issues about the awareness of the changes that occur with advancing age as measured in this indirect manner. Although older persons may be aware that memory generally declines with age, translating this into a realistic expectation of performance on a specific or a novel task is likely to be difficult.

One of the overarching aims of the present project was to examine the utility of a computer-based analogue of a real-life task to examine remembering. The advantages of this style of task is that it opens up the opportunity to examine the effects on behaviour of task parameters that are significant in the real world but hard to incorporate into laboratory tasks. A good example is the manipulation of familiarity of a real environment as in Study 2. Overall, the present investigation provided encouragement for the use of simulated environments for studying cognitive processes. Virtual environments are being created for the assessment of memory and attentional deficits consequent on neurological damage (e.g. Brooks, Rose, Potter, Jayawardena, & Morling, 2004; Rose & Foreman, 1999). In the case of the virtual street, participants find the use of the touch screen simple and the use of naturalistic pictures engaging. Because the nature of the task (carrying out specific errands) is one with which participants typically have a vast amount of experience, they know how to approach the task, are practiced at the cognitive strategies needed, and can predict what they will be able to achieve. For older persons, the fact that the shopping task is familiar is an advantage and the naturalistic stimuli are sights and sounds they are used to.

One limitation of our current procedure as a measure of real-life performance that should be acknowledged is the time frame of the task. Intentions are often executed over a period of several hours or days, whereas our task is completed in the span of an hour. There is no reason, however, that the procedure cannot be used to study after lengthy delay periods. We also intend future research to focus on tasks where strategic planning is a more prominent feature and where it is necessary to move backwards and forwards down the street, for example, to obtain all the things necessary to go on a trip. Prospective remembering becomes more complex to measure but more interesting to observe when strategic multi-tasking is necessary to achieve a particular end. In tasks such as those developed by Shallice & Burgess (1991) to examine executive functioning, the participant has almost complete control of the situation, and their self-selected strategy determines the outcome. This is in marked contrast to the usual situation in clinical practice where retrospective memory is studied in situations where the experimenter exercises total control. Under circumstances where attentional and memory strategy are self-determined, it is likely that the kind of difficulties that come with age or are inflicted by brain injury will become more pronounced.

APPENDIX

Abbreviated lists of instructions: DN versions

[List A]: Buy a large chocolate letter from EC; order pork fried rice from S; buy a comb from DV; withdraw $200 from Westbank ATM; enquire about a corkscrew at R bottle store;

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order a coffee to go from DD; buy a pair of shoelaces from FR; enquire about cost of reprints at PP; enquire whether they sell vases at P gift shop; enquire about the price of a wallet at C; buy a $40 gift voucher from JJ; enquire about A accommodation guides at B Travel; buy a backpack from PT; ask the price of silk scarves at LE.

[List B]: Buy birthday cake candles from EC; order chicken satay from S; buy a hairbrush from DV; withdraw $50 from W ATM; enquire about a wine cooler bag at R Bottle Store; buy a pair of inner soles from FR; order an apple pie at DD; enquire about the cost of processing a film at PP; enquire whether they sell table mats at P gift shop; enquire about the price of a leather belt at C; buy a $20 gift voucher from JJ; enquire whether they sell books on African safaris at B Travel; buy sunglasses from PT; ask about the price of leather gloves at LE.

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