WHO DID WHAT?

AGE-RELATED DIFFERENCES IN MEMORY

FOR PEOPLE AND THEIR ACTIONS

Thesis presented to the Faculty of the Graduate School

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Master of Arts

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by

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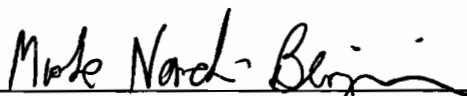
WHO DID WHAT?

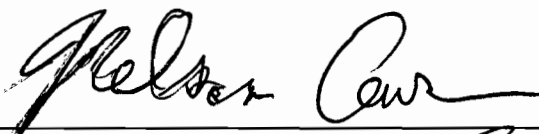AGE-RELATED DIFFERENCES IN MEMORY

FOR PEOPLE AND THEIR ACTIONS

Presented by Susan Old

A candidate for the degree of Master of Arts

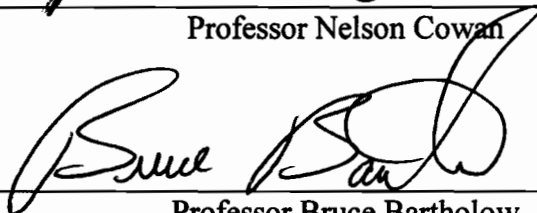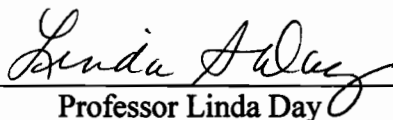And hereby certify that in their opinion it is worthy of acceptance.

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WHO DID WHAT? AGE-RELATED DIFFERENCES
IN MEMORY FOR PEOPLE AND THEIR ACTIONS

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ABSTRACT

The associative-deficit hypothesis (ADH), proposed by Naveh-Benjamin (2000),

holds that the decline in episodic memory that accompanies aging is at least partially due

to an inability to bind single units of information into more complex units. The present

study attempts to extend the ADH to relatively dynamic, unexplored stimuli. In each of

two experiments, participants viewed a series of brief video clips, each showing a

different person performing a different action. Their memory for individual people,

individual actions, and the associations between those components, was then tested.

Different versions of the tests were completed on the following day. In Experiment 1,

older and younger adults received either intentional or incidental learning instructions.

Experiment 2 examined the possibility that the age-related associative deficit is due to a

decrease in attentional resources (e.g., Craik, 1983) by testing young adults under divided

attention (DA) at encoding or at encoding and retrieval.

Results showed that older adults did exhibit a larger deficit in memory for who

did what than for individual people or actions, but only under intentional learning

instructions and only on Day 1. Young adults whose attention was divided at both

encoding and retrieval, but not those under DA at encoding only, exhibited a similar

deficit. The associative deficit of older participants, however, stemmed from a tendency

to produce false alarms, while that of the young group under DA at study and test was

due to a decreased proportion of hits. Taken together, results suggest that the age-related

associative deficit is partially due to a decline in strategic processing and may involve

difficulties retrieving bound information.

Introduction

Anyone who is even modestly familiar with news headlines from recent years has likely noticed a change in the media's intended audience. Whereas just a few decades ago, the spotlight centered on early life and child-rearing, attention is now geared toward aging and later life. As the baby boomer generation enters retirement, the public's general interest in healthy aging is further illustrated by the growing list of instructive books such as *Keep Your Brain Alive: 83 Neurobic Exercises*[1] and *Memory Fitness: A Guide for Successful Aging*.[2] These titles, as well as many others, indicate that it may be possible to limit age-related memory deficits. While the roots of some of these deficits are fairly well-understood, numerous questions remain. Memory processes must be further investigated in order to better determine how and why age-related changes occur. A deeper understanding of memory deficits may then, in turn, lead to valuable interventions that will aid the aging population.

The study of the mechanisms behind age-related memory changes can take various approaches. One valuable strategy involves the comparison of two divisions of memory that are differentially affected by aging. While memory abilities do generally decline as people grow older, some forms of memory, such as that involving vocabulary, may become *enhanced* with age (e.g., Kausler & Puckett, 1980). If one form of memory

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[1] Katz, L., & Rubin, M. (1999). *Keep your brain alive: 83 neurobic exercises*. New York: Workman Publishing.

[2] Einstein, G. O., & McDaniel, M. A. (2004). *Memory fitness: A guide for successful aging*. New Haven, CT: Yale University Press.

is affected less negatively by aging than is another, the mechanisms behind age-related deficits can be better localized by assessing the differences between those two forms of memory.

When comparing different forms of memory, categorizations of these forms must not be overly broad. Craik (1986) warns that if researchers focus on the role of the structures and mechanisms involved in memory, they may fail to detect important age differences. Such an approach would lead to the erroneous conclusion that aging affects all aspects of an entire memory structure, such as long-term memory, in a homogeneous manner. This assumption could easily result in the neglect of important, yet relatively subtle, effects of aging. For example, episodic memory (i.e., conscious recollection of personal experiences) is affected more negatively by aging than is semantic memory (i.e., general knowledge), even though both are forms of long-term memory.

Craik (1986) suggests that, instead of the structural approach, researchers should attempt to understand memory in terms of the interaction among internal and external factors. From this point of view, the effect of aging on memory is allowed to vary in magnitude along a number of dimensions. For example, certain stimuli or methods of retrieval—external factors—may interact with internal factors associated with age, by putting older adults at a relatively large disadvantage, as compared to younger adults. The value of this approach is exemplified by the consistent finding that aging affects free recall more than it affects recognition (e.g., Schonfield & Robertson, 1966; Craik & McDowd, 1987). Craik (1986) uses such findings to support the idea that self-initiated

processes, which are required by recall to a larger extent than by recognition, decline with age.

Another notable distinction in this area, which will be the focus of the present paper, is that between item and associative memory. It has been shown that aging has a greater effect on memory for the associations between single units of information than on memory for those units themselves. For example, Chalfonte and Johnson (1996) found that older adults were just as able as were younger adults to remember individual colors and individual objects that had been viewed during a study session. However, the older participants were relatively unable to remember which object had appeared in which color. These researchers suggested that one component of older adults' deficit in episodic memory is their inability to bind features together into relatively complex memories. Thus, by comparing two specific forms of memory, it was possible to more precisely recognize a mechanism behind a more general age-related memory loss, and to also show that item memory and associative memory play unique roles in human cognition.

While the results of Chalfonte and Johnson (1996) clearly showed an age-related deficit in the associations made between feature information, there is a wider range of information to which the item-associative distinction may apply. Naveh-Benjamin (2000) extended the scope of the feature-binding notion by proposing an associative-deficit hypothesis (ADH). The ADH holds that older adults have difficulties forming and retrieving links among single units of information. These units are not limited to two features, but may also include an item and its context or two contextual elements. For

example, while older adults may be reasonably able to remember a favorite story from their childhood, they may have trouble linking that story to the context in which they have told it. Thus, they may repeat the same anecdote to people who have heard it countless times before.

As noted by Naveh-Benjamin (2000), in order to directly investigate the ADH, it is necessary to compare two memory tasks which differ in only one way: one requires encoding and retrieval for item, or component, information, whereas the other requires encoding and retrieval of associations between those components. In a typical test of the ADH, a study session involves the presentation of paired information, such as pairs of pictures (e.g., Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003) or single words presented in different fonts (e.g., Naveh-Benjamin, 2000). Participants are then tested over the individual items (e.g., a picture or word) or contexts (e.g., a font) and also over the item-item or item-context pairings. Different testing methods, including recognition, free-recall, and cued-recall, may be used for the tests, but within a given experiment, the same method must be used for tests of both item and associative memory.

Using such a paradigm, the ADH has been supported by studies involving a variety of learning materials. For example, older adults exhibited a larger deficit, when compared to younger adults, when they were required to remember word pairings than when memory for single words was tested (Naveh-Benjamin, 2000). The ADH has also been applied to nonverbal materials. While the advantage of pictures over words in memory—the picture superiority effect—has been shown to be larger in younger than in older adults when memory for *single* pictures is tested, (Kausler, 1994), there seem to be

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even larger age deficits in memory for *associations* between two pictures. This applies whether the pictures depict simple objects (Naveh-Benjamin, et al., 2003) or more complex faces (Bastin & Van der Linden, 2006).

While the ADH has perhaps been most frequently investigated in terms of memory for item-item pairs, it has also been shown to apply to item-to-context binding. In support of an age-related associative deficit using such stimuli, Naveh-Benjamin (2000) found that older adults were able to recognize individual fonts and single words relatively well, but performed significantly worse than younger adults when they were required to bind this information together (i.e., when they had to recognize which word had appeared in which font). Similarly, it has been found that, while there were no age differences in the ability to recognize individual faces, older adults were relatively unable to recognize which face had been presented in a particular spatial location (Bastin & Van der Linden, 2006).

Even though the ADH is a relatively new proposal, it is relevant to research conducted years ago. Experiments predating the ADH generally did not assess separate item and associative memory, so are not directly applicable to the hypothesis, but they do provide enticing arenas in which the associative deficit may be explored. Source memory, for example, may involve memory for the pairing between a voice and a sentence. Perhaps the inability to bind such information together can explain why source memory seems to be highly affected by aging (e.g., Erngrund, Mantyla, & Nilsson, 1996).

Another important area of study that pertains to the ADH is that of eyewitness identification, an area to which the present experiments are intended to relate. Crime situations consist of various bits of information, including both an action (i.e., a crime) and an actor (i.e., a lawbreaker). Past research has found a relatively small age-related deficit in face recognition (e.g., Naveh-Benjamin, Guez, Kilb, & Reedy, 2004), or no age difference at all (e.g., Bastin & Van der Linden, 2006).

Results of studies on age differences in memory for the other major component of eyewitness events—actions—vary widely. Bäckman and Nilsson (1984, 1985), for example, found that older adults were just as able as were young adults to remember actions that they had performed, or "self-performed actions". However, Rönnlund, Nyberg, Bäckman, and Nilsson (2003) have more recently concluded that there are significant age-related deficits in memory for actions, and that these deficits are similar whether those actions are presented verbally or are self-performed. There has been little research on memory for observed actions, but the discovery of mirror neurons, which fire both when one performs an action and when one views someone else performing the action, suggests that memory for witnessed actions may be quite similar to that for self-performed actions. Thus, memory for this single aspect of eyewitness events may or may not be negatively impacted by the aging process, as previous findings are mixed.

While research on memory for each component of an event is interesting, it cannot relate a complete picture of age-related changes. Eyewitnesses must remember not only that they have previously seen a certain person and a crime itself, but must piece these components together in order to correctly identify the person responsible for the

action in question. An example of mistaken binding is known as the *mugshot exposure effect* (e.g., Memon, Hope, Bartlett, & Bull, 2002), in which participants are more likely to mistakenly select as a target a person presented in a mugshot than a person not previously viewed in a mugshot. "Innocent" faces that are shown in mugshots may, in fact, be mistaken as perpetrators just as often as the perpetrators themselves are correctly identified (Brown, Deffenbacher, & Sturgill, 1977). Thus, regardless of age, people seem to have trouble binding together a memory for a person and a memory of a specific action.

The present experiments will test the ADH using relatively dynamic, unexplored stimuli, by assessing memory for people, simple actions, and the person who performed each action, as viewed in video clips. It has been shown that older adults are able to recognize people's names and faces relatively well, but have difficulty recognizing which name applies to a specific face (Naveh-Benjamin, et al., 2004). Such a task is highly relevant to everyday life, as forgetting of people's names is a common complaint of the elderly (e.g., Cohen & Faulkner, 1984). However, the name-face experiment was not able to fully capture the dynamic experience of everyday life. There may be important differences between memorizing names of people presented in static pictures than in a more realistic, dynamic setting. Being presented with multiple views of a person has been shown to aid older adults' face recognition more than that of younger adults, a finding which led Bartlett and Leslie (1986) to conclude that "elderly witnesses might identify a suspect with high reliability, especially if they originally experienced more

than a single view" of that suspect (p. 380). The present experiments take this point into consideration, testing memory for people in motion.

Experiment 1 will test both younger and older adults under either intentional or incidental learning instructions. One main prediction for Experiment 1 stems directly from the ADH. There should be a larger age-related deficit in memory for who performed which action than for the actions or for the people alone. Somewhat similar studies do support this hypothesis. For example, in an unpublished work, Kersten, Earles, Curtayne, and Lane (2003) instructed older and younger adults to study 30 short video clips, each showing a different person performing a different simple action. A week later, participants viewed similar clips and were asked, for each clip, whether it showed an actor performing the same action as during study. Each of these test clips was from one of five categories. Some clips ("targets") showed events as they took place in the study session. "Conjunction events" depicted people from the study session performing actions that had been performed by someone else during study. Other clips involved either a new actor and old action, new action and old actor, or both a new action and a new actor.

In accord with the ADH, results showed that older adults were more likely than were younger adults to falsely believe that they had seen the conjunction events during study. The age groups, however, performed equally well in terms of correctly rejecting clips involving new actors or new actions. This finding may indicate that older adults are able to remember individual people and individual actions relatively well, allowing them to reject whole events that include any new information. However, the experiment was

not designed specifically to separate item and associative memory, and thus did not include "pure" tests (e.g., those without contextual cues) of item information. This complicates interpretation of the results in terms of the ADH.

One important aspect of eyewitness situations is that encoding takes place incidentally; that is, eyewitnesses are not aware ahead of time that they will need to remember details about the event that they are about to experience. For this reason, it is important to assess whether the age-related associative deficit differs under incidental and intentional encoding. Thus, in Experiment 1, study instructions are manipulated to make participants aware or unaware of the upcoming memory tests.

Previous research has in fact found that the associative deficit of older adults differs in magnitude according to study instructions. In a study by Naveh-Benjamin (2000; Experiment 2), for example, participants were made aware of either an upcoming recognition test over individual words or of a test over word pairs. After being shown pairs of words during study, all participants were tested over *both* the individual words and their pairings. This experiment found larger age differences in memory for word pairs than for individual words whether the information was learned intentionally or incidentally. However, older adults performed similarly on the associative test whether or not they had expected it, while younger adults performed better when made aware of the test than when they were unaware. Thus, while the group expecting only the item test, in which the associations had been incidentally encoded, showed a larger age difference on the associative than on the item test, this age difference was even greater when the subjects expected the associative test (i.e., when pairings were intentionally

learned). Based on such previous findings, it is expected that, in Experiment 1, older

adults receiving intentional and those receiving incidental learning instructions will show

an associative deficit, but that this deficit will be larger in the former group.

The topic of eyewitness research also shown that older adults are

Past research on eyewitness identification has also shown that older adults are

more likely than are young adults to falsely identify an innocent person as a culprit, while

the two age groups identify the actual perpetrators at equal rates (e.g., Wells & Olson,

2003). In other words, the decreased performance of older adults in eyewitness

identification seems to be due entirely to an increase in false alarms, not to a decrease in

hits. It appears that in eyewitness settings, younger adults use a more conservative

approach than do older adults when identifying the executor of a crime. Based on such

evidence, a third prediction for Experiment 1 is that the age-related associative deficit

will be due more to an increase in false alarms on the part of the older adults than to a

decrease in hits.

The topic of eyewitness research also highlights another common problem in the

generalization of laboratory research to real-life settings. While participants in

experiments are often tested over information shortly after encoding takes place,

eyewitnesses may not be questioned until days, or even weeks, after an incident has

occurred. This situation provides just one reason why it is important to assess any

existing changes in the age-related associative deficit that occur at different intervals of

time after initial encoding of the information.

The following experiments will assess the effects of time on the associative

deficit, a topic which has not yet been explored. Generally, age differences in rates of

forgetting are slight (see Kausler, 1994, for a review). Such a conclusion, though, is based on tests involving individual units of information. It is possible that those small age differences in rates of decline will be exaggerated on associative tests. In one experiment involving identification of a perpetrator as viewed in a video clip, age differences existed a week after the initial viewing of the crime, but not after just 35 minutes (Memon, Bartlett, Rose, & Gray, 2003). However, such previous studies did not assess separate measures of item and associative memory, making it difficult to form a prediction as to how the age-related associative deficit will change as the retention interval increases.

A final issue of interest in Experiment 1 involves the way in which characteristics of the stimuli affect the associative deficit. Specifically, the ages of the to-be-remembered people could affect the performance of younger and older participants in different ways. List (1986) found an age deficit when participants answered questions about young suspects in an eyewitness study, but no age deficit when the suspects were older. Similarly, Bartlett and Leslie (1986) found evidence for this "other age effect" in younger, but not older, participants. In other words, their older subjects were able to recognize older and younger faces at similar rates, while younger participants performed better when stimulus faces were young than when they were older. Such results were expected to be replicated in the person test in Experiment 1, in which case it would be interesting to assess whether this effect would extend to the associative test. Older adults may be better able to bind other older, as opposed to younger, actors to their actions,

resulting in a smaller age-related associative deficit in memory for information involving older actors than younger actors.

With consistent findings that episodic memory declines with age, it is important to determine the factors involved in this deficit. One proposed cause is that aging leads to a reduction in attentional resources, or "mental energy" (e.g., Craik, 1983, 1986; Craik & Byrd, 1982). These resources provide people with the ability to carry out challenging mental operations, such as using mnemonic devices to encode information. Some researchers propose that a decline in attentional resources as people age is one of the main factors in the change in cognitive efficiency; this occurs by reducing the "richness, extensiveness, and depth of processing operations at both encoding and retrieval" (Craik & Byrd, 1982, p. 208).

One way to assess the reduced resources hypothesis is to compare the performance of older adults to that of younger adults whose attentional resources are reduced by performing two tasks simultaneously; this method is used in Experiment 2 of the present paper. If older adults' attentional resources are in fact limited, and if this is the cause of their age-related decline in episodic memory, then their patterns of memory performance should be similar to that of young adults under divided attention (DA). Clearly, both age and DA do create reductions in episodic memory performance. However, there is disagreement as to the extent to which young adults under DA resemble older adults in terms of memory performance.

Tests of the ADH are quite applicable to the reduced resources hypothesis. If older adults do in fact possess fewer cognitive resources than do younger adults, DA of

young participants should produce an associative deficit similar to that produced by aging. Some research suggests, however, that this is not the case. Studies involving word pairs, picture pairs, and name-face pairs (Naveh-Benjamin, et al., 2003; Naveh-Benjamin, et al., 2004), for example, have found that whereas aging affected associative more than item memory, DA at encoding impaired the two forms of memory to a similar extent. Based upon such results, Naveh-Benjamin, et al. (2003) suggested that older adults have a deficit beyond that of reduced attentional resources. On the other hand, Castel and Craik (2003) did find an associative deficit in both older adults and in young adults under DA, when testing memory for words and word pairs. This deficit, however, in partial agreement with Naveh-Benjamin and colleagues (e.g., Naveh-Benjamin, et al., 2003; Naveh-Benjamin, et al., 2004), was larger in the former than in the latter group of subjects.

In Experiment 2, the attention of young adults will be divided during either encoding only or during both encoding and retrieval. By using both of these DA conditions, it will be possible to evaluate the role of reduced attentional resources in older adults' memory deficit during each of the individual stages of processing. For example, if young adults show an associative deficit when under DA at encoding only, with no increase in magnitude for subjects under DA at encoding and retrieval, it can be reasoned that the associative deficit of older adults is due to problems that occur primarily during encoding. If, on the other hand, an associative deficit is exhibited by young adults under DA at study and test, but not those under DA at study only, then the age-related

associative deficit may be attributed to older adults' reduced attentional resources during retrieval.

One basic, yet important, question in the study of memory and aging, is whether older adults' waning memory abilities—and the associative deficit, in particular—are due to a decline in strategic processing, automatic processing, or both. The present experiments relate to this question through two manipulations—that of learning instructions (in Experiment 1) and that of divided attention (in Experiment 2).

When participants are led to expect a test, they learn information intentionally, and are able to use both automatic and strategic processes in order to perform well on a test. When they are not warned about an upcoming test, however, they must rely to a large extent on automatic processes. Thus, if age differences on a given test are larger under intentional than under incidental learning instructions, it may be reasoned that older adults are less able to effectively use strategies than are younger adults. In other words, younger adults may be better able to take advantage of the knowledge that they will be tested over certain information. Conversely, the finding of a deficit under incidental learning that is equally large or larger than that under intentional learning, would suggest that the age groups utilize strategy to a similar degree, and that any age differences are due instead to a decline in automatic processing.

The division of attention in younger adults in Experiment 2 provides further insight into the mechanisms involved in the age-related decline in episodic memory. A concurrent continuous response time (CRT) task is assumed to affect the strategic, effortful processing required by the memory task, while leaving automatic processing

relatively untouched. This idea is supported by neuropsychological evidence showing that DA generally affects the frontal lobes, which are assumed to be involved in strategic processing, but does not affect the medial temporal/hippocampal areas, which are involved in automatic processing (Anderson, et al., 2000; Fletcher et al., 1995). Thus, if older adults' deficits are effortful in nature (that is, if the frontal lobes are highly involved in these deficits), their performance while under intentional learning instructions should be similar to that of younger adults under DA (whose frontal lobes are affected). On the other hand, age-related decline in automatic processing should result in dissimilar patterns between young adults under DA—whose automatic mechanism is intact—and older adults.

Briefly, in each of the following experiments, younger and older participants viewed a series of short video clips, with each clip showing a different person performing a different action. In Experiment 1, older and younger participants studied the clips under either intentional learning instructions, in which they were aware of the three tests that would follow, or incidental learning instructions, in which this information was withheld. Experiment 2 included only younger adults under intentional learning, and participants' attention was divided during study only or during both study and test. Participants in each experiment completed three recognition tests; two of these assessed memory for component information (i.e., the actions or the people alone), and the third evaluated memory for associative information (i.e., who performed which action). Each subject returned the following day to complete a different version of the tests.

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Experiment 1

As discussed, Experiment 1 was intended to investigate the following hypotheses:

1. Age deficits will be larger on the associative test than on either the action or the person test.

2. This age-related associative deficit will exist under both intentional and incidental learning conditions, but will be larger under the former than the latter.

3. The associative deficit will be due more to an increase in false alarms on the part of the older adults than to a decrease in hits.

4. The memory deficit of older adults will remain constant on memory for single components, from Day 1 to Day 2. However, it is possible that this deficit will increase in magnitude on the associative test.

5. Age differences on all tests, but particularly the person test, may be reduced when older, as opposed to younger, actors are shown in the video clips.

Method

Participants

Participants in this experiment were 48 older adults (65 to 81 years of age) and 49 younger adults (between 18 and 32 years of age). The older adults were community-dwellers reporting no serious health problems and were paid $15 for their participation. The younger adults were undergraduates enrolled in an introductory psychology course at the University of Missouri-Columbia and received course credit for their participation.

The two age groups were equated on level of formal education. Half of each age group

was randomly assigned to the intentional learning condition, and the other half to the

incidental learning condition. A summary of demographic information is presented in

Table 1.

Table 1 : Demographic Information for Participants in Experiments 1 and 2

	Age (Years)	Education (Years Completed)	Proportion Male
Younger (Exp. 1)	21.0 (3.00)	14.0 (1.48)	.47
Older (Exp. 1)	71.3 (4.42)	14.3 (1.70)	.29
Younger (Exp. 2)	20.0 (3.00)	13.0 (1.56)	.38

Note. Means are presented, with standard deviations in parentheses.

Design

This experiment consisted of a 2 (age: older, younger) x 2 (learning condition:

intentional, incidental; between subjects) x 3 (test: action, person, associative; within

subjects) x 2 (test interval: Day 1, Day 2; within subjects) design.

Materials

Study materials consisted of 75 5-second video clips of different people (ranging

in age from 18 to over 80 years, half male and half female) performing various simple

actions, such as peeling a banana or tearing paper. Clips were shown continuously on a

computer monitor, separated by one second of blank space, and were presented in a randomized order for each participant.

Four different overall test versions were drawn from the study list, each consisting of three tests: action, person, and associative. Video clips in each test were played continuously, separated by a 2-second space. Each clip remained on the screen for 5 seconds, even if the participant responded after a shorter period. Test clips were presented in a randomized order for each participant. Five of the study clips were used to create three 2-item practice tests.

Each action test included seven actions drawn from the study list (targets) and seven new actions (distractors). They were all performed by the same person, whose face was not shown. Person tests included clips of people sitting still[3]. Each version consisted of seven targets (people from the study list) and seven distractors (people never before seen by the participants). Finally, associative tests included nine targets (intact pairs), which were exactly the same clips that were presented at study, and nine distractors (recombined pairs), which showed a person from the study list performing an action that someone else had performed in the study list.[4] Recognition responses and reaction times to each clip were recorded by the computer program.

Items in the tests were non-overlapping, meaning that for any given participant, no person or action was presented more than once during the tests. Furthermore, no

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[3] Thus, no targets or distractors in either of the item tests were exactly as they were during study.

[4] Actors in the recombined pairs were matched according to sex and age group (young, middle-aged, or older), so that remembering only this information would not aid performance on the associative test.

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subject was presented with a person or action in the test on Day 2 that had been presented in the test on Day 1.

Procedure

Participants were tested individually. After signing consent forms, they were told that they would watch a series of video clips, each showing a different person performing a different action. Participants in the intentional learning condition were informed of the three tests to follow, and it was emphasized that they should attend to the actions, people, and the combination of the person with the action in each video clip. Those in the incidental learning condition were told that they would be watching the video clips as part of a later experiment.[5]

Subjects then viewed three example video clips, and any questions were answered (except for those that would provide information about the tests to the incidental learning group). Next, they viewed the entire study list of 75 clips, with a short (30-second) break approximately halfway through.

Following the study session, subjects took part in a five-minute interpolated activity (working a crossword puzzle). They then completed the three tests in an order counterbalanced across subjects. Before the action test, subjects were instructed that they would see only a person's hands performing various actions, and in preparation for the person test, they were informed that they would see clips of people only (i.e., people not performing any actions). In each of those two tests, they were aware that exactly half of

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[5] Pilot versions of this experiment were tested in which participants were given a cover task. Due to low performance, however, it was decided to use the present instructions.

the items were taken from the study list, and that the other half had not been viewed during study. They were instructed to press "1" on the keyboard for items they remembered and "0" for those which they did not remember. Finally, before the associative test, subjects were told that they would now see a person they saw during the study phase performing an action from the study phase, but that only half of the time would the person be doing the same thing as during study. In this case, they were to respond by pressing "1". Subjects were instructed to press "0" if the person in the test clip was performing an action that someone else had performed during the study phase. Each test was preceded by two practice items so that any questions could be answered before the recorded tests began.

After the testing session, all participants filled out a post-test questionnaire. They returned the next day to complete a different version of the tests, much as before, except without the practice tests. Again, order of tests (i.e., action, person, and associative) and test versions were counterbalanced across subjects. A second post-test questionnaire was then completed and subjects were debriefed.

Results

Memory performance was measured in terms of the proportion of hits minus the proportion of false alarms produced by each participant. Figure 1 presents the results for Day 1 and Day 2, separated by age group, learning condition, and type of test. Performance was above chance on all tests except for scores on the Day 2 person test produced by the older group under incidental learning, $t(23)=1.130$, $p=.270$.
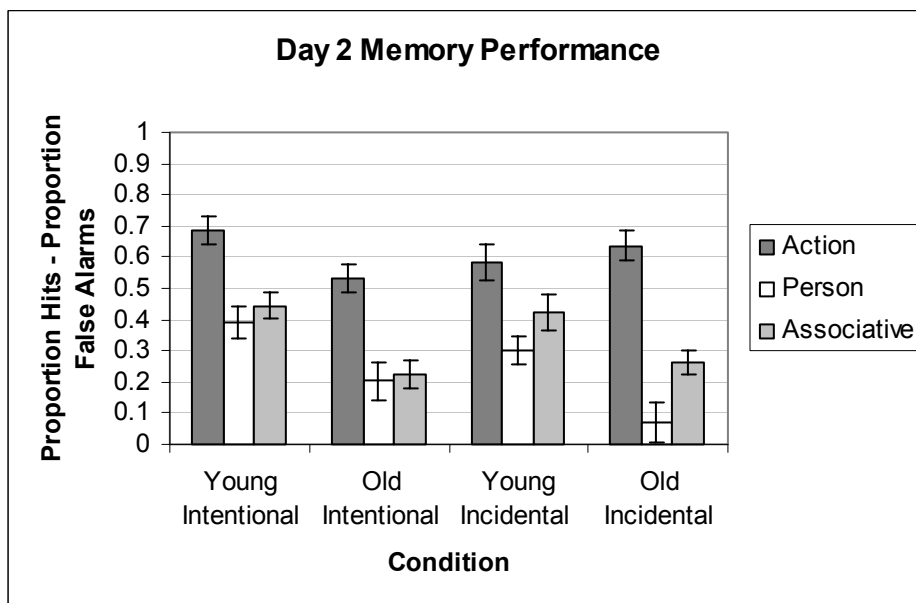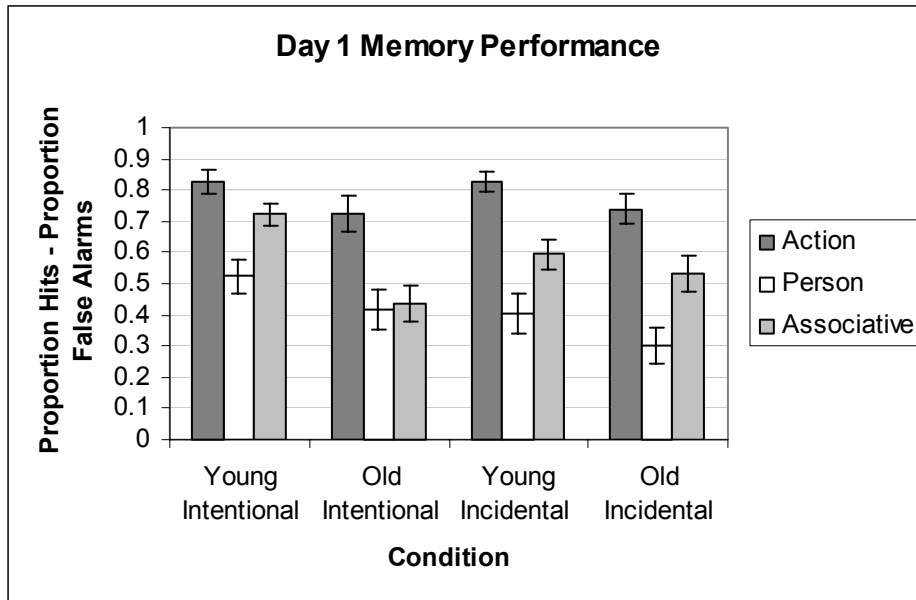
Figure 1. **Memory performance as a function of retention interval, age, learning condition, and test.**

(*Note.* Error bars represent standard errors around the mean.)

The first analysis conducted was a 4-way analysis of variance (ANOVA): 2 (age: young, old) x 3 (test: action, person, associative) x 2 (learning condition: intentional, incidental) x 2 (retention interval: Day 1, Day 2). This analysis revealed a significant effect of age, $F(1,93)=25.73$, $p<.001$, with younger participants ($M=.56$, $SD=.14$) outperforming older participants ($M=.42$, $SD=.13$). As expected, there was an effect of retention interval, $F(1,93)=123.91$, $p<.001$, with overall performance being higher on Day 1 ($M=.59$, $SD=.19$) than on Day 2 ($M=.40$, $SD=.16$). The effect of test was also significant, $F(2,92)=81.62$, $p<.001$. Performance on the action test ($M=.69$, $SD=.19$) was higher than that on the associative test ($M=.46$, $SD=.22$), $t(96)=10.15$, $p<.001$, which was higher than that on the person test ($M=.33$, $SD=.23$), $t(96)=5.20$, $p<.001$. Finally, the effect of learning condition was not significant, $F(1,93)=1.85$, $p=.18$; there were no significant differences between the intentional ($M=.51$, $SD=.15$) and incidental ($M=.47$, $SD=.15$) learning groups in terms of overall memory performance.

The 4-way interaction approached significance, $F(2,92)=2.72$, $p=.071$. For this reason, two 3-way ANOVAs were conducted, which tested the age x test x learning condition interaction separately for each day. This 3-way interaction was marginally significant on Day 1, $F(2,92)=2.67$, $p=.075$, but was nonsignificant on Day 2, $F(2,92)=1.30$, $p=.28$. Thus, Day 1 results were followed up, while Day 2 results were not analyzed further.

Day 1 results showed a nearly-significant age x test interaction for the intentional learning group, $F(2,45)=2.981$, $p=.061$, but this interaction was not significant for the incidental learning group, $F(2, 46)=.164$, $p=.849$. To locate the source of the interaction

in the intentional learning group, several 2 x 2 ANOVAs were conducted. These analyses revealed that age differences were larger on the associative test than on the action test, $F(1,46)=4.21$, $p=.046$ and were somewhat larger on the associative test than on the person test, $F(1,46)=3.70$, $p=.061$. Age differences did not differ between the action and person tests, $F(1,46)=.003$, $p=.96$. Furthermore, when scores on the action and person tests were averaged into one measure of "item memory", there was a significant interaction between age (older, young) and test (item, associative), $F(1,46)=6.08$, $p=.018$. Thus, by either analysis, this experiment provides evidence for an associative deficit of older adults, but only when encoding took place intentionally and when test occurred shortly after study.

Matched Groups Analyses

While an associative deficit was found for older adults under intentional learning, it is possible that this was merely the result of their poorer memory for individual people and individual actions. In other words, the age-related associative deficit could potentially be explained by older adults' inferior ability to recognize component information. In order to rule out this idea, a subset of older participants was matched with younger participants on Day 1 performance for both the action and person tests. In total, 14 pairs (i.e., 14 subjects in each age group) under intentional and 13 pairs under incidental learning instructions were included in the analysis. These data are shown in Figure 2.
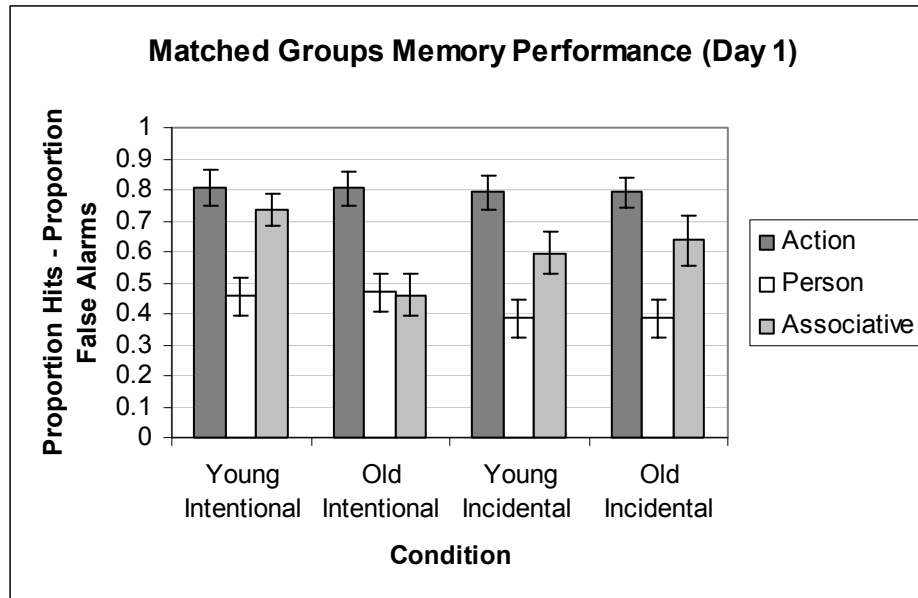
Figure 2. **Day 1 memory performance, when younger and older subjects were matched on action and person test scores.**

(*Note.* Error bars represent standard errors of the mean.)

Within these matched groups, there was a significant test x age x learning condition interaction, $F(2,49)=3.34$, $p=.044$. Follow-up analyses investigated the age x test interaction separately for each learning condition. This 2-way interaction was significant for subjects under intentional learning instructions, $F(2,25)=4.211$, $p=.027$; age differences were larger on the associative test than on the action or person tests, $F(1,26)=5.77$, $p=.024$; $F(1,26)=6.79$, $p=.015$, respectively. The age x test interaction was not significant for the incidental learning group, however, when all three tests were compared, $F(2,23)=.197$, $p=.82$. Thus, as made clear in Figure 2, a Day 1 age-related associative deficit existed even when the age groups were equated on both measures of item memory, but this effect was found only under intentional learning instructions.

Hits and False Alarms

In order to further assess the Day 1 associative deficit found in the intentional learning group, the proportion of hits and false alarms were examined for each test. These data are presented in Table 2. Both learning conditions are included in the table, but the following analyses were conducted only on the intentional learning group, as the other learning condition did not exhibit an associative deficit.

Table 2: Proportions of Hits and False Alarms on Day 1, Experiment 1

Learning	Age	Action Test			Person Test			Associative Test		
		Hits	FA	**H-FA**	Hits	FA	**H-FA**	Hits	FA	**H-FA**
Intent	Young	.86	.04	**.83**	.73	.20	**.52**	.91	.19	**.72**
	Old	.77	.04	**.73**	.68	.26	**.42**	.84	.40	**.44**
Incid	Young	.88	.05	**.83**	.64	.23	**.41**	.83	.23	**.60**
	Old	.76	.02	**.74**	.61	.31	**.30**	.87	.33	**.53**

Note. Intent=Intentional learning condition; Incid=Incidental learning condition; H=hits; FA=false alarms.

Age x test ANOVAs were conducted separately for proportion hits and proportion false alarms, based only on Day 1 results for participants under intentional learning instructions. In terms of hit rates, age differences were similar among the three tests, as revealed by a 2 (age) x 3 (test) ANOVA; this 2-way interaction was not significant, $F(2,45)=.21$, $p=.81$. There was a significant age x test interaction, however, involving the proportion of false alarms, $F(2,45)=7.19$, $p=.002$. Age differences were significantly larger on the associative than on the action test, $F(1,46)=14.69$, $p<.001$, and tended to be larger on the associative than on the person test, $F(1,46)=3.77$, $p=.058$, with older adults producing more false alarms than younger adults. There were no differential effects of aging when false alarm rates on the action test were compared to those on the person test, however, $F(1,46)=.60$, $p=.44$. These findings indicate that the associative deficit of older

adults under intentional learning conditions was due entirely to their increase in false alarms, as opposed to a decrease in hits, compared to younger adults.

Effects of Stimulus Age

In order to test the effect of actors' age on the associative deficit, a score for each subject was calculated for clips involving each age group of actor. In other words, each participant was given a separate score according to the proportion of correct responses to clips involving younger actors, for those involving middle-aged actors, and for those involving older actors. Day 1 results for older and younger actors are shown in Figure 3, and the following analyses are based on scores from Day 1 performance only, for those two age groups of actors.[6]

One hypothesis was that age differences on all tests might be reduced when older, as opposed to younger, actors were shown in the video clips. To assess this idea, a 3 (test) x 2 (stimulus-age) x 2 (participant-age) x 2 (learning condition) ANOVA was first conducted. This revealed a significant test x stimulus-age x participant-age interaction, $F(2,68)=3.140$, $p=.05$.[7] Separate stimulus-age x participant-age ANOVAs were conducted on each of the three tests. For the action and associative tests, these 2-way interactions were not significant, $F(1,71)=.23$, $p=.63$ and $F(1,95)=.90$, $p=.35$, respectively. The interaction was significant, however, for the person test, $F(1,95)=15.19$, $p<.001$.

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[6] The middle age group of actors was not included in the analysis, in order to maximize the detection of possible effects of stimulus age.

[7] The differences in degrees of freedom are due to the removal of scores from one version of the tests, as the number of actions that had been performed by young actors in the study clips was quite low.

Performance on Test Clips Involving Young Actors

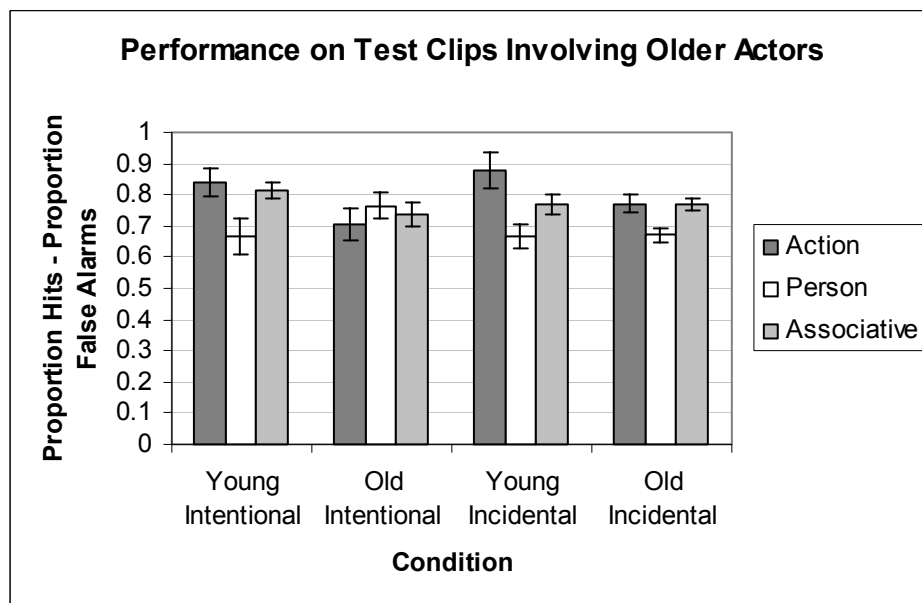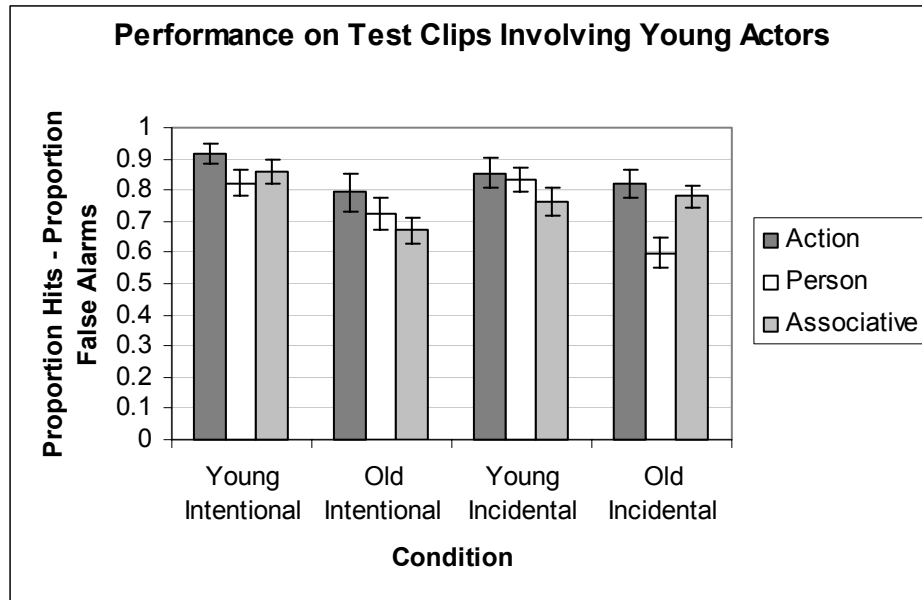**Performance on Test Clips Involving Older Actors**

Figure 3. **Memory performance as a function of test, participant age, and learning condition, separated by age of actor.**

(*Note.* Vertical bars represent standard errors around the mean.)

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Specifically, on the person test, young participants performed significantly better when asked to identify young, as opposed to older, stimuli, $t(48)=4.35$, $p<.001$. Older adults, on the other hand, did not show significantly higher scores for one than for the other stimulus age group, $t(47)=-1.33$, $p=.19$, but did tend to remember older actors better than younger actors. Thus, participants—especially the young adults—did exhibit an "other age effect" on the person test.

In order to test whether the associative deficit of older adults in the intentional learning group was ameliorated when the people in the clips were older, analyses similar to those above were conducted on only the intentional learning groups. The test x stimulus-age x participant-age interaction was not significant, $F(2,33)=1.42$, $p=.26$, indicating a similar age-related deficit on each of the three tests, whether older or younger actors were involved in the clips. Thus, the associative deficit of older adults under intentional learning was not significantly affected when older, as opposed to younger, actors were viewed in the video clips.

Discussion

One of the main goals of this experiment was to extend the ADH to a novel, dynamic set of stimuli. The central hypothesis was that there would be an age-related deficit in memory for people bound with their actions, as compared to memory for individual people or actions. This hypothesis was partially supported. An associative deficit of older adults was found, but only under intentional—not incidental—learning instructions. This finding was somewhat unexpected; while past research has found a

larger age-related associative deficit when material was intentionally encoded than when learning occurred incidentally, participants under incidental learning instructions have nevertheless exhibited this deficit to some degree (e.g., Naveh-Benjamin, 2000).

There are several possible reasons for the discrepancies between this experiment and previous ones. First, in the present experiment, subjects either expected all three tests or none of them. In previous experiments, however, (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000), participants were led to expect a test on only the item information or only the associative information, and were then tested over both. Younger adults attempting to learn the items may have been better able than the older adults to automatically encode the way in which items were paired during study. This would produce an age-related associative deficit in participants whose associative learning took place incidentally. In the present experiment, however, the incidental learning group presumably did not attempt to encode even the item information. Thus, the instructional differences between experiments may have resulted in the discrepant findings in question.

Another possible explanation for the lack of an associative deficit of older adults under incidental learning conditions in the present study is that, because many of the older participants had been involved in somewhat similar research before, they might have expected the associative test regardless of the learning instructions. In a post-test questionnaire, older adults in the incidental learning group rated the associative test somewhat higher than the item tests when asked how strongly they had suspected that

each test would be given.[8] Thus, perhaps older adults under incidental learning focused

their attention on the associative information, while those under intentional learning

attempted to learn all of the information necessary for the upcoming tests. If attentional

resources become limited with age, as suggested by Craik and colleagues (e.g., Craik,

1983, 1986), then older subjects may have had difficulties in learning both item and

associative information.

Further support for this idea is provided by conducting a median split within each

age group in terms of overall self-reported test expectancy levels[9], and then comparing

Day 1 memory scores of participants with high levels of test expectancy to those with

low levels. When results of only those subjects who reported that they had not

anticipated the tests—the "pure incidental" group—were analyzed, there was a trend

toward an associative deficit of the older adults.[10] However, the older adults in the

incidental condition who expected the tests did not exhibit such a deficit. Thus, the lack

of an associative deficit of older adults under incidental learning may have been driven

by a subgroup of subjects who had expected the tests. This idea, of course, brings up

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[8] Expectation levels for each test were provided by participants on a ten-point scale. The 3 (test) x 2 (age) interaction was not significant, $F(2,41)=1.76$, $p=.18$, but there was a tendency for young adults to report expecting the item tests more than the associative tests, while older adults showed a trend in the opposite direction.

[9] These levels were calculated by averaging each subject's self-reported expectations of each of the three tests; values lying on the exact median were excluded from the reported analyses.

[10] The 2 (test: item, associative) x 2 (age) x 2 (test expectancy level: high, low) ANOVA revealed a significant 3-way interaction, $F(1,34)=6.19$, $p=.018$. For participants with low expectation levels, a test x age interaction was not significant, $F(1,17)=2.39$, $p=.14$, but age differences were somewhat larger on the associative than on the item measure. This two-way interaction in the high expectation group approached significance, $F(1,17)=3.87$, $p=.066$; interestingly, the older adults actually (nonsignificantly) outperformed the younger adults on the associative test, while the opposite effect of age was exhibited on the item measure.

another question, namely, why did the high-expectancy incidental group *not* show an associative deficit, whereas the intentional learning group *did*? One possibility is that, in the former group, learning occurred intentionally mainly for the associations, creating relatively low scores on the item memory measures and thus negating an associative deficit. This issue must be investigated in future experiments, but will be discussed further in the General Discussion.

Another finding, which is in line with previous research on eyewitness testimony, was that the age-related associative deficit of participants (in the intentional learning condition) was due fully to an increased proportion of false alarms, as opposed to a decrease in hit rates, on the part of the older adults. It seems that older adults adopt a less conservative approach when identifying actors, compared with younger adults. Possible reasons for this finding will be discussed in the General Discussion.

This experiment also investigated the effect of retention interval on the associative deficit. While for the intentional learning group, an age-related associative deficit did exist on Day 1, this deficit was not found on Day 2. This result was somewhat surprising. In a previously mentioned study using similar stimuli (Kersten, et al., 2003), there were some indications of an age-related associative deficit even after a weeklong retention interval. One explanation for this discrepancy between experiments is that the present experiments required learning of more than twice as many video clips as in the Kersten, et al. study, likely making the task more difficult. Possible floor effects may have obscured significant effects on Day 2. It is also possible that differences in

methodology (e.g., Kersten, et al. did not explicitly test memory for item information) are responsible for the conflicting findings.

Finally, this study evaluated one possible factor which might reduce the associative deficit—the factor of the actors' ages in the video clips. An "other age" effect was found on the person test; younger adults performed better on clips showing young actors than those showing old actors, while older adults tended toward a bias in the opposite direction. However, the age-related associative deficit was not reduced when older actors, compared to younger actors, were shown in the video clips.

Experiment 2

Experiment 2 was intended to evaluate one possible source of older adults'

decline in episodic memory—a reduction in attentional resources (e.g., Craik, 1983,

1986). In this experiment, young adults under intentional learning instructions took part

in a concurrent continuous response time (CRT) task during encoding only (the "DA/FA"

condition) or during both encoding and retrieval (the "DA/DA" condition).

Employing this manipulation of attention allows for the formation of assumptions

regarding whether older adults' decline in memory performance is due to a reduction in

attentional resources, and if so, whether those resources are reduced at encoding,

retrieval, or both. If the age-related reduction in episodic memory is mediated by reduced

attentional resources, then the DA group—and the DA/DA group, in particular—should

produce patterns of performance that are similar to those of older adults under intentional

learning conditions. Specifically, the DA groups should exhibit an associative deficit.

Additionally, if older adults' attentional resources are in fact reduced,

comparisons between the two young DA groups may provide clues as to when during

processing older adults' deficit occurs. If the reduction occurs only at encoding, then

older adults' results should be resembled by the DA/FA and DA/DA groups to a similar

extent. If this reduction occurs at both encoding and retrieval, then performances of both

of the young DA groups should show similarities to that of the older intentional learning

adults, but this resemblance should be most apparent in the DA/DA group. Finally, it is

possible that older adults' resources are limited mainly during retrieval. If this is the

case, then the DA/DA group, but not the DA/FA group, should show similarities in performance to the older group.

Furthermore, a CRT task is presumed to affect strategic, effortful processing, while leaving automatic processing relatively intact. Thus, the finding that DA in young adults leads to a similar decline on all three tests (compared to younger adults under full attention in the intentional learning condition from Experiment 1), would suggest that the associative deficit of older adults is due to a decline in the automatic processing of associative information. On the other hand, if younger adults produce an associative deficit when under DA, thus resembling older adults, this would suggest that the age-related associative deficit is a result of older adults' difficulties using strategy to create and/or retrieve links between associated information.

Briefly, the following hypotheses were tested in this experiment:

1. There will be a main effect of attention, in that both DA groups in Experiment 2 will perform more poorly than the young FA group under intentional encoding from Experiment 1.

2. Young adults under DA at encoding will be disadvantaged to a similar degree on each of the three tests (i.e., they will not show an associative deficit). This prediction is based on previous findings mentioned earlier (Naveh-Benjamin, et al., 2003; Naveh-Benjamin, et al., 2004).

3. The effect of DA at both encoding and retrieval has not been previously investigated in terms of the associative deficit. However, if a reduction in

attentional resources is a mediator of the associative deficit, and older adults'

resources are assumed to be reduced at both encoding and retrieval, then young

adults whose attention is divided at both study and at test should exhibit an

associative deficit.

Method

Participants

Data were collected from 48 young adults between the ages of 18 and 33 years.

Participants were students at the University of Missouri-Columbia, and received credit in

their introductory psychology course in return for their participation. They were

randomly assigned to the DA at encoding only ("DA/FA") group or to the DA at both

encoding and retrieval ("DA/DA") group. The male to female ratio was similar to that of

younger subjects from Experiment 1. Participants in this experiment averaged about one

fewer year of formal education, compared to the younger adults from Experiment 1,

$t(95)=3.145$, $p=.002$.[11] This difference is most likely due to the time of year during

which testing occurred. Additional demographic information is provided in Table 1.

The FA (full attention) group involved in some of the following analyses is

simply the young, intentional learning group from Experiment 1. This group's results

from the first experiment were reproduced here in order to detect the effects of DA in

Experiment 2.

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[11] *t*-tests revealed no significant differences in performance between participants with more and those with fewer years of education, for any condition of young adults, on any of the tests.

Design

This experiment consisted of a 3 (test: action, person, associative; within subjects) x 2 (attention: divided at encoding only, divided at encoding and retrieval; between subjects) x 2 (time interval: Day 1, Day 2; within subjects) design.

Materials

Materials for the memory task were identical to those used in Experiment 1. In addition, the concurrent continuous response time (CRT) task in this experiment required continuous responses to a series of three different pitches of tones. Each tone sounded immediately after a response was made to the previous tone. The sounds were played through headphones, and responses were made by pressing one of three adjacent keys on a keyboard, which were labeled "L", "M", and "H", corresponding to the low-, medium-, and high-pitched tones.

Procedure

The procedure was quite similar to that of Experiment 1, with two modifications. First, because this experiment was intended to investigate the associative deficit of older adults found in Experiment 1, which was present only in the intentional learning condition, all subjects in Experiment 2 received intentional learning instructions. Second, half of the subjects performed a concurrent CRT task during encoding only; the other half performed the concurrent task during both encoding and retrieval.

After signing a consent form, subjects were told that they would hear a series of tones in three different pitches and that they should respond to each tone by pressing the

appropriate key on a keyboard. Participants were informed that each of their responses

would immediately elicit the next tone, and were asked to respond as quickly and as

accurately as possible to each tone. This task was chosen because it does not involve a

memory component, resulting in a relatively pure effect of DA on memory performance.

Each subject first performed two one-minute practice sessions for the concurrent

CRT task, and then a baseline lasting approximately two minutes. The study session and

test session were conducted as in Experiment 1, with subjects performing the tone task

either during study only or during both study and test. Participants were instructed to

divide their attention equally between the two tasks.

Following the test session, subjects performed a second baseline on the tone task.

As in Experiment 1, all participants returned on the following day. Session 2 for those in

the DA/FA condition was the same as for those in Experiment 1. Those whose attention

was divided at study and at test began Day 2 with a 1-minute practice session for the tone

task, then a third baseline. Following the test, a fourth baseline was taken.[12]

Results

As in Experiment 1, memory performance was measured in terms of the

proportion of hits minus the proportion of false alarms produced by each participant.

Figure 4 presents the results for Day 1 and Day 2, separated by learning condition and

test type. In the following analyses, data for the FA group are taken directly from the

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[12] Baselines were not taken on Day 2 in the DA/FA group, because these participants did not undergo DA
at all on Day 2. Furthermore, this group would be more comparable to the younger, full attention group
under intentional learning instructions from Experiment 1 if a baseline was not taken on Day 2.

Day 1 Memory Performance

Day 2 Memory Performance

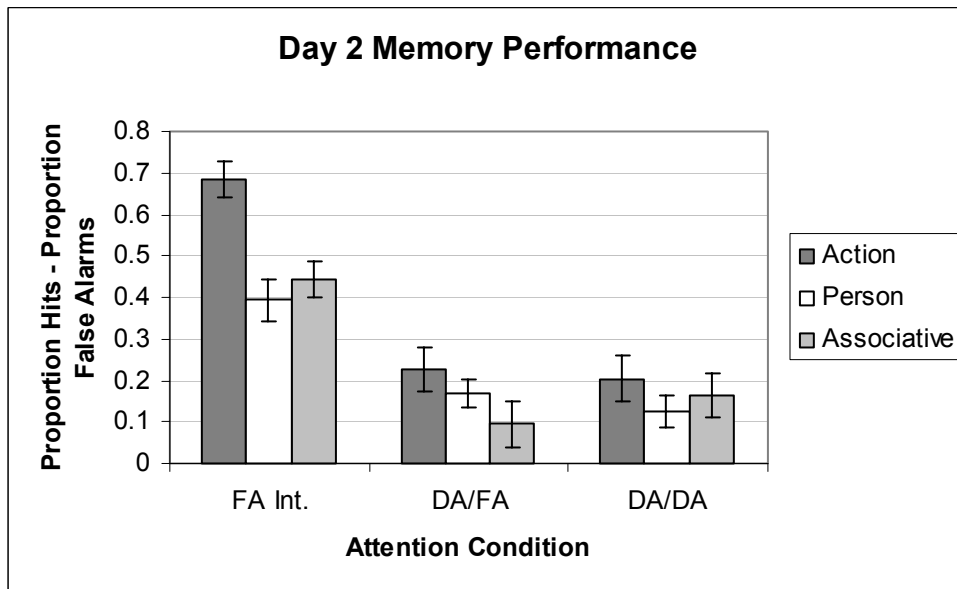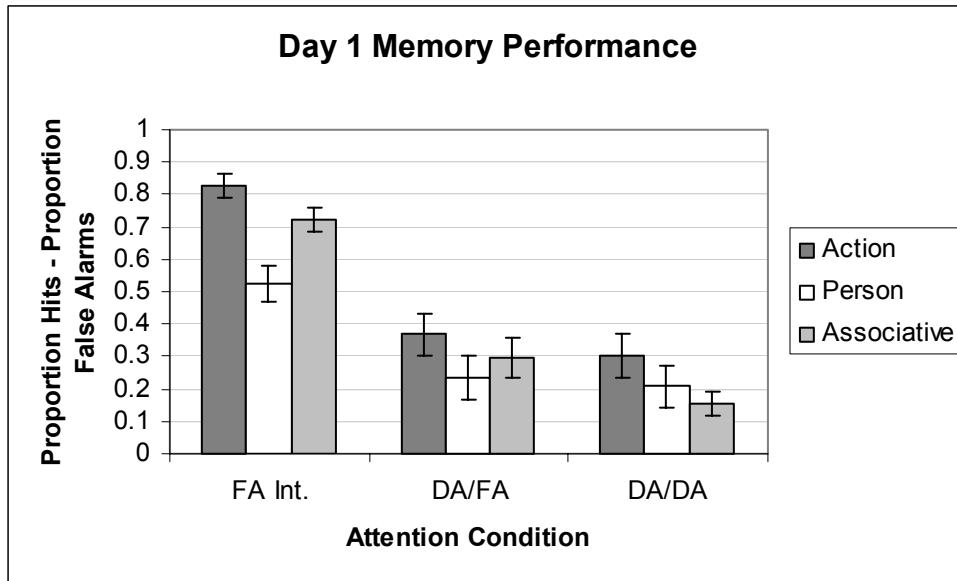*Figure 4.* **Memory performance as a function of retention interval, attentional condition, and test.**

(*Note.* FA Int.=Young adults under intentional learning instructions, taken from Experiment 1; DA/FA=young adults under divided attention at encoding only (Experiment 2); DA/DA=young adults under divided attention at encoding and retrieval (Experiment 2); error bars represent standard errors around the mean.)

results of the young adults under intentional learning instructions from Experiment 1, as this group differs from the Experiment 2 groups in terms only of attention.

The first analysis conducted was a 3 (attention: FA, DA/FA, DA/DA) x 3 (test: action, person, associative) x 2 (retention interval: Day 1, Day 2) ANOVA. This analysis revealed a main effect of day, $F(1,69)=24.47$, $p<.001$, with Day 1 performance ($M=.26$, $SD=.21$) being higher than Day 2 performance ($M=.16$, $SD=.14$). A main effect of test, $F(2,68)=23.79$, $p<.001$, indicated that action test scores ($M=.28$, $SD=.17$) were higher than those on the person ($M=.18$, $SD=.17$) and associative ($M=.18$, $SD=.21$) tests. There was also a main effect of attention, $F(2,69)=82.08$, $p<.001$, with the FA group ($M=.60$, $SD=.11$) outperforming the DA/FA group ($M=.23$, $SD=.12$) and the DA/DA group ($M=.19$, $SD=.13$).[13] The 3-way interaction was not significant, $F(4,138)=1.48$, $p=.21$. This analysis revealed only one significant interaction, that between test and attention, $F(4, 138)=3.84$, $p=.005$. In order to detect the source of this 3 x 3 interaction, more specific comparisons were made, in which each DA group was individually compared to the FA group.

A 2 (attention) x 3 (test) ANOVA was conducted to compare only the FA and DA/FA groups, using scores on each test averaged across the two days. This interaction was significant, $F(2,45)=5.50$, $p=.007$. Two 2 (attention) x 2 (test: action versus associative or person versus associative) ANOVAs showed that the differences in

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[13] As additional evidence that attention was divided between the two tasks, response times to the CRT task were significantly slower for the DA/FA group during study, $t(23)=7.24$, $p<.001$ for Day 1, and for the DA/DA group during both study, $t(23)=8.01$, $p<.001$ and test, $t(23)=7.75$, $p<.001$, on Day 1, as compared to baseline (i.e., when the CRT task was performed alone).

performance between these two groups were similar on the action and associative tests, $F(1,46)=.96$, $p=.33$, but were somewhat larger on the associative than on the person test, $F(1,46)=2.99$, $p=.09$. The latter of these findings offers some evidence of an associative deficit created by dividing the attention of younger adults during encoding, although this evidence is somewhat ambiguous.

A second 2 (attention: FA, DA/DA) x 3 (test) ANOVA was conducted to compare only the DA/DA group to the FA group. This interaction was also significant, $F(2,45)=6.18$, $p=.004$. Follow-up analyses were conducted in the same manner as in the above comparisons. Attentional differences were not significantly different on the action than on the associative test, $F(1,46)=1.57$, $p=.22$, but were larger on the associative than on the person test, $F(1,46)=6.93$, $p=.012$. Thus, dividing the attention of younger adults during encoding only or during both encoding and retrieval processes did lead to an associative deficit when memory for component information involved people only, but not when it involved actions only.

Next, in order to examine whether an associative deficit existed when scores on the action and person tests were averaged into one measure of "item memory," two 2 x 2 ANOVAs were conducted. Whether the DA/FA or the DA/DA group was compared to the FA group, the attention x test (item, associative) interaction was not significant, $F(1,46)=.19$, $p=.66$ and $F(1,46)=.38$, $p=.54$, respectively. Thus, by this measure, neither of the DA groups exhibited an associative deficit.

Day 1 Results

Although the retention interval factor was not involved in a significant interaction, it was felt that the analysis of Day 1 results alone was justified by findings from Experiment 1.[14] Thus, because the older adults under intentional learning instructions in Experiment 1 exhibited an associative deficit only at the shorter of the two retention intervals, additional analyses were conducted on performance from Day 1 only. These analyses were intended to more precisely determine to what extent the performance of younger adults under DA resembled that of older adults. First, using scores from Day 1 only, a 3 (attention: FA, DA/FA, DA/DA) x 3 (test: action, person, associative) ANOVA was conducted. This revealed an effect of test, $F(2,68)=8.60$, $p<.001$ and of attention, $F(2,69)=42.09$, $p<.001$. The test x attention interaction was not significant, $F(4, 138)=1.80$, $p=.13$. Because this interaction approached significance, however, follow-up analyses were conducted to compare each individual DA group with the FA group.

The 2 (attention) x 3 (test) interaction was not significant when the FA and DA/FA groups were compared, $F(2,45)=1.34$, $p=.27$, but was significant when the FA and DA/DA groups were compared, $F(2,45)=5.03$, $p=.011$. In the latter comparison, attentional differences were larger on the action than on the person test, $F(1,46)=4.05$, $p=.05$, and larger on the associative than on the person test, $F(1,46)=10.28$, $p=.002$. Attentional costs did not differ, however, between the action and associative tests, $F(1,46)=.301$, $p=.582$, again making the results difficult to interpret. When the action

[14] Furthermore, Day 2 scores were not significantly above chance on the associative test for the DA/FA group, $t(23)=1.72$, $p=.10$; low scores may have made it difficult to detect test differences.

and person test scores were averaged into one "item memory" measure, though, the

attention (FA, DA/DA) x test (item, associative) ANOVA was significant, $F(1,46)=5.84$,

$p=.02$. Thus, by this analysis, younger adults whose attention was divided during both

study and test did tend to exhibit a deficit similar to that of older adults, while younger

adults whose attention was divided at only study did not.

Hits and False Alarms

As in Experiment 1, rates of hits and false alarms were also analyzed. These

proportions for each test are reported in Table 3, along with the results of the younger

adults under intentional learning instructions from Experiment 1.

Table 3: Proportions of Hits and False Alarms on Day 1, Experiment 2

Age	Attention	Action Test			Person Test			Associative Test		
		Hits	FA	**H-FA**	Hits	FA	**H-FA**	Hits	FA	**H-FA**
Young	FA	.86	.04	**.83**	.73	.20	**.52**	.91	.19	**.72**
	DA/FA	.56	.19	**.37**	.52	.29	**.23**	.62	.32	**.30**
	DA/DA	.59	.29	**.30**	.63	.42	**.21**	.59	.44	**.15**

Note. FA=young adults under full attention and intentional learning instructions, taken
from Experiment 1; DA/FA=divided attention at encoding; DA/DA=divided attention at
encoding and retrieval; H=hits; FA=false alarms.

Although Table 3 shows both DA groups, analyses were performed comparing

only the DA/DA group to the FA group, as the DA/FA group did not exhibit an

associative deficit. The following analyses were conducted in order to determine if the

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associative deficit of younger adults under DA at encoding and retrieval stemmed from the same source as that of the older adults under intentional learning instructions from Experiment 1—namely, an increased proportion of false alarms, as compared to young adults under FA and intentional learning instructions.

Testing the proportion of hits produced on Day 1, a 2 (attention: FA, DA/DA) x 3 (test) ANOVA revealed a significant interaction between attention and test, $F(2,45)=7.75$, $p=.001$. Follow-up analyses showed that attentional differences were similar on the action and associative tests, $F(1,46)=.65$, $p=.42$. However, those differences were significantly larger on the associative than on the person test, $F(1,46)=15.36$, $p<.001$ and on the associative test than on an overall "item test" (i.e., proportion of hits averaged across the action and person tests), $F(1,46)=7.81$, $p=.008$. Thus, it appears that the associative deficit of the younger adults under DA at study and test was at least partially due to decreased hit rates on the associative test. However, this conclusion may be drawn only when performance on the person test is involved in the analysis, either alone or averaged with action test performance.

Similar analyses were conducted on rates of false alarms. A 2 (attention: FA, DA/DA) x 3 (test) ANOVA was not significant, $F(2,45)=.10$, $p=.91$. Thus, while the DA/DA group resembled older adults under intentional learning, in that both groups showed an associative deficit on Day 1, the source of this deficit was different for each group. Whereas older adults' associative deficit stemmed from an increase in false alarms, that of the younger group was due mainly to a decrease in hits.

Discussion

Experiment 2 produced somewhat ambiguous—yet interesting—results. There were some indications that younger adults whose attention was divided at either study only or at both study and test did exhibit an associative deficit. These results, however, are largely open to interpretation. When scores were averaged across the two retention intervals, both DA groups exhibited an associative deficit when item memory scores were based upon performance on the person test. Neither group, however, showed this deficit when item memory scores were based on action test performance; thus, in that analysis, there was not convincing evidence of an associative deficit of younger adults under DA.

Results were slightly less ambiguous when the results from just Day 1 were considered; the DA/DA group exhibited an associative deficit on Day 1, while the DA/FA group did not. This result must be interpreted with caution, as retention interval was not involved in any interactions, and action and person test scores were merged into an overall measure of "item memory". Nevertheless, this finding is quite interesting. Young adults under DA at both encoding and retrieval exhibited similar patterns of memory performance as those produced by older adults.

Furthermore, in line with previous findings (e.g., Naveh-Benjamin, Craik, Guez, & Dori, 1998; Naveh-Benjamin, Craik, Perretta, & Tonev, 2000), DA at retrieval did not generally reduce memory performance more than did DA at encoding, but retrieval resulted in greater costs on the concurrent task than did encoding.[15] These findings

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[15] This is shown by comparison of attentional costs, figured by subtracting response times to the secondary task during baseline from those during study or test. On Day 1 for the DA/DA group, attentional costs were larger during test than during study, $t(23)=3.95$, $p=.001$.

support the view that while only encoding is under cognitive control, both encoding and retrieval require attentional resources (e.g., Anderson, Craik, & Naveh-Benjamin, 1998).

The present experiment extended beyond the methods used in previous studies, in that it included a group in which attention was divided during both encoding and retrieval. Performance of dual tasks during study and test tended to reduce performance on the associative test beyond the reduction produced by DA at encoding only; this effect was not seen, however, on either of the item tests.[16] This suggests that DA may interfere with the retrieval of relational information. As noted above, then, the associative deficit of older adults could be partially due to insufficient attentional resources during the retrieval of associative information.

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[16] On Day 1, the DA/FA and DA/DA groups performed similarly on the action test, $t(46)=.70, p=.49$ and on the person test, $t(46)=.26, p=.80$, but the DA/FA outperformed the DA/DA group on the associative test, $t(46)=2.00, p=.05$.

General Discussion

Results of these experiments vary in the degree to which they support the hypotheses under investigation. Findings of Experiment 1 provided partial support for the ADH; an associative deficit was exhibited by older adults on Day 1 when learning occurred intentionally. A similar deficit, however, was not found in the incidental learning group, and did not exist on Day 2 for either of the learning conditions. Experiment 2 found some evidence of an associative deficit in young adults whose attention was divided at encoding and retrieval. That group's deficit, though, seemed to involve different mechanisms than that of the older intentional learning participants; the former group exhibited a decreased rate of hits, whereas the latter group produced high rates of false alarms, on the associative test. Young adults whose attention was divided only at encoding did not show major signs of an associative deficit.

In attempting to explain the present results, it is informative to closely examine the way in which the test clips were constructed. For both item tests, all targets and distractors were created separately from the study clips from which they were derived; action test clips showed only a person's hands doing an action—and that person was different than the original actor—and clips in the person test showed people sitting idly. However, the targets from the associative test were the exact same clips as those shown during study, while distractors in that test included actions that may have been performed slightly differently than those in the study clips. This design would have allowed participants who had focused on only the actions during study—without paying attention

to the actor—to achieve high scores on the associative test. In other words, an associative test clip could be correctly accepted if an action was performed in the exact same way as in the study clip, and could be correctly rejected if the action was performed any differently than in the study clip. The way in which an action was performed, therefore, would have aided performance on the associative test, but not on the action or person tests. For example, if a study clip showed a man pressing buttons on a calculator using only his index finger, a distractor from the associative test could be rejected if the actor in that clip used several different fingers to press the calculator keys. In the present experiment, then, correct responses on the associative test did not necessarily require recognition of either the person or the action, but instead may have relied on memory for how an action was performed.

These differences between item and associative test construction may help to explain the lack of an associative deficit of older adults under incidental learning. Perhaps older adults in that condition focused on the actions being performed, as movement is likely to draw one's attention, while those under intentional learning attempted to learn a large amount of specific information. If older adults do indeed have fewer available processing resources than do younger adults, as proposed by Craik and colleagues (e.g., Craik, 1983, 1986), the younger group under intentional learning instructions may have been able to learn information for all three tests, while the older group could not.

If participants did in fact benefit from learning the way in which an action was performed, it might be reasoned that scores on the associative test should be more highly

correlated with action test performance than with performance on the person test. Furthermore, this difference in correlations should be more apparent in groups that were able to use this contextual information—presumably, the incidental learning groups— than in those that were less able to use the information—especially the older, intentional learning group. Table 4 presents the correlations among each of the three tests.

Table 4: Pearson Correlations Between Action, Person, and Associative Test Scores on Day 1

	Y-Int	O-Int	Y-Inc	O-Inc	Y-DA/FA	Y-DA/DA
Action-Person	.26	-.15	.23	-.09	.23	.13
Action-Associative	.47 *	-.05	.67 **	.63 **	.36 ^	.07
Person-Associative	.23	.30	.36 ^	.22	.02	.55 **

Note. "Y" and "O" refer to participant age, young and older, respectively; "Int" and "Inc" refer to learning condition, Intentional and Incidental, respectively; "DA/FA" is the condition in which attention was divided at encoding only, and "DA/DA" is the condition in which attention was divided at both encoding and retrieval. (** $p<.01$; * $p<.05$; ^ $p<.10$)

Data did, in fact, show significant correlations between action and associative test scores for young adults in either learning condition and for older adults under incidental learning instructions; correlations between person and associative test scores were not significant in any of those groups. However, the pattern of correlations was quite different for the older adults under intentional learning. For this group, neither of the two

correlations of interest was significant, with that between the person and associative measures being somewhat *stronger* than that between the action and associative measures (with the latter correlation being slightly *negative*). These findings lend support to the idea that older adults who are instructed to learn the actions, people, and associations, are unable to utilize the contextual cues associated with the way in which an action is performed.

Table 4 also shows the test correlations for the young DA groups from Experiment 2. When attention was divided at encoding only, the pattern of correlations was similar to those for the young FA participants. Interestingly, however, the DA/DA group exhibited correlations resembling those of the older intentional learning group, with the only significant correlation being that between the person and associative test scores. This finding could indicate that, at least in younger adults, peripheral cues are encoded even when a concurrent task is being carried out, but that attention is required in order for those cues to be used effectively during retrieval. It is also possible that manual responses to the concurrent task interfered with retrieval of visually perceived motor information. Furthermore, these analyses provide additional evidence of the similarity between the older intentional learning group from Experiment 1 and the young DA/DA group from Experiment 2.

The finding that young adults under DA at both study and test did exhibit an associative deficit (on Day 1) that was similar to that of older adults provides a limited degree of evidence for Craik's (1983, 1986) notion that older adults' attentional resources are depleted. This deficit, however, differed with respect to patterns of hits and false

alarms, with the young DA/DA group producing relatively low rates of hits, and the older intentional learning group producing high rates of false alarms on the associative memory measure. No associative deficit was exhibited by young adults under DA at encoding only, a finding which is consistent with some previous studies (e.g., Naveh-Benjamin, et al., 2003; Naveh-Benjamin, et al., 2004), but contrasts with other evidence (e.g., Castel & Craik, 2003). The results of Experiment 2 are partially in line with the finding of Troyer and Craik (2000) that DA at encoding equally disrupted memory for words and for word order, while DA at both encoding and retrieval disrupted memory for word order—the binding of verbal and temporal information—more than that for individual words. Taken together, results of the two DA groups in Experiment 2 suggest that the associative deficit of older adults is partially due to a reduction in attentional resources, and that this deficit involves retrieval rather than encoding processes.

Another issue brought forth by the present experiments involves why the associative deficit of older adults was due to a tendency to commit false alarms, while that of young adults under DA at encoding and retrieval was largely due to a decreased proportion of hits. Perhaps this question can be answered through the distinction between recollection (i.e., memory for qualitative information from an encoded event), and familiarity, which is a sense of having encountered a stimulus before without recollecting contextual information. Familiarity alone would have allowed participants to accept or reject clips from the action or person tests, as only the targets had been seen during study. On targets and distractors from the associative test, however, participants were familiar

with both the actions and the people. Thus, recollection may have been required in order to respond correctly to associative test items.

Given a distractor from the associative test, young adults under full attention may have recalled the action which the person in that distractor had performed in the study clip; this recollection would have led to the correct rejection of that distractor. Older adults, however, may have been less able to use this recall-to-reject strategy, which would explain their tendency to produce false alarms on the associative test. Along the same line of reasoning, though, the associative deficit exhibited by young adults under DA at study and test—who presumably were forced to rely on familiarity—should have also been due to increased false alarm rates. Perhaps those participants were more aware of their limitations than were the older adults, and thus responded more conservatively.

One goal of the present studies was to assess possible mechanisms behind the age-related decline in episodic memory. Taken together, the results of Experiments 1 and 2 generally support the idea that strategic processes are more affected by aging than are automatic processes. In Experiment 1, it is assumed that subjects in the intentional learning condition were able to use both strategic and automatic resources, while those in the incidental learning condition relied mainly on automatic processes. There were age differences in memory performance for both learning conditions, suggesting that a decline in automatic processing does play a role in the overall effects of aging on episodic memory. However, on the associative test, only the intentional learning group showed significant age differences. This suggests that the age-related associative deficit is largely related to a decline in strategic—but not automatic—processes. It appears that

young adults were more able than were older adults to take advantage of receiving a warning about the upcoming tests.

Results from Experiment 2 offer further insight into the mechanisms behind the age-related associative deficit found in Experiment 1. As noted earlier, it can be assumed that divided attention mainly interrupts strategic processing, while leaving automatic processing relatively intact. In the present experiment, young adults whose attention was divided at encoding and retrieval showed a pattern of Day 1 performance—including an associative deficit—similar to that shown by the comparable group of older adults in Experiment 1. This corroborates the previous argument that older adults' associative deficit stems from difficulties in strategic processing. Furthermore, because the younger adults whose attention was divided during only encoding did not exhibit an associative deficit, it may be surmised that the age-related associative deficit is largely due to problems (in strategy use) that occur during the retrieval processes of older adults. While such an interpretation must be made cautiously, this idea is definitely worthy of further investigation.

With the quickly expanding use of neuroimaging, it is also profitable to investigate the neurological correlates of age-related changes in memory functioning. While there seems to be some consensus that older adults are more disadvantaged in memory for associative than for item information, the neurological component related to this difference is still being debated. One model of memory which is highly relevant to the ADH was proposed by Moscovitch (1992). This model holds that effortful, strategic processing is carried out by the frontal lobes, while the medial temporal/hippocampal

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areas are involved in the automatic binding of events. In a somewhat opposing view, McDaniel, Butler, and Dornburg (in press) believe that memory for "relevant" information depends on medial-temporal processes, while that for "peripheral" information depends on frontal processes. If relevant information is encoded strategically and peripheral information is encoded automatically, then the suggestion of McDaniel, et al. directly contrasts with Moscovitch's model.[17]

It is thought that the decline of medial-temporal structures that occurs with aging is not as extreme as that of the frontal structures (e.g., Raz, 2000; West, 1996), although it has been shown that feature binding deficits of older adults are partially due to hippocampal dysfunction (Mitchell, Johnson, Raye, & D'Esposito, 2000). If frontal structures do in fact suffer more from aging than do hippocampal structures, then Moscovitch's (1992) model predicts a greater decline in strategic than in automatic binding as people age. The view of McDaniel, et al. (in press), on the other hand, predicts that memory for peripheral information will suffer more with aging than will memory for relevant information.

As discussed, results of both of the present experiments suggest that the age-related associative deficit is due mainly to strategic differences between age groups, which supports Moscovitch's (1992) model. This does not necessarily preclude support for McDaniel, et al.'s (in press) model, however. It seems that at least some older adults—those in the intentional learning condition—were unable to use the peripheral

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[17] However, this assumption of such a sound relationship between focus and relevant processes is imprecise, especially in laboratory experiments. For example, even peripheral information may be learned intentionally.

information regarding details of the way in which an action was performed, in order to boost their performance on the associative test. Support for this latter model, however, is obviously quite mixed in regard to the present experiments; older adults seem to have been able to remember peripheral information when that information was learned incidentally.

Finally, while the present experiments do provide interesting results, it is important to note several limitations. One of these, as discussed, is the matter of greater contextual support in the associative test than in the item tests. One way in which to limit these effects would be to rerecord the associative test targets, so that there would be a degree of difference between all test clips and the study clips from which they were derived. Another possibility is to include only verbal descriptions of the actions in the action and associative tests; this would prevent the way in which an action was performed from influencing results.

A second limitation of the present experiments lies in the ambiguity in interpretation of the results. Different conclusions may be drawn when associative performance is compared to action performance than when it is compared to person performance or to an average of those two measures. Perhaps future experiments will help to elucidate a concrete method by which two measures of item memory may be compared to a single measure of associative memory.

A few other limitations apply only to Experiment 2. One of these involves the low performance of the younger adults under divided attention; this made it somewhat difficult to compare these groups to the higher-performing groups from Experiment 1.

Levels of performance could perhaps be raised by employing a less-demanding concurrent task, although this task would need to be non-visual and nondependent upon memory processes. Future experiments could also limit the number of stimuli in order to raise performance; this was not possible in the present experiments because the effect of retention interval was of interest, requiring twice as many stimuli as would otherwise be needed.

Furthermore, Experiment 2 might have been more powerful if a within-subjects design had been used in conjunction with the full attention condition from Experiment 1 (i.e., if each participant had performed the memory task both alone and during the concurrent task). Such a design, however, would be highly impractical. One of the advantages of the present experiments was that, in general, each study clip provided information for only one test clip. For example, if the actor from a particular study clip was included in the person test, then the action that the person had performed in the study clip could not be presented in the action test; this design eliminated the possibility that the ineffective encoding of just one pairing could reduce performance on more than one test. A within-subjects design would have required the study—and filming—of an impractical number of video clips. Despite such limitations, however, these experiments are the first to apply the ADH to memory for dynamic events. Thus, they provide a point from which future research may extend.

To summarize the results of the present experiments, an associative deficit was exhibited by older adults under intentional, but not incidental, learning instructions. Patterns of performance of young adults under DA at both encoding and retrieval—but

not of those under DA at encoding only—resembled, to a limited degree, that of the older

intentional learning group. These results raise the possibility that the age-related

associative deficit stems from an inability of older adults to use effective strategies during

retrieval processes, a suggestion which awaits further investigation.

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