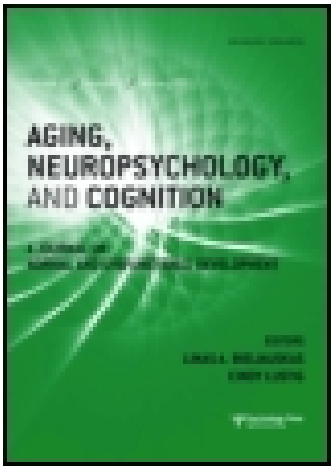

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Direct and Indirect Measures of Contextual Information: Older Versus Young Adult Subjects*

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ABSTRACT

Several reports in the literature suggest that older adults have impaired memory for contextual information. Support for this approach was derived from studies that tested different aspects of contextual information by direct measures of memory (i.e., recall or recognition). The purpose of the present study is twofold: first, to test the possibility that contextual information, although inaccessible via direct measures, may be evident via indirect measures of memory; and second, to evaluate the contribution of duration of exposure to direct and indirect memory measures of contextual information. Two groups of subjects participated in the present study, 35 younger and 30 older subjects. Duration of exposure was not found to have a differential effect on the groups, in either direct or indirect memory tasks. As predicted, age-related differences emerged when direct, but not indirect, measures of contextual memory were tested. These findings argue against the context-memory deficit hypothesis in elderly sbjects, and are interpreted in terms of the theoretical distinction between implicit and explicit memory, where the former is found to be preserved in older adult subjects.

Older adults are reported to perform more poorly than young adults on different memory tests. These tests include free recall, cued recall and recognition of verbal and nonverbal material (Burke & Light, 1981; Light, 1991; Poon, 1985). Some investigators have proposed a *contextual theory* as an explanation for the underlying impaired cognitive mechanism in this age-related memory decline (Balota, Duchek, & Paullin, 1989; Craik & Simon, 1980) as well as in amnesia (Hirst & Volpe, 1984; Huppert & Piercy, 1976; Kinsbourne & Wood, 1975). According to this view, recall and recognition that depend on elaborate processing of contextual information is impaired in old age. It is assumed that at least part of the age-related memory decline is the result of older adults' difficulty in making a connection between information they are trying to learn (i.e., target) and background information, such as time and place (i.e., context). Thus, poor target memory is a consequence of insufficient encoding of contextual information that normally serves as cues in the retrieval stage.

There are several reports in the literature suggesting that the elderly have impaired contextual memory or problems in utilization of contextual information. For example, elderly adults were less accurate than younger adults in recalling contextual information such as the specific color stimuli presented (Park & Puglisi, 1985), whether information was presented by a male or female voice (Kausler & Puckett, 1981b), in upper- or lowercase letters (Kausler & Puckett, 1981a), aurally or visually (Kausler & Puckett, 1981a; McIntyre & Craik, 1987). Elderly subjects also find it more difficult than young adults to monitor the source of information, such as judging whether a word has been thought or said (Hashtrudi, Johnson, & Chrosniak, 1989), or whether information was learned recently or previously known (Janowsky, Shimamura, & Squire, 1989). On the other hand, the contextual theory has difficulty in interpreting certain find-

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ings about the elderly. For example, Denney, Miller, Dew, and Levav (1991) have shown that memory for context in the elderly is no more impaired than target information (for review see Light, 1991).

Graf and Schacter (1985) have introduced a distinction between two types of memory processes – explicit (e.g., recall and recognition) and implicit (e.g., priming). According to Schacter (1987), explicit memory is said to require effortful and intentional retrieval and "is revealed when performance on a task requires conscious recollection of previous experiences" (p. 501), whereas implicit memory is automatic and incidental in nature, and "is revealed when previous experiences facilitate performance on a task that does not require conscious or intentional recollection of these experiences" (p. 501). Other researchers have used other terms for the same distinction: declarative and nondeclarative (Squire, 1992); and direct and indirect measures of memory (Johnson & Hasher, 1987). Most studies that tested these different processes on amnesic patients found that while explicit memory is impaired, implicit memory is usually preserved (for review see Shimamura, 1986). Similarly, several studies with elderly subjects have reported minimal age-related differences when implicit-indirect measures of memory were used. Tasks that require only activation of preexisting representations are preserved in the elderly (Balota & Duchek, 1988; Howard, 1988; Light & Singh, 1987; Park & Shaw, 1992). However, some studies have reported reliable age differences under some conditions even in indirect memory tasks (Chiarello & Hoyer, 1988; Hultsch, Masson, & Small, 1991).

In most of the studies conducted to test the contextual theory, contextual information has been tested by direct measures. As described above, difficulty in recall or recognition of contextual information was interpreted as supporting this theory (Burke & Light, 1981; Light, 1991; Light, LaVoie, Valencia-Laver, Albertson-Owens, & Mead, 1992; Poon, 1985). One of the few studies that assessed elderly subjects' memory for contextual information, directly and indirectly, is the study conducted by Light et al. (1992). In their study they presented a list of words, half auditorially and half visually. Memory for context, that is, modality of presentation, was then tested directly and indirectly. In the direct test subjects were asked to judge whether a particular word had been previously presented. If the answer was yes, then they had to judge whether they had *seen* or *heard* the word previously. The indirect measure was a priming, perceptual-identification task, in which words were presented visually (Experiment 1) with a very brief duration of exposure (mean exposure = 43 ms for the young and 74 ms for the old). As expected, an age effect was found in the direct measure of contextual information, whereas no such effect was found in the indirect measure of contextual information. The authors interpreted their results to argue against the context-deficit theory in the elderly, since they demonstrated that contextual information is encoded. Despite the importance of this conclusion, it does not seem to get to the heart of the contextual-deficit theory under consideration. According to the theory, as described above, contextual information serves as cues to facilitate *retrieval* of target information, whether recall or recognition are required (Balota et al., 1989; Craik & Simon, 1980). The findings by Light et al. (1992) have clearly demonstrated that contextual information is encoded and that it facilitates the *perceptual identification* of target information. But it does not necessarily suggest that this information would facilitate retrieval of target information from memory, as claimed by the contextual theory. In other words, the encoding of contextual information should not be seen as an all-or-none phenomenon but rather as a continuum. The amount of information required to support perceptual identification is not necessarily identical to that required to support explicit recall of modality. Furthermore, Light et al. (1992) used a very specific type of contextual information that was a parameter of the target itself, that is, the modality, in which the word-target was presented.

The purpose of the present study is to test the memory of contextual information both directly and indirectly, using a recognition task. This appears to be a more appropriate test of the con-

text-deficit hypothesis since it directly addresses the question of whether contextual information will facilitate retrieval of target information as claimed by the theory. In addition, in order to expand on the results of Light et al. (1992), the present study utilizes contextual information that is distinct and independent of target stimuli. It is hypothesized that even such contextual information, though inaccessible via direct measures, may be evident via indirect measures of memory. Many studies have shown that the elderly fail to recall or recognize contextual information directly. However, this finding does not necessarily indicate total failure to encode information or to use it indirectly to facilitate retrieval of target information. More specifically, it is expected that target items will be recognized better when contextual cues presented at the encoding stage are also made available at the retrieval stage. This hypothesis is based on Tulving and Thomson's (1973) principle of *encoding specificity*, and on a more recent version of this theory, Transfer Appropriate Processing (TAP; Blaxton, 1989). These theories emphasize the advantage of testing memory under conditions similar to those that held during learning, since under these conditions memory performance is maximized. In contrast with the contextual theory prediction, we expect that the younger and older groups will benefit to the same extent from the similarity of the context in the learning and testing conditions. However, when memory for context is assessed directly by testing recognition for items previously shown as context, in accordance with the contextual theory it is expected that the older group will be inferior to the younger group in this task.

Some theorists have suggested that memory decrements in old age stem at least partially from cognitive slowing (for review see Light, 1991). The elderly have been shown to require more time to accomplish almost every task where speed is assessed (Baddely, Thomson, & Buchanan, 1975; Cerella, 1985; Myerson, Hale, Wagstaff, Poon, & Smith 1990; Salthouse, 1985). Myerson et al. (1990) noted that increased duration of presentation would not necessarily compensate for cognitive slowing. Nevertheless, since the contribution of duration of exposure to direct and indirect memory measures of contextual information has not been previously evaluated, it will be evaluated in the present study.

METHOD

Subjects

Two groups of subjects participated in the present study. The younger group consisted of 35 volunteers: 15 males and 20 females, undergraduate students from Bar-Ilan University, Israel. Ages ranged from 18 to 27 years (mean = 22.50); education ranged from 12 to 16 years (mean = 13.70) of schooling. The elderly group was composed of 30 volunteers: 7 males and 23 females, from local senior citizens' centers in Tel Aviv, Israel. Ages ranged from 77 to 93 years (mean = 84.0); education ranged from 8 to 17 years (mean = 11.8) of schooling. They were retired, middle-income people. All participants were reported to be in good health and had no uncorrected vision or hearing problems. None of the participants had a history of alcohol, drug abuse, or psychiatric illness.

Testing Material

Three sets of slides were used in the present study.

1. Learning set: 30 slides with pictures of a common object (i.e. a target) placed on top of another common object (i.e. context), such as a book placed on a chair. Objects were chosen so that there was no natural relationship between the target and context items. For example, we did *not* present a picture of a book on a bookshelf.

2. Testing set: 60 slides like those in the learning set. The 30 target objects used in the learning set were presented again, but one-third (10) were in the old context, one-third in a neutral context – white background, and one-third were in a new context consisting of new items as background. In addition, there were 30 slides with pictures of new targets. Ten of them were presented with a neutral context and the other 20 with new context. Slides were presented in random order.

3. Context set: 20 slides, including 10 slides with pictures of objects used in the learning set as context, and 10 slides of completely new objects. Slides were presented in random order.

Procedure

Subjects were tested in small groups of three to six subjects at a time. The 30 learning set slides were projected by a slide projector, from a distance of about 2 m. Many studies used 3-4 s duration of exposure, so in order to maximize the effect of duration of exposure, 1 and 6 s were chosen. For 20 (out of 35) of the younger group and 15 (out of 30) of the older group, each

slide was projected for 1 s. For the remaining 15 subjects of each group, each slide was projected for 6 s. Subjects were told the following: "You will be presented with a series of slides in which one object is placed on top of another object. You are asked to pay close attention to the object *on top* since your memory for *these* objects will be tested." Following presentation of the learning set, free recall of the target objects was tested. Subjects were given a blank sheet of paper and asked to write down as many target items as they could remember. Following the free recall task, the 60 testing set slides were projected. With each slide subjects were asked to decide whether the object presented appeared in the learning set. The answer (i.e., yes or no) was recorded by subjects on a sheet of paper, numbered from 1 to 60. In order to avoid errors, the experimenter announced the number of each slide presented. Finally, the 20 slides of the context set were presented, of which half the objects had appeared in the learning set as context and half were completely new objects. Subjects were asked to identify the context objects that had appeared in the learning set. As above, all answers were recorded by the subjects on a sheet of paper, numbered this time from 1 to 20.

RESULTS

Three memory measures were analyzed in this experiment: free recall and recognition of target items, and recognition of context items.

Free Recall of Target Items

Table 1 presents the mean number (and standard deviations) of target items recalled by each age group at the two exposure durations.

Table 1. The Mean Number (and Standard Deviations) of Target Items Recalled by Younger and Older Groups at the Two Exposure Durations.

	Age group	
Exposure duration	Young (n = 35)	Old (n = 30)
1 s	13.73 (3.17)	7.27 (2.43)
6 s	15.25 (3.97)	7.07 (2.43)

Analysis of variance was used to analyze the effect of age group (young vs. old) by exposure duration (1 vs. 6 s), both of which are between-subjects factors. The only result to reach statistical significance was age group effect: $F(1, 61) = 88.08$, $p < .001$. The younger group recalled more target items overall than the older group. The main effect of exposure duration did not reach significance, nor did its interaction with group.

Recognition of Target Items

For the recognition of target items, the hit rate and false alarm rate were obtained for each subject. A corrected recognition score was derived by subtracting the number of false alarms from the hits. Table 2 presents the corrected recognition scores (and standard deviations) for the older and younger groups as a function of the different context of testing and exposure duration.

A mixed design ANOVA was conducted on the corrected recognition scores, to analyze the effect of age group (young vs. old) by exposure duration (1 vs. 6 s) by context (old context, as in the learning condition, neutral context, and new context). The former two are between-subjects factors, and the latter a within-subjects factor. The three main effects reached significance: a) age group: $F(1, 61) = 51.84$, $p < .001$, the younger group correctly recognized more target items overall than the older group; b) exposure duration: $F(1, 61) = 7.34$, $p < .01$, more words were recognized correctly overall under the 6 than the 1 s duration of exposure; and c) context: $F(2, 122) = 19.61$, $p < .001$, more words were correctly recognized overall under the old as compared to the new context condition. None of the interactions between these effects reached significance. Follow-up analysis using the Newman-Keuls procedure was conducted in order to identify the source of significance in the context main effect. Results indicate that performance differed significantly among the three context conditions. Both groups recognized the target objects best when presented in the old context, as in the learning set, and recognized them least in the new context condition.

Table 2. Mean of Corrected Recognition Score (and Standard Deviations) for the Older and Younger Groups as a Function of the Different Context of Testing and Exposure Duration.

	Context					
	Old		Neutral		New	
	Exposure duration					
Age group	1 s	6 s	1 s	6 s	1 s	6 s
Young ($n = 35$)	.847 (.19)	.880 (.14)	.780 (.13)	.865 (.10)	.693 (.21)	.800 (.17)
Old ($n = 30$)	.527 (.22)	.687 (.25)	.453 (.19)	.567 (.20)	.373 (.25)	.527 (.21)

Recognition of Context Items

For the recognition of context items, the hit rate and false alarm rate were obtained for each subject. A corrected recognition score was derived by subtracting the number of false alarms from the hits. Table 3 presents the corrected recognition scores (and standard deviations) of context items by each age group at the two exposure durations.

The number of context items correctly recognized by the two age groups was subjected to analysis of variance to analyze the effect of age group (young vs. old) by exposure duration (1 vs. 6 s), both of which are between-subjects factors. The main effect for age group was found to be significant: $F(1, 61) = 33.33$, $p < .001$. The younger group recognized more context items overall than the older group. The main effect of exposure duration did not reach significance, nor did its interaction with group.

Table 3. The Mean Number of Corrected Recognition Scores (and Standard Deviations) of Context Items Recognized by Each Age Group at the Two Exposure Durations.

	Age group	
Exposure duration	Young ($n = 35$)	Old ($n = 30$)
1 s	4.60 (2.44)	1.73 (1.79)
6 s	5.30 (1.87)	2.20 (2.21)

DISCUSSION

Overall, our results suggest that exposure duration did not have a significant effect on younger or older subjects in the free recall of target items and recognition of context items. In the recognition of target items both groups benefited equally from the longer exposure duration. Thus, at least for the type of tasks and the exposure durations used in the present study, there is no indication that elderly subjects would benefit more than younger subjects from longer duration of exposure for recall or recognition. These results should not be interpreted as necessarily contradicting the cognitive slowing hypothesis, since as Myerson et al. (1990) claimed, increased duration of presentation does not necessarily compensate for cognitive slowing.

The paradigm used in this study enabled us to measure direct and indirect aspects of memory for contextual and target information within the same task. The results of the present study replicate previous findings that recall is impaired in the elderly (Burke & Light, 1981; Light, 1991; Poon, 1985). Furthermore, the results reported here accord with several previous reports in the literature suggesting that the elderly have im-

paired memory for contextual information when measured directly (Kausler & Puckett, 1981a, 1981b; McIntyre & Craik, 1987). However, as in Denney et al.'s (1991) findings, there are no indications in our results that memory for context in the elderly is more impaired than memory for target, as would be predicted by the contextual theory.

However, the most important contribution of this study is that groups were compared not only on the traditional measure of direct memory of context, but also on indirect memory of context. As predicted, both groups showed the same pattern of results: They remembered better when stimuli were presented in the same old perceptual context as in the original presentation, as compared with new or even neutral contexts. These results are an extension of Light et al.'s (1992) results, which demonstrate that contextual information is encoded and that this information not only facilitates perceptual identification (as demonstrated by Light et al., 1992), but also facilitates recognition of target information to the same extent in both age groups. Furthermore, these results are obtained even when target and context stimuli are independent and new associations have to be learned. The fact that subjects benefited from contextual cues accords with Tulving and Thomson's (1973) principle of encoding specificity and with the TAP theory mentioned above (Blaxton, 1989). These theories emphasize the advantage of testing memory under conditions similar to those that held during learning. The finding that the older group benefited from contextual cues may be viewed in terms of the distinction between implicit and explicit memory (Schacter, 1987). Implicit memory is reported by most researchers to be preserved in amnesics and the elderly, since it does not require intentional retrieval of information, but rather is expressed indirectly in the form of facilitation of test performance without conscious recollection (Balota & Duchek, 1988; Howard, 1988; Light & Singh, 1987; Park & Shaw, 1992). The present study goes a step further by demonstrating that implicitly encoded information has a facilitating effect even when explicit recognition is required. These findings imply that contextual information is registered and stored but is unavailable via direct-explicit retrieval mechanisms. This does not prevent the information from being available and useful as retrieval cues via indirect-implicit retrieval mechanisms. Thus, on the one hand these findings support the contextual theory as an explanation of normal memory mechanisms by demonstrating that contextual information plays a significant role in the retrieval process. On the other hand, these findings argue against the context-deficit hypothesis, suggesting that it is the above mechanism that is impaired as a function of age, since both groups were equally affected by the contextual cues. Similar studies should be conducted with other memory impaired populations (e.g., amnesics) for which context deficit has been suggested as the underlying impaired mechanism.

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