Age Differences in Time Estimation and their Relationship to Prospective Memory

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Running Head: TIME ESTIMATION AND PROSPECTIVE MEMORY

Ulric Neisser's 1978 opening address at the International Conference on Practical Aspects of Memory was pessimistic about the amount of progress in practical memory research since the time of Ebbinghaus. The emphasis of memory research had been focused on laboratory studies for the last 100 years, which Neisser believed was done in hopes of moving toward a general theory of memory. Neisser's pessimism was caused by the lack of useful information provided by the many years of memory research. He stated that "if _X_ is an interesting or socially significant aspect of memory, then psychologists have hardly ever studied _X_" (Neisser 1978).

According to Neisser (1982), the study of memory has followed two routes. He refers to the routes as the high road and the low road. "The travelers of the high road hope to find basic mental mechanisms that can be demonstrated in well-controlled experiments; those on the low road want to understand the specific manifestations of memory in ordinary human experience" (Neisser, 1982). Since Neisser's 1978 opening address, memory research has turned more toward the ecological study of memory, as opposed to controlled laboratory experiments. Ten years after his negative quote about _X_ not being studied, he now believes the reverse to be true. "If _X_ is an interesting or socially significant aspect of memory, some psychologist is probably trying to study it at this very moment!" (Neisser, 1988).

Though the study of memory in the ecological or natural setting has increased substantially during the 80's,(Neisser 1988) it has predominately been the study of retrospective memory (Harris, 1984). Retrospective memory is memory concerned solely with the recall of information about the past (Meacham & Singer, 1977; Harris, 1984). Another part of memory, prospective memory, is currently receiving more attention in the research arena and has been found to be quite different from retrospective memory. Prospective memory is the ability to remember to recall a certain task or event in the future (Meacham & Singer, 1977; Harris, 1984). Therefore, retrospective memory is remembering what to recall and prospective memory is remembering to recall (Harris, 1984).

An example that distinguishes retrospective memory from prospective memory is delivering a phone message. "In order to deliver a message one must remember not only the content of the message (retrospective), but also to find the person for whom the message is intended, and deliver the message (prospective)" (Meacham & Singer, 1977). Without prospective memory, people would not be able to remember to take their medication at the correct time, would be late for appointments, or any number of activities that require planning and remembering in the future.

There are two main categories of prospective memory, habitual and episodic. Habitual prospective memory is remembering what is engaged in routinely, such as taking a shower, brushing one's teeth, a morning walk, or other activities of daily living (Meacham & Singer, 1977). This type of memory may be guided by spatial and temporal cues in the environment (Meacham & Singer, 1977). Episodic remembering involves actions performed infrequently and on an irregular basis. This type of remembering relies on the person remembering to carry out the action (Meacham & Singer, 1977). An example of episodic prospective memory would be filling the car with gas on the way home from work. Since this is probably not an activity that is performed at the same time and at the same location, external cues are not able to develop. The inability of external cues to develop for episodic prospective memory decreases the chances that the task will be remembered and executed. In helping to remember future actions, there are a variety of internal and external cues that people employ to help them to remember.

A study by Harris (1978) observed the use of internal and external memory aids. The internal memory aids asked about in this study were "first letter mnemonics, rhymes, the method of loci, the story method, mentally retracing a sequence of events or actions, the peg method, turning numbers into letters, face-name associations, and searching through the alphabet to find the initial letter of a forgotten name or word." The external aids were "shopping lists, diaries, writing on the hand, alarm clocks, watches and timers, writing paper memos to oneself, writing on or marking calendars, year planners, asking someone else to give a reminder, and leaving something in a special place where it will be encountered at the time it needs to be remembered." Harris found a significant difference in the use of external and internal memory aids, with the external aids being used more frequently. The external aids that were used most often in their study were diaries and calendars. In a similar study by (Meacham & Singer, 1977) they found their subjects used external aids 80% of the time and internal aids 20% of the time.

External aids can be divided into two groups. One group of external aids can be used for external storage of information because it's more accurate, or because internal storage may be overloaded (Harris, 1978). An example of an external aid as storage would be a shopping list. A shopping list gives the specific items needed when at the store instead of only reminding a person that they need to go to the store. The second group of external aids are those that are cues for action. This group is a cue for action because whatever the cue, it will be sufficient information to carry out the appropriate action. An example would be a reminder that it's someone's birthday (Harris, 1978). Knowing that it's someone's birthday, is a sufficient cue for further action.

Criteria that increase the effectiveness of external cues are; (1) the cue is given as close as possible before the time of the desired action; (2) the cue is active, and (3) the cue is specific. A timer (active) may be more efficient than a diary (passive) because the user may forget to look at the diary. The specificity of the reminder is also important. If a timer is used to help a person remember many different activities or events, when the timer rings, the person may remember that something needs to be done, but may not remember what that something is (Harris, 1978). The timing of the cue is also important because the more time lapse between the cue and the desired action, the less likely the action will be remembered (Harris, 1978; Loftus, 1971). Other criteria that increase the effectiveness of external aids are that it's portable, it can be used to store information for a long period of time, and that it's easy to use (Harris, 1978).

Recognizing the need for assistance in remembering future events appears to develop after the pre-school years. Ritter (1978) used a shell game with pre-school children and found they didn't appear to understand the need to mark the shell that had candy under it. When they were given a demonstration of marking a shell to help keep track of the candy, some of the children then marked all of the shells. Other studies have found the similar results as Ritter (Beal, 1985; Beal, 1988), indicating that pre-school children may not understand the need for external retrieval cues.

A study by Kreutzer, Leonard, and Flavell (1975) found that children have a great deal of knowledge about ways to help them remember. They asked children in kindergarten, first, third, and fifth grade how they would remember to take their ice skates to school the following morning. All age groups provided viable ways to assist them in remembering. The main devices to help them remember were external cues. They would leave their skates in an area where they would see them the next morning, or else some form of written reminder. They also used others to remind them and some chose to remind themselves. These children revealed that they do understand how to help themselves remember, but this study doesn't provide information about the effectiveness of their cues.

Meacham & Colombo (1980) attempted to ascertain if six and eight-year-old children would benefit from external retrieval cues. They found that the children's prospective memory was improved significantly when they were asked to use an external retrieval cue, and there was no difference in performance between the six and eight-year-olds.

There has been a vast amount of research that provides evidence for retrospective memory loss as people age, (Mitchell, Brown, & Murphy 1990; Hill, Crook, Zadek, and Sheckh, et al. 1989; Murrell & Humphries, 1978) however, the way in which prospective memory is effected by age is not clear. One current theory of aging (Craik, 1986) suggests that prospective memory may be especially difficult for the elderly. According to Craik's theory, prospective memory is the memory task that requires the most self-initiation, so without the help of external cues, he predicts the elderly would not do as well as younger people on prospective memory tasks. In studies of prospective memory by West (1988) and Poon & Schafer (1982), neither found reliable differences between the older and younger subjects. Einstein & McDaniel (1990) attempted a laboratory study of prospective memory with two groups of subjects. The first group had a mean age of 68.83, and a second group consisted of individuals 17-24 years of age. Their results are consistent with West (1988) and Poon & Schafer (1982), indicating no age-related decrements in prospective memory. They did find differences between familiar and unfamiliar external cues, but again there were no differences between age groups (Einstein & McDaniel, 1990). Though research has yet to find age related differences for prospective memory (Einstein & McDaniel, 1990), there is reason to doubt past studies.

Past studies have been criticized for using trivial tasks unrelated to everyday behaviors, and for employing naturalistic settings in which subjects' use of aiding devices and memory aids could not be experimentally controlled (Harris, 1984; Einstein & McDaniel, 1990). Also, several studies of prospective memory have been criticized for using single-item criteria or multiple items of corresponding content. Einstein and McDaniel (1990) make a distinction between event-based and time-based prospective memory tasks. Time-based tasks require that a task be performed at a specific time or after the specific time has passed and event-based tasks require that a task be performed when a specific event occurs. Einstein and McDaniel (1990) performed a study in which no age-related effects were found on event-based prospective memory. However, they hypothesize that age differences may be found if time-based tasks were used and the results of younger and older subjects were compared.

An area that may benefit from prospective memory research, is medication compliance in the elderly. "Studies have shown that while persons over the age of 65 years of age represent about 12 per cent of the population, they receive 25 per cent of all prescribed drugs in the United States" (Lanny, 1980, cited in Stewart & Caranasos, 1989). Stewart and Cluff (1972), reviewed numerous studies of compliance in ambulatory patient populations and found that the percentage of patients making errors in self-administration of prescribed medications ranged between 29 and 59 per cent. It's believed that the elderly have more trouble complying with prescription instructions because they usually have more medications prescribed, often suffer from cognitive decline, and frequently have physical limitations that limit them from following through with instructions (Young, 1987).

There is reason to believe that time monitoring may influence the effectiveness of prospective memory. There are many everyday tasks that require time monitoring until a critical time, which then necessitates a certain behavior (Harris & Wilkins, 1982). This concept has been known as TOTE (Test-Operate-Test-Exit) By Miller Galanter and Pribram (1960). Miller et al uses an example of hammering a nail flush with the surface as an example. The user of the hammer alternates the test (checking to see if the nail is flush) and operate phases (hammering) until the desired outcome is reached. When the desired outcome is reached, the person can then exit the test-operate loop. Harris & Wilkins (1982) believe there is little opportunity for the tester to forget to continue in the TOTE task, because the person always has to be present for the operation phase to continue. A variation of the TOTE is TWTE (Test-Wait-Test-Exit) (Harris & Wilkins, 1982). With this variation, they used an example of checking whether something needed to be cooked longer in the oven. The difference in this example is that the Wait (Operate) cycle continues independently of the person, which gives them time to focus their attention on other activities. When to make the next test and how a person decides is of particular interest. How well does the tester think they can estimate the passage of time? What are the costs of performing a test? What are the costs of being too early or too late (Harris & Wilkins, 1982)?

Harris & Wilkins (1982) did a study to test TWTE tasks and the time monitoring between the test and wait periods. Twenty-nine female students were asked to watch a film that they would be given a questionnaire about afterwards. They were also given eight sheets of paper with different times written on them. Throughout the film, they were to hold up the sheets of paper when the time on their paper matched the time on the clock. If they held up the sheet within the first fifteen seconds of the minute, it was counted as a success. Anything after that was recorded as a failure.

Though the relationship of time estimation to prospective memory has not been studied, research may provide information that helps explain the difference between people with good prospective memory and those with poor prospective memory. Empirical studies have used three methods to measure time estimation: reproduction, production, and estimation (Fraisse, 1963). The reproduction method is characterized by the subject receiving a temporal interval and are then asked to reproduce it. A light may come on the screen for 10 seconds and then disappear. The subject is then asked to press a lever that turns on the light. The goal is to keep the light on the screen for the same amount of time as was presented to them. With the production method, the examiner states a certain duration (eg. 12 seconds) and the subject tries to produce the interval (e.g. by pressing a lever that turns on a light and keeping it on for 12 seconds). With the estimation method, (which will be called numerical estimation in the current study) the subject is presented with a temporal interval and is then asked to estimate the duration (Fraisse, 1963). When considering short durations, work done with the reproduction method is the most reliable (Fraisse, 1963).

There is a distinction to be made between prospective and retrospective studies of time estimation.

Retrospective studies of time estimation require the subject to recall how long a passage of time is, whereas with prospective time estimation, they are told beforehand they will be asked to estimate the passage of time after it has elapsed. Besides the difference between retrospective and prospective time estimation, there are many variables that may affect how someone perceives the passage of time.

"Among the variables that have been shown to affect the subjective perception of duration are: (1) the number of events occurring during the interval (e.g., Adams, 1977; Block, 1974; Poynter & Holma, 1985), (2), the complexity of stimulus events (e.g., Block, 1978; Ornstein, 1969), (3) the type of cognitive or information processing required (e.g., Hicks, Miller & Kinsbourne, 1976; Thomas & Weaver, 1975), and (4) the amount of attention given to the passage of time (e.g., Brown, 1985; McClain, 1983)" (cited in Coren and Ward 1989). When subjects are required to do an effortful or difficult task while estimating the passage of time, their estimation of time decreases (Hicks & Brundige, 1974). "As nontemporal task demands increase, less attentional capacity is allocated to temporal processing, and duration judgements become more unreliable" (Hicks, Miller, & Kinsbourne, 1976). When subjects are required to only estimate the passage of time, their estimation of time increases (Brown, 1985). Situations such as boredom, impatience, and anticipation, often produce an apparent lengthening (or slowing down) of external time (Brown, 1985). "The classic example of this effect is the "watched pot phenomenon" (Fraisse, 1963) where time seems to drag slowly by.

Though time appears to drag when we are young and move quickly as we age, there has been little evidence to substantiate this concept. Surwillo (1964) used the method of production to compare the time estimations of three different age groups. The mean ages of the groups were 37.5, 56.1, and 73.7. The results failed to reveal a significant difference between the time estimations of the three groups. There was a significant difference though when the older group was compared to an institutionalized group of the same age. The institutionalized group significantly underestimated the passage of time on all three intervals.

Newman (1982) compared the production estimates of three different age groups. The mean ages were 23, 28, and 72. Preliminary findings showed that the middle group and the oldest group significantly overestimated time compared to the youngest group. When sex of the subjects were taken into account, it showed that the youngest group was all male, the middle group was 89% female, and the oldest group was 80% female. This revealed that the difference in time estimation may have been related to sex instead of the age of the subjects.

The present study was similar to Montare (1988) in that all three types of time estimation were used and the subjects received feedback after every duration estimation. The current study is different from Montare (1988) in that there were no trials without feedback. Montare found that knowledge of results significantly decreased the variance of time estimations on all methods of time estimation. He also found that knowledge of results significantly increased the accuracy of time estimation for the methods of estimation and production, but not for reproduction. This could be due to practice effects since the reproduction method was done before the other two, or it could point toward reproduction as using different perceptual processes than the other two methods of estimation (Montare, 1983b).

The goals of the present study were (1) to study the relationship of age to an individual's capacity for time estimation and, (2) to study the relationship of prospective memory to an individual's capacity for time estimation.

Method

Subjects

Thirty-nine elderly subjects were volunteers recruited from two churches and a retirement village in the Dallas area. They consisted of 9 males and 25 females (mean age = 76.5; range = 66-88). To avoid artifacts due to lower education or intellectual ability, elderly subjects were admitted to the study only if they had at least one year of college education. All subjects in the elderly group had at least 2 years of college and 14 had advanced degrees. Furthermore, subjects were eliminated if they reported a history of stroke or other CNS disease, or if they were unable to meet criteria on a brief test of visual and auditory acuity. Of the original 39 elderly subjects, 2 were eliminated because they reported a history of strokes. Two others were eliminated because they reported less than 2 years of college education, and one because he became ill during the testing session. Thus, results from only 34 elderly subjects were included in the final analysis.

Thirty-four young subjects were recruited from undergraduate psychology classes at the University of North Texas and received extra credit for their participation. They consisted of 6 males and 28 females (mean age = 20.5; range = 18-26). No young subjects were eliminated from the study.

All subjects had participated in an earlier experiment which involved the administration of a neuropsychological test battery, including the Wood Prospective Memory Test.

Procedure

At the beginning of the testing session, the subject read and signed a consent form which described the purpose of the study in general terms. If the subject was wearing a watch, s/he was asked to give it to the experimenter during the session. The subject was then seated comfortably in front of a Zenith Supersport 286e lap-top computer. A series of computer-administered time estimation tasks were then administered lasting approximately 25 minutes.
Tasks were always administered in the same order and are described below.

REPRODUCTION TASK. The following instructions appeared on the computer screen.

> I want to study your sense of time. Here's how we will do it. The 'c' key works like the button on a stopwatch. If you press and release the 'c' key, you will start the clock. If you press and release the 'c' key again, the clock will stop. Give it a try. Run the clock for eight seconds.

When the subject depressed the 'c' key, the message "Timer running . . ." appeared on the screen. Trial runs were continued until the subject stopped the clock between 4 and 12 seconds. After stopping the clock between 4 and 12 seconds, the following instructions appeared on the screen.

> Now I am going to give you a series of trials in which you are to try to reproduce as exactly as possible a given period of time. To begin each trial, a small block will appear in the center of the computer screen. After the block disappears you are to run the timer for exactly the same amount of time the block was originally on the screen. You may keep track of the passage of time any way you like, EXCEPT by using a watch or clock. After each trial I will tell you exactly how long to the nearest hundredth of a second each of your judgments were. Before each appearance of the block I will prompt 'Ready?'.Do you understand the instructions (y for yes, n for no).

If the subject indicated s/he did not understand the instructions they were repeated again. If s/he still did not understand them, the experimenter offered clarification.

The block was then displayed on the computer screen for 12 seconds. Afterwards, the subject was instructed to press and release the key to start the clock. The subjects pressed and released key to stop the timer when they thought the clock ran the same length of time that was displayed. The computer informed the subject how much shorter or longer s/he had estimated time compared to the display.

The block was displayed for five 12-second trials, then for five 20-second trials. The first 12-second trial was considered a practice run and dropped from analyses, although the subject was not informed of this fact.

PRODUCTION TASK. Next the following instructions appeared on the computer screen.

> Now I want to continue to study your sense of time. When you press and release the 'c' key you will start the clock. Press it again to stop. On each trial I will then prompt you to run the clock for either 10 or 18 seconds. I want you to run the clock for that same amount of time. After each trial I will tell you exactly how long to the nearest hundredth of a second your judgments were. Do you understand the instructions (y for yes, n for no)".

After the subject had indicated that s/he understood the instructions, ten trials followed. On the first 5 trials the subject was asked to run the clock for 10 seconds, and on the second 5 trials to run it for 18 seconds. Feedback was given immediately following each trial. The first 10-second trial was considered a practice run, although the subject was not informed of this fact.

NUMERICAL ESTIMATION. Next the following instructions appeared on the computer screen.

> Now I want to continue to study your sense of time. Here's how we will do it. You will see the block appear in the center of the screen. The block will come on for a period of time and then go off. After each appearance of the block I want you to estimate to the nearest second the amount of time the block was on the screen. After each estimate I will tell you whether your estimate was too long, too short, or exactly correct to the nearest second. I will prompt 'Ready' before the block comes on. Do you understand the instructions (y for yes, n for no)?

After the subject had indicated that s/he understood the instructions, ten trials followed, with the block being shown for 9, 13, 14, 11, 7, 15, 6, 16, 5, and 17 seconds. The subject recorded his/her numerical estimates by hitting the appropriate computer keys. Feedback was given immediately following each trial. The first 9-second trial was considered a practice run, although the subject was not informed of this fact.

CLOCK STOPPING AND DIGIT STRING MATCHING. Next the following instructions appeared on the computer screen. This next task will require you to distinguish between groups of characters to see whether they are the same or different. An example would be whether these two groups are the same or different:

abcdef abcdcf

If the groups are the SAME, you should hit the 's' key. If the groups are DIFFERENT, you should hit the 'd' key. You will have 90 seconds to do as many of these as you can. You can keep track of the time by pushing the 'c' key (for 'clock')" which will display the time that has elapsed. It's important to work as fast as you can, but remember to quit as close to 90 seconds as possible by hitting the 'q' key. Do you understand the instructions (y for yes, n for no)?

After the subject had indicated that s/he understood these instructions, additional instructions appeared on the screen.

> Take a moment to find these keys. First find the 's' key. You should hit this key when the pairs are the SAME. Next find the 'd' key. You should hit this key when the pairs are DIFFERENT. Next find the 'c' key. You should hit this key to check the CLOCK. Next find the 'q' key. You should hit this key to QUIT as close to 90 seconds as possible. Each time you check the clock, it will stay displayed on the screen until you hit the 's' 'd' or 'q' key again. Do you understand the instructions (y for yes, n for no)?

After the subject indicated that he/she understood these instructions, pairs of digit strings were displayed on the screen sequentially and the subject was asked to indicate whether they were the same or different. Digit strings were 5 to 8 digits long, and included numerical digits, upper and lower-case letters, and symbols such as "#" and "%". Display of digits continued until (a) the subject hit the "q" key or (b) 120 seconds (90 + 30) had elapsed, whichever came first.

After completion of the 90-second clock-stopping trial, the full set of instructions and the entire procedure were repeated, but for a 150 second trial. For the second trial, display of digits continued until (a) the subject hit the "q" key or (b) 180 seconds (150 + 30) had elapsed, whichever came first.

In addition to the four types of time estimation tasks just described, subjects were administered a battery of neuropsychological tests, including the Wood Prospective Memory Test (WPMT) at an earlier session as part of another experiment.

The WPMT is designed to measure a subject's ability to carry out novel instructions in the future. The test yields three sub-scores directly relevant to prospective memory ability: (1) the CLOCK sub-score indicates the subject's ability to use a clock to cue future actions; (2) the COVERT sub-score indicates the subject's ability to initiate actions in response to covert cues (i.e. cues that are "disguised" as something else. For example, one covert item tests a subject's ability to carry out a predesignated action when told "That's the end of the session."); and (3) the DETAIL sub-score indicates the subject's ability, once cued, to remember and follow detailed instructions given earlier.

Results

Results are shown in Table 1. As stated above, the first trials of the Reproduction, Production and Numerical Estimation tasks were dropped before analyses were performed.

Each subject's Reproduction "Average" score was calculated by summing his/her scores on trials 2 to 10 of the Reproduction task and dividing by 9. Because there were four 12-second trials and five 20-second trials, a "perfect" average Reproduction score would have been 16.44.

Each subject's Reproduction "Error" score was calculated by subtracting his/her score on each trial from the correct score to yield an "error" for that trial, then summing the absolute value of all nine errors and dividing by 9. A "perfect" error score would be equal to zero.

Thus, the Reproduction "Average" score indicated whether a particular subject was _biased_ toward overestimating or underestimating time on the reproduction task, whereas the "Error" score indicated the degree to which a subject was <u>inaccurate</u> in estimating time on the reproduction task, even though the inaccuracies were not necessarily biased toward either under- or over-estimation. In the remainder of this article, "Average" scores will be referred to as measures of bias, and "Error" scores as measures of accuracy. The internal consistency from the nine Reproduction trials as measured by coefficient alpha was .76 for raw scores and .79 for error scores among young subjects, and .82 for raw scores and .79 for error scores among elderly subjects. These coefficients indicate that the combination of trial scores into single measures is reasonable.

"Average" and "Error" scores for Production and Numerical Estimation were calculated in a manner analogous to that used for Reproduction Scores. A perfect "Average" score would have been 14.44 for Production and 11.55 for Numerical Estimation. Among young subjects, coefficient alpha was .88 for raw scores and .93 for error scores on the Production task, and .77 for raw scores and .82 for error scores on the Numerical Estimation task. Among elderly subjects coefficient alpha was .90 for raw scores and .89 for error scores on the Production task, and .95 for raw scores and .95 for error scores on the Numerical Estimation task.

Digit String Discrimination scores were calculated by subtracting the number of incorrect same-different decisions from the number of correct decisions.

Table 1 provides not only means and standard deviations, but percentile scores, to give a fuller picture of the distribution of scores. For example, on the Reproduction task, 90% of young subjects had scores below 16.57 and 50% below 16.03.

Results for each of the tasks are provided below.

<u>REPRODUCTION.</u> A perfect "Average" score on the Reproduction task would have been 16.44. Both young and elderly subjects showed a small bias toward underestimation, with old subjects showing slightly though not significantly less bias. The elderly showed significantly more "Error" on the Reproduction task, indicating less accuracy.

<u>PRODUCTION.</u> A perfect "Average" score on the Reproduction task would have been 14.44. As with Reproduction scores, both groups showed a small bias toward underestimation, with elderly subjects showing slightly but not significantly less bias. The "Error"

scores on the Production task were very close, indicating little or no difference in accuracy.

NUMERICAL ESTIMATION. A perfect "Average" score on the Numerical Estimation task would have been 11.55. Young subjects showed a small tendency toward underestimation. Although elderly subjects showed a tendency toward overestimation, their bias was not significantly different from that of young subjects. However, the errors made by elderly subjects on the numerical estimation task were over twice as large as those made by young subjects, indicating significantly less accuracy.

CLOCK STOPPING. Elderly subjects showed significantly more bias and less accuracy on both Clock Stopping tasks than young subjects did. These findings reflect the fact that elderly subjects went over the designated stopping time much more frequently than young subjects did. On the 90-second Clock Stopping task, only 3 (9%) of the young subjects failed to hit the 'q' key before 120 seconds had elapsed, as compared with 10 (30%) of the elderly subjects (chi-square (1) = 4.44, $p = .04$). On the 150-second Clock Stopping task, none of the young subjects failed to hit the 'q' key before 180 seconds had elapsed, as compared to 7 (21%) of the elderly subjects (chi-square (1) = 7.83, $p = .005$).

DIGIT STRING DISCRIMINATION. The scores of young subjects were over 50% higher than those of elderly subjects on the Digit String task, indicating substantially better performance.

Tables 2 and 3 present correlations among time estimation measures and the subscales of the Wood Prospective Memory Test (WPMT) for young and elderly subjects. As can be seen, none of the time-estimation tests described above significantly correlated with the WPMT subscales.

Table 1

Performance on Time Estimation Tasks

Young versus Old Subjects

	Mean	St Dev	90%	50%	10%	Kruskal Wallis	p value
Reproduction							
Average							
Yng	15.76	1.40	16.57	16.03	15.09	1.55	.21
Old	16.00	1.40	17.32	16.47	14.52		
Error							
Yng	1.37	1.22	2.03	1.14	0.64	3.80	.0511
Old	1.55	0.89	2.46	1.31	0.90		
Production							
Average							
Yng	14.12	1.44	15.00	14.37	13.37	.02	.90
Old	14.33	1.33	15.55	14.32	13.44		
Error							
Yng	1.27	1.25	1.63	1.01	0.55	.45	.50
Old	1.33	.85	2.34	1.12	.07		

Table 1 (cont'd)

Performance on Time Estimation Tasks

Young versus Old Subjects

	Mean	St Dev	90%	50%	10%	Kruskal Wallis	p value
Numerical Estimation							
Average							
Yng	11.50	1.06	12.22	11.44	10.56	2.49	.11
Old	11.72	2.97	13.89	11.00	9.78		
Error							
Yng	.83	.86	1.44	0.67	0.11	18.19	.0001
Old	1.96	2.36	2.89	1.35	.78		
Clock Stopping: 90 second							
Average							
Yng	100.00	9.72	110.45	97.41	92.16	3.85	.0498
Old	107.08	11.88	120.00	105.18	91.57		
Clock Stopping: 150 second							
Average							
Yng	151.31	14.17	164.34	151.93	143.79	15.35	.0001
Old	163.54	11.10	180.00	159.01	151.04		
Clock Stopping: 90 & 150 second							
Error							
Yng	18.37	18.10	36.37	13.26	4.20	7.71	.0055
Old	29.67	18.50	60.00	29.61	6.23		

Table 1 (cont'd)

Performance on Time Estimation Tasks

Young versus Old Subjects

	Mean	St Dev	90%	50%	10%	Kruskal Wallis	p value
Digit String Discrimination							
Average No. Correct							
Yng	95.35	16.57	122.00	93.00	77.00	35.54	.0001
Old	60.38	16.20	76.00	61.00	35.00		

Table 2
Correlations of Time Estimation
and WPMT Scores
Old Subjects

	1	2	3	4	5	6	7
REPRODUCTION							
1. Average	1.0						
2. Error	-.72*	1.0					
PRODUCTION							
3. Average	.37*	-.38*	1.0				
4. Error	-.18	.19	-.05	1.0			
NUMBER ESTIMATION							
5. Average	-.32	.49*	-.57*	.30	1.0		
6. Error	-.37*	.55*	-.38*	.45*	.88*	1.0	
DIGIT STRING							
7. Average	.06	.01	-.18	-.02	.04	-.03	1.0
STOP CLOCK 90 SEC							
8. Average	-.11	.09	-.13	-.11	.23	.24	
STOP CLOCK 150 SEC							
9. Average	-.04	.07	-.45*	.09	.40*	.36*	
STOP CLOCK, 90 & 150 SEC							
10. Error	-.14	.13	-.36*	.01	.38*	.38*	
PMT CLOCK							
11. Average	.33	-.27	.20	.13	-.16	-.05	
PMT COVERT							
12. Average	.18	-.25	.19	-.05	-.12	-.06	
PMT DETAIL							
13. Average	.10	-.04	.32	.21	-.11	.10	
PMT PROSPECTIVE TOTAL							
14. Average	.25	-.22	.31	.14	-.16	.01	

* = significant at .05.

PMT = Prospective Memory Test

Table 2 (con't)
Correlations of Time Estimation
and WPMT Scores
Old Subjects

	8	9	10	11	12	13	14
REPRODUCTION							
1. Average	-.11	-.04	-.14	.33	.18	.10	.25
2. Error	.09	.07	.13	-.27	-.25	-.04	-.22
PRODUCTION							
3. Average	-.13	-.45	-.36	.20	.19	.33	.31
4. Error	-.11	.09	.01	.13	-.05	.21	.14
NUM. ESTIMATION							
5. Average	.23	.40	.38	-.16	-.12	-.11	-.16
6. Error	.24	.36	.38	-.05	-.06	.10	.01
DIGIT STRING							
7. Average	-.22	.06	-.10	.05	.24	.22	.21
STOP CLOCK 90 SEC							
8. Average	1.0						
STOP CLOCK 150 SEC							
9. Average	.35*	1.0					
STOP CLOCK, 90 & 150 SEC							
10. Error	.84*	.80*	1.0				
PMT CLOCK							
11. Average	-.17	.04	-.12	1.0			
PMT COVERT							
12. Average	-.13	.01	-.16	.33*	1.0		
PMT DETAIL							
13. Average	-.12	-.10	-.12	.46*	.25	1.0	
PMT PROSPECTIVE TOTAL							
14. Average	-.17	-.03	-.16	.81*	.64*	.80*	1.0

* = significant at .05.

PMT = Prospective Memory Test

Table 3
Correlations of Time Estimation
and WPMT Scores
Young Subjects

	1	2	3	4	5	6	7
REPRODUCTION							
1. Average	1.0						
2. Error	-.95*	1.0					
PRODUCTION							
3. Average	.06	-.10	1.0				
4. Error	.06	-.01	-.89*	1.0			
NUM. ESTIMATION							
5. Average	.01	-.01	-.76*	.75*	1.0		
6. Error	.15	-.11	-.79*	.84*	.59*	1.0	
DIGIT STRING							
7. Average	-.32	.24	.14	-.22	-.04	-.45*	1.0
STOP CLOCK 90 SEC							
8. Average	-.38*	.37*	.07	-.14	-.04	-.10	
STOP CLOCK 150 SEC							
9. Average	.02	-.003	-.34	.30	.16	.01	
STOP CLOCK< 90 & 150 SEC							
10. Error	-.18	.21	-.04	.08	.04	.14	
PMT CLOCK							
11. Average	-.04	.02	.01	-.07	.04	-.10	
PMT COVERT							
12. Average	.33	-.44*	.31	-.23	-.25	-.20	
PMT DETAIL							
13. Average	.02	-.09	.29	-.32	-.23	-.35*	
PMT PROSPECTIVE TOTAL							
14. Average	.11	-.18	.24	-.25	-.17	-.27	

* = significant at .05.

PMT = Prospective Memory Test

Table 3 (con't)
Correlations of Time Estimation
and WPMT Scores
Young Subjects

	8	9	10	11	12	13	14
REPRODUCTINO							
1. Average	-.38	.02	-.18	-.04	.33	.02	.10
2. Error	.37	-.001	.21	.02	-.44*	-.09	-.18
PRODUCTION							
3. Average	.07	-.34	.21	.01	.31	.29	.24
4. Error	-.14	.30	.08	-.07	-.23	-.32	-.25
NUM. ESTIMATION							
5. Average	-.04	.16	.04	.04	-.25	-.23	-.17
6. Error	-.10	.01	.14	-.10	-.20	-.35*	-.27
DIGIT STRING							
7. Average	.22	.09	.10	-.06	-.07	.29	.08
STOP CLOCK 90 SEC							
8. Average	1.0						
STOP CLOCK 150 SEC							
9. Average	-.51*	1.0					
STOP CLOCK, 90 & 150 SEC							
10. Error	.81*	-.63*	1.0				
PMT CLOCK							
11. Average	-.52*	.55*	-.64*	1.0			
PMT COVERT							
12. Average	-.66*	.38*	-.62*	.21	1.0		
PMT DETAIL							
13. Average	-.39*	.40*	-.51*	.22	.25*	1.0	
PMT PROSPECTIVE TOTAL							
14. Average	-.63*	.56*	-.72*	.70*	.61*	.76*	1.0

* = significant at .05.

PMT = Prospective Memory Test

Discussion

Three findings of the present study appear particularly interesting. First, elderly and young subjects showed approximately the same levels of bias on the three time estimation tasks of Reproduction, Production, and Numerical Estimation, but significantly less accuracy on the Reproduction and Numerical Estimation tasks. Second, elderly subjects showed substantially poorer performance than young subjects on the Clock-Stopping task. Third, scores on the time-estimation and Clock Stopping tasks were not significantly related to performance on the Wood Prospective Memory Test (WPMT). These results are discussed below.

<u>1. Age effects on accuracy but not bias.</u> Surwillo (1964), Surwillo (1968), and Salthouse, Wright, and Ellis, (1979) failed to find a difference in time estimation abilities between younger and elderly subjects. The present study replicates these findings: young and elderly subjects showed approximately the same amount of bias on the Reproduction, Production and Numerical Estimation tasks. However, the present study indicates that time estimates of the elderly are less

accurate in general than those of younger subjects. A difference between the current study and the aforementioned studies is that feedback was provided after every trial in the current study, whereas feedback was not provided in the previous studies. The current study replicates the lack of age related differences in time estimation bias, but feedback after every trial may have been a factor in the differences between the groups in accuracy. The differences in accuracy on the Numerical Estimation and Reproduction tasks suggests that the young group was better able to utilize feedback, though there were no differences in accuracy on the Production task.

A possible explanation for the difference between the young and elderly subjects on the Numerical Estimation task could be that on this task there were 10 different times to be estimated, whereas with the reproduction and production tasks there were only two different times. This may indicate that the younger subjects were better able to utilize their feedback when the times to be estimated were less predictable. The differences in accuracy on the Reproduction task may have resulted from being the first test. It may have taken the elderly longer to use their feedback to help them get closer to the target time. If this is true, this would explain the lack of differences on the second task (Production).

Another possible explanation for the differences between the groups on the Numerical Estimation task may be fatigue or lack of continued concentration. The elderly did worse on tasks toward the middle and the end of testing. If fatigue or lack of continued concentration are factors, changing the order of the tests in future research may produce different results. If changing the order of the tests failed to produce different results, then there may be a difference between the elderly and young subjects in time estimation, but only for Numerical Estimation and when different times are being estimated.

<u>2. Age effects on Clock Stopping.</u> Differences on the stop clock tasks between the young and elderly are very intriguing when considered in the field of prospective memory research. To date, there has been no evidence of age related differences in prospective memory (West 1988, Poon & Schafer 1982, and Einstein & McDaniel, 1990). The stop clock task is actually a prospective memory task because it requires the subject to perform an action (stop the clock) in the future while doing another task.

Though the tasks were very short compared to other prospective memory research studies, there were significant age related differences. Not only was it interesting that the elderly, on the average, stopped the clock later than the younger subjects, but 30% of the elderly forgot to stop the clock on the 90 second task and 21% forgot to stop the clock on the 150 second task.

The higher education of the elderly subjects rules out the differences that may have been caused by not having subjects matched on education. For the subjects that forgot to stop on the 90 and 150 second tasks, this may be explained by a diminished-short-term-memory capacity in elderly adults. "That is, elderly adults perform less proficiently than young adults under conditions of divided attention because the former either store less relevant information about the to-be-performed tasks, or deploy their processing resources less proficiently while performing the tasks" (Kausler, 1991).

A possible explanation for the differences on the stop clock tasks may be that the elderly did not understand the instructions quickly enough to perform the task, even though all subjects claimed to understand the instructions. Every effort was made to help the subjects understand the directions, by reading the instructions again, or by having the experiemter explain the procedure. When a subject let the time expire on the stop clock task before stopping it themselves, they were asked if they understood the instructions. All subjects said they understood the instructions, but forgot what they were suppose to do, or that the time passed sooner that they thought.

The diminished short-term-memory capacity may account for the individuals who forgot to stop the task, while the decreased proficiency of divided attention may account for the greater error on the tasks. The decreased capacity for divided attention may also account for the amount of items completed on the tasks. The younger subjects completed significantly more than the older subjects. Some also mentioned that their visual acuity had deteriorated through the years, which made distinguishing between the string of letters more difficult.

While performing the stop-clock tasks the subjects were encouraged to distinguish as many digit strings as possible. It may be interesting in the future to encourage the subjects to work at their own pace, instead of putting the added pressure of distinguishing as many digit strings as possible, while also trying to remember to watch the clock.

3. Absence of correlations with the WPMT. The different methods of time estimation failed to be significantly correlated with the Wood Prospective Memory Test (WPMT). The failure to find correlations may have been due to low internal reliability on the WPMT. Grimes (1991) reports that among 68 college students the internal reliabilities of the Clock, Covert and Detail subscales as measured by coefficient alpha were .50, .63 and .44 respectively. A more reliable measure of prospective memory is needed before the relationship between time estimation and prospective memory can be properly explored.

4. Additional comments. Many of the elderly subjects claimed to have never used a computer before and some had never typed. Some of these subjects approached the testing situation apprehensively. Though this is a possible explanation for the results, it seems that the elderly would have shown deficits on all tasks instead of specific areas. For the subjects who felt too uncomfortable operating the keyboard, the experimenter operated it while they relayed the commands.

A hypothesis for future research is that the elderly subjects benefitted more from the feedback than the younger subjects. While administering the test, it was noticed that many of the elderly subjects were required to do the practice trial more than once. Many were surprised by the amount of error on the practice trial and the first trial of the Reproduction task. Although as shown in the results, the subjects adjusted their estimation according to the feedback.

In future research it would be helpful to perform the three methods of estimation without feedback and also with feedback. Montare (1985, 1988) did both and found that providing feedback significantly increased the mean accuracy for time estimation and production, but not reproduction. This would be an interesting study to replicate with the current studies' sample.

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