Serial Position Effects Across the Adult Lifespan

Lisa C. McGuire, K. Warner Schaie, and Sherry L. Willis

Gerontology Center
The Pennsylvania State University
105 Henderson Building South
University Park, PA 16802

DRAFT: November 16, 1994

Running Head: VERBAL MEMORY

Expanded version of a paper presented at the annual meeting of the Gerontological Society of America, November 21, 1994, Atlanta, Ga. This research is supported by Grant R37 AG08055 from the National Institute on Aging to the second author. Partial support for preparation of this manuscript was from Grant T32 MH18904 The authors gratefully acknowledge the cooperation of the Group Health Cooperative of Puget Sound.

Abstract

Longitudinal changes in serial positions effects of verbal memory and the covariates of change across the adult lifespan were examined in 1011(n = 461 males and n = 550 females) from the Seattle Longitudinal Study (1984 and 1991 assessments). Participants were divided into three age groups: middle-aged (22 to 49 years old, n = 298), young-old (50 to 70 years old, n = 533), and old-old (71 to 86 years old, n = 180). Participants studied a list of 20 concrete nouns and immediate and delayed free-recall was assessed. Age-related changes were examined over a 7-year interval (1984 - 1991) by a repeated measures 3 (age) x 2 (gender) x 2 (occasion) x 2 (task) x 3 (position) Analysis of Variance (ANOVA). Analysis of Covariance was used to statistically control vocabulary and perceptual speed. Similar patterns of findings held for age group and gender main effects, and occasion x age, task x age, position x age, position x age x gender, occasion x task x age, and occasion x position x gender interactions for the both models. However, task x gender interaction was not statistically significant in the ANCOVA models, while the position main effect and the occasion x task x position interaction were significant only after controlling for vocabulary and speed.

Serial Position Effects Across the Adult Lifespan

Memory for serial order is an important aspect in daily life with tasks such as language comprehension, as language is processed serially (Lewandowsky & Murdock, 1989). In addition, serial position effects are an explicit memory phenomenon found in many species (Wright, Santiago, Sands, Kendrick, & Cook, 1985). When presented with a fairly lengthy list of words and asked to immediately recall the list of words, participants typically remember words from the beginning (primacy effect) and end (recency effect) of the list better than those words from the middle during immediate recall. However, in real life recall of learned material is often delayed. The question arises of whether serial order effects are maintained under delayed conditions.

Researchers have examined differences in serial positions effects as a function of both immediate and delayed recall. The shape of the delayed recall serial position curve is thought to be different from the immediate recall position curve (Craik, 1970; Keppel & Underwood, 1962; Murdock, 1962). Keppel and Underwood (1962) and Murdock (1961) reported that recall performance deteriorates across trials due to a buildup of proactive interference. Craik (1970) described the shape of the delayed recall serial position curve, which contains entirely words recalled during immediate recall. The delayed recall curve consists of a primacy effect, a flat middle portion, and a slight but consistent negative recency effect. The last few words in a list are the best recalled on immediate recall but show the least probability of recall on a subsequent trial. The key factor appeared to be whether the words were initially recalled from short-term or long-term memory (Craik, 1970) consistent with a dual-process model.

The explanation of why serial position effects occur is controversial. There are two competing explanations for whether serial position effects are similar under immediate and delayed recall conditions. The first perspective is the dual-process model (e.g., Atkinson & Shiffrin, 1968, 1978; Waugh & Norman, 1965). The primacy effect reflects the retrieval of information that has been transferred from short-term memory to long-term memory. The recency effect occurs when information is retrieve from short-term memory. The dual-process model predicts that the terminal items should be recalled less well on

subsequent recall trials (Craik, 1970), because short-term memory contains a rehearsal buffer that can hold 4-5 words. Once this buffer is full, incoming information removes information already present in the buffer. Thus, information in short-term memory is successfully recalled on the initial trial and the probability of recall is less likely on subsequent recall trials. Distractor tasks have been shown to eliminate the recency effect (Glanzer & Cunitz, 1966).

The second perspective argues that the major components of serial position effects may be observed when information is stored in secondary memory (Fritzgerald, 1988; Pillemer, Goldsmith, Panter, & White, 1988). This approach postulates that individuals consciously use the beginning and the end of a time segment as "anchors" from which to search long-term memory for retrieval. For example, students have been shown to have more vivid memories from the beginning and the end of the freshman year in college (Pillemer et al., 1988). The "anchors" hypothesis predicts that the primacy and recency effects would be maintained across recall trials, as the information is stored in long-term memory.

The literature examining serial position effects is quite extensive; however, little is known about developmental changes in serial position effects across the entire adult lifespan. The majority of the research exploring serial position effects has been limited to the examination of specific age groups of individuals. For example, serial position effects have been investigated in research examining only younger adults' performance (e.g., Craik, 1970; Greene, 1986; Nairne, 1991; Paul & Whissell, 1992; Rybash & Osborne, 1991; Thapar & Greene, 1993) or only older adults' performance (Colsher & Wallace, 1991; Hultsch, Hertzog, Small, McDonald-Miszczak, & Dixon, 1992). List learning performance has been shown to demonstrate the impact of aging and neurological dysfunction on memory performance (Buschke, 1984; Hultsch, 1975; Schmidt, Tombaugh, & Faulkner, 1992). Based on the results from age-group comparison studies of general verbal memory performance, older adults tend to perform less well than younger adults on verbal memory tasks that involve deliberate recall, such as a list learning task (McGuire, Schaie, & Willis, 1994; Poon, 1985; Verhaeghen & Marcoen, 1993; Zelinski, Gilewski, & Schaie, 1993). On average, the recall performance of older adults on memory tasks such as list learning is about one standard

deviation below that of younger adults (Verhaeghen, Marcoen, & Goossens, 1993).

Research suggests that the difference between age groups in memory performance may be attributable at least in part to differences in the level of verbal ability and processing speed. The relationship between verbal ability and memory in adults is thought to be interactive (Zelinski, Gilewski, & Schaie, 1993). Individuals with higher verbal skills are thought to hone memory skills by more frequent practice in memory-enhancing activities. There is general agreement that older adults with low to average verbal ability perform more poorly on memory retrieval tasks than younger adults with comparable memory (Dixon & von Eye, 1984; Spilich, 1983; Taub, 1979). The results are not as clear for highly verbal adults as for younger adults with lower levels of verbal ability. Zelinski and her colleagues (1993) indicated that vocabulary was a reliable cross-sectional predictor of list recall performance but not a significant predictor of longitudinal recall performance. In contrast, McGuire, Schaie, and Willis (1994) reported that verbal ability was a longitudinal predictor of verbal memory.

Processing resources are an additional factor that has been hypothesized to influence cognitive processes, such as speed or working memory capacity (Salthouse, 1985). Declines in speed of performance on cognitive tasks are thought to be a universal phenomenon (Salthouse, 1985). Schaie (1989) reported that when perceptual speed was partialled out of performance scores on cognitive abilities (i.e., verbal meaning, inductive reasoning, spatial orientation, number, and word fluency), the effects of age were markedly reduced for all abilities.

Gender is usually examined in relation to performance on verbal memory tasks. Typically, females perform significantly better on verbal memory recall tasks than males (e.g., Hultsch et al., 1990; Hultsch et al, 1992; McGuire et al., 1994; Schaie, in Press; Schaie & Willis, 1993). Zelinski and her colleagues (1993) indicated that gender was a reliable cross-sectional predictor of list recall performance but not a significant predictor of longitudinal recall performance.

The purpose of the present investigation was two-fold. First, the longitudinal change in serial positions effects of verbal memory over a 7-year interval was examined for 3 age groups by gender (age

range = 22 - 86 years). Second, the influence of vocabulary and perceptual speed on longitudinal changes in serial positions effects of verbal memory was examined.

Several hypothesis were considered. Younger adults were hypothesized to perform at higher levels across positions on the recall tasks than older adults (McGuire, Schaie, & Willis, 1994; Poon, 1985; Verhaeghen & Marcoen, 1993; Zelinski, Gilewski, & Schaie, 1993). It was hypothesized that females would perform at a higher level on verbal memory tasks across positions than males (Hultsch et al., 1990; Hultsch et al, 1992; McGuire et al., 1994; Schaie, in Press; Schaie & Willis, 1993; Zelinski et al., 1993). Recall performance was hypothesized to be greater on the immediate recall tasks than the delayed recall tasks across positions (Craik, 1970; Keppel & Underwood, 1962; Murdock, 1962). Vocabulary and perceptual speed were speculated to minimize the age-related changes across testing occasions (Dixon & von Eye, 1984; McGuire et al., 1994; Salthouse, 1985; Schaie, 1989; Spilich, 1983; Taub, 1979).

Method

Participants

Participants in the present investigation were obtained from the Seattle Longitudinal Study (SLS), which is a large scale longitudinal-sequential study examining adult cognitive development in more than 5,000 participants between the ages of 22 and 86 since 1956 (Schaie, 1983, 1993, in Press). SLS participants are selected randomly from within gender and age-cohort groups from the membership of a large Health Maintenance Organization in the Seattle area. The sampling frame was a community dwelling population representing a wide range of occupational, educational, and economic backgrounds. All participants in the present investigation took part in the 1984 and in the 1991 assessment sessions of the SLS.

Participants (N = 1011; n = 461 males and n = 550 females) were divided into three age groups according to their age at the first assessment session (1984). The middle-aged group ranged in age from 22 to 49 years old (M = 39.85, SD = 6.83, n = 298), the young-old group ranged in age from 50 to 70 years old (M = 60.85, SD =5.63, n = 533), and the old-old group ranged in age from 71 to 86 years old

(M = 77.09, SD = 3.54, n = 180). The age groups differed in their level of education, income, verbal ability, and speed ($p < 0.05$). Old-old adults had less education, lower incomes, and slower processing speed than young-old adults; while young-old adults had less education, lower incomes, and slower processing speed than middle-aged adults ($p < 0.05$). Middle-aged adults and young-old adults had equivalent levels of verbal ability, while old-old adults had less verbal ability than young-old adults ($p < 0.05$). A description of the sample by age group and gender is shown in Table 1.

Insert Table 1 about here

Attrition is an important factor to consider in longitudinal research. Previous research has shown that those participants who return to later assessment sessions tend to perform higher on the study's measures than those participants who did not return to the later assessment sessions (Baltes, Schaie, & Nardi, 1971; Schaie, Labouvie, & Barrett, 1973). The present investigation consists solely of those participants who took part in both the first and second testing occasions. In general, individuals who returned for the second testing occasion were better educated, more verbal, had faster perceptual speed, and correctly recalled more words on the immediate and delayed verbal memory tasks than those who did not return ($p < 0.05$). The effects of attrition can further be seen within each age group. Middle-aged adults who returned for the second assessment were more educated, more verbal, faster perceptual speed, and recalled more words on the verbal memory tasks than those who did not return ($p < 0.05$). Young-old adults who returned for the second assessment did not differ from the non-returners on education, verbal ability, perceptual speed, or verbal memory ($p > 0.05$). The old-old adults who returned for the second assessment were more verbal and recalled more words on the verbal memory tasks than those who did not return ($p < 0.05$).

Materials and Procedure

Verbal Memory. Verbal memory is the ability to encode, store, and recall meaningful language

units. Verbal memory was measured by an Immediate Recall test and a Delayed Recall test (Zelinski, Gilewski, & Schaie, 1979). Participants were administered the Immediate Recall and the Delayed Recall tests, consisting of the same list-learning task both in 1984 and in 1991. Participants studied a list of 20 concrete nouns for 3.5 minutes and then engaged in free-recall. Immediate recall was assessed immediately following stimulus presentation and delayed recall was assessed after a 1 hour delay. The two-week test-retest correlation for the Immediate Recall task was .820 and .732 for the Delayed Recall task.

Vocabulary. Recognition vocabulary serves as an index of a person's language knowledge and comprehension. The present investigation used three recognition vocabulary tasks to assess participants' level of verbal ability.

ETS Vocabulary Test from the Educational Testing Service (ETS) Factor-Referenced Tests (Ekstrom, French, Harman, & Derman, 1976) is a recognition five-choice synonym test in which the participant selects the correct response. The ETS Vocabulary Test consists of 2 parts with 18 items each and each part is completed in 4 minutes. The two-week test-retest correlation was .928.

ETS Advanced Vocabulary Test from the ETS Factor-Referenced Tests (Ekstrom et al., 1976) is a five-choice synonyms test similar to the ETS Vocabulary Test, but the Advanced Test consists mainly of difficult words and less frequently used words. The ETS Advanced Test consists of 2 parts with 18 items each and each part is completed in 4 minutes. The two-week test-retest correlation for the ETS Advanced Test was .954.

Primary Mental Abilties (PMA) Verbal Meaning test (Thurstone & Thurstone, 1949) is a four-choice synonym test consisting of 50 items to be completed in 4 minutes. The two-week test-retest correlation was .890.

Perceptual Speed. Perceptual speed is the ability to make simple discriminations involving visual perception with speed and accuracy. Measures of perceptual speed are typically long, highly speeded, and

require very quick scanning speed. The three measures below have been found to be markers of perceptual speed in the ETS Kit of Factor-Referenced Tests (Ekstrom et al., 1976).

Finding A's test has the participant must identify 5 words containing the letter *a* from a column of 40 simple words. There are 25 columns of words and the entire task is to be completed in 2 minutes. The two-week test-retest correlation for the Finding A's task was .860.

Identical Pictures consists of a stimulus and five item choices including the target item and four distractor items. Participants are to select the target item from among the distractors. The Identical Pictures task consists of 48 test items to be completed in 1.5 minutes. The two-week test-retest correlation was .814.

Number Comparison has participants inspect pairs of multi-digit numbers and determines whether the two numbers are identical. The 48 item task is limited to 1.5 minutes for completion. The two-week test-retest correlation for the Number Comparison task was .865.

In order to create the verbal and speed factor scores, test results from the tasks representing each ability for both testing occasions were used. Following an orthonormal transformation of the appropriate factor weights obtained from a LISREL analysis (Jöreskog & Sörbom, 1989), factor scores were calculated to create the verbal and speed factors and then used in the subsequent analyses.

Results

The number of words correctly recalled on immediate and delayed recall tasks were independently summed for each task (immediate vs. delayed), for each testing occasion (1984-1991), and for each age-cohort group to created the recall scores. The immediate and delayed recall scores for 1984 and 1991 were the dependent variables.

To examine the position effects, the stimulus list from the immediate and delayed recall task was classified according to serial position. For a list of 20 words, the initial 3 words were classified at primacy words, the next 12 words were classified as center words, and the final 5 words were classified as recency words (Craik, Personal Communication). The Immediate and Delayed serial position curves are shown in

Figure 1 by occasion and age-cohort group.

Insert Figure 1 about here

Position scores were calculated for each participant for each type of task (immediate vs. delayed) and for each occasion (1984-1991). Scores were converted to standardized T-scores with a mean of 50 and a standard deviation of 10. The standardized position scores were used in the following analyses.

The influence of vocabulary and perceptual speed on longitudinal change in verbal memory was examined. Pearson product-moment correlation coefficients were calculated to determine the relation between recall and vocabulary, and perceptual speed. The significance level selected for all analyses was $p \leq 0.05$ and only significant results will be described. Vocabulary and perceptual speed were significantly correlated ($r = 0.223$, $p < 0.001$). As shown in Table 2, vocabulary and perceptual speed were significantly correlated with performance on the immediate and delayed recall tasks ($rs = 0.19$ to 0.57). The strength of the association between vocabulary, perceptual speed, and recall remained consistent across trials.

Insert Table 2 about here

To investigate the role of gender, age-cohort, testing occasion, task type, and recall position on participants' recall, a repeated measures 3 (age-group) x 2 (gender) x 2 (occasion) x 2 (task) x 3 (position) Analysis of Variance (ANOVA) was calculated. In order to explore independently the role of vocabulary score or perceptual speed and the combination of vocabulary and perceptual speed on recall, repeated measures 3 (age group) x 2 (gender) x 2 (occasion) x 2 (task) x 3 (position) Analysis of Covariance (ANCOVA) were performed. Tukey's honestly significant difference test for unequal *ns* was computed for the significant main effects and interactions. The ANOVA and ANCOVA results are presented in Table 3. Recall scores unadjusted and adjusted for the covariates are found in Table 4.

Insert Tables 3 & 4 about here

ANOVA Model

A significant main effect was found for age group. Middle-aged adults' levels of performance were significantly higher than young-old adults and old-old adults ($p < 0.05$). The gender main effect was significant, as females recalled more words than males ($p < 0.001$).

The interaction between occasion and age-cohort was significant. Old-old adults remembered more words ($p < 0.05$) on the verbal memory tasks during the first testing occasion than the second testing occasion, while middle-aged and young-old age-cohorts recalled an equivalent number of words on the first and the second testing occasions. In addition, significant differences in recall performance was found among all age-cohort groups at both occasions ($p < 0.05$).

Recall task and age interacted significantly. The difference between the number of words remembered on the immediate and delayed recall task increased with age, with old-old adults having the largest difference in performance between immediate and delayed and the middle-aged adults having the smallest difference ($p < 0.05$). The task x gender interaction was significant. Males exhibit declines in performance between immediate and delayed recall while females' performance increased ($p < 0.05$).

The position by age interaction was statistically significant. Middle-aged adults' recall performance differed significantly from young-old adults on the center position ($p < 0.05$), while middle-aged adults recalled significantly more words in the primacy and recency positions than old-old adults ($p < 0.05$).

Position, age, and gender interacted significantly as shown in Figure 2. Old-old females recalled more primacy words and recency words than center words. The old-old males remembered equivalent numbers of primacy and recency words and fewer center position words. However, the gender difference for primacy and center words favored women, while performance was equivalent for males and females on

the recency words.

Insert Figure 2 about here

The occasion x task x age interaction was also statistically significant as shown in Figure 3. Middle-aged adults recall more words on the delayed recall tasks than the immediate recall task across occasions, with an increase in the level of performance from the first occasion to the second occasion. The young-old adults' performance was equivalent across occasions and tasks. For the old-old adults, at the first testing occasion immediate recall performance was greater than delayed recall performance but at the second testing occasion immediate and delayed performance was equivalent.

Insert Figure 3 about here

Occasion, position, and gender interacted significantly. Females' word recall remained constant across positions and testing occasions as shown in Figure 4. However, males exhibited a decline in performance from the first occasion to the second on all positions, with the greatest magnitude of decline for the primacy position.

Insert Figure 4 about here

ANCOVA Models

A similar pattern of findings held for the age group and gender main effects, and occasion x age, task x age, position x age, position x age x gender, occasion x task x age, and occasion x position x gender interactions for the ANOVA and the ANCOVA models. The task x gender interaction was no longer statistically significant in the ANCOVA models. However, the position main effect and the occasion x task

x position interactions were now significant after vocabulary and speed were statistically controlled.

The position main effect was statistically significant. More primacy words were recalled than words in any other positions, followed by more center words than recency words. Significantly more primacy words were remembered than recency words ($p < 0.05$). An equivalent number of primacy and center words and center and recency words were recalled ($p > 0.05$).

Insert Figure 5 about here

The occasion x task x position interaction was statistically significant as shown in Figure 5. More primacy words were recalled during the first occasion than the second testing occasion on the immediate recall task ($p < 0.05$). Recall performance was equivalent across occasion and task for the center and recency positions ($p > 0.05$).

Discussion

Similar patterns of findings held for age group and gender main effects, and occasion x age, task x age, position x age, position x age x gender, occasion x task x age, and occasion x position x gender interactions for the both models. However, task x gender interaction was not statistically significant in the ANCOVA models, while the position main effect and the occasion x task x position interaction were significant only after controlling for vocabulary and speed.

The shape of the serial position curves differed depending on task. Immediate position curves show both primacy and recency effects as expected. In addition, the delayed serial curves demonstrate primacy and recency effects. This is inconsistent with Craik's (1970) negative recency effect. The delayed serial curves, as expected were lower than the immediate curves in magnitude consistent with previous findings (Keppel & Underwood, 1962; Murdock, 1962). The occurrence of a recency effect, especially after distractor tasks, does not support the dual-process model (Atkinson & Shiffrin, 1968, 1978; Waugh & Norman, 1965). It would be expected in the present investigation that the distractor tasks would eliminate

the recency effect (Glanzer & Cunitz, 1966). Based on the assumptions of the hypotheses explaining serial position effects, the present investigation supports the "anchors" hypothesis (Fritzgerald, 1988; Pillemer et al., 1988) due to the presence of a recency effect during delayed recall.

List learning tasks have been shown to demonstrate the impact of aging and neurological dysfunctioning on memory performance (Buschke, 1984; Hultsch, 1975; Schmidt et al., 1992). This effect appears in the present investigation as differences in the level of recall by occasion when comparing the serial curves across age-cohort groups. Middle-aged adults' serial position curves were higher on the second testing occasion, while young-old and old-old adults' level of performance on the second occasion was lower than on the first occasion. The serial position curves illustrate aging effects in verbal memory, with young-old and old-old adults having a lower level of memory performance than middle-aged adults. This is consistent with the general verbal memory literature (McGuire, Schaie, & Willis, 1994; Poon, 1985; Verhaeghen & Marcoen, 1993; Zelinski, Gilewski, & Schaie, 1993) with age differences in the present investigation observed across occasion, across task, and across serial positions.

Our findings also support the observation that verbal memory in general remains relatively stable over 7-year intervals, which is consist with the findings of Hultsch et al. (1992) and McGuire et al. (1994). Also, consistent with the verbal memory literature (e.g., Hultsch et al., 1990; Hultsch et al, 1992; McGuire et al., 1994; Schaie, in Press; Schaie & Willis, 1993), we found significant gender differences in memory performance. As hypothesized, females in the present investigation performed higher than males.

Verbal ability and perceptual speed are important individual difference characteristics that have primarily been implicated to effect memory performance (Dixon & von Eye, 1984; McGuire et al., 1994; Salthouse, 1985; Schaie, 1989; Spilich, 1983; Taub, 1979). These effects are further documented in the present investigation. Overall, position effects as well as the interaction between testing occasion, task, and position attained significance only when verbal ability and perceptual speed were statistically controlled. On the other hand, the task by gender interaction disappeared after controlling for verbal ability and perceptual speed. This finding suggests that vocabulary and perceptual speed serve to mediate position

effects. In addition, when vocabulary and perceptual speed were controlled, the magnitude of the age difference was minimized.

References

Atkinson, R.C., & Shiffrin, R.M. (1968). Human memory: A proposed system and its control processes. In K.W. Spence and J.T. Spence (Eds.), *The psychology of learning and motivation, Vol 2,* (pp. 189-195). NY: Academic Press.

Atkinson, R.C., & Shiffrin, R.M. (1977). Human memory: A proposed system and its control processes. In G.W. Bower (Ed.), *Human Memory: Basic Processes.* NY: Academic Press.

Baltes, P.B., & Kliegl, R. (1992). Further testing of limits of cognitive plasticity: Negative age differences in a mnemonic skill are robust. *Developmental Psychology, 28,* 121-125.

Baltes, P.B., Schaie, K.W., & Nardi, A.H. (1971). Age and experimental mortality in a seven-year longitudinal study of cognitive behavior. *Developmental Psychology, 5,* 18-26.

Buschke, H. (1984). Cued recall in amnesia. *Journal of Clinical Neuropsychology, 6,* 433-440.

Craik, F.I. M. (1970). The fate of primary memory items in free recall. *Journal of Verbal Learning and Verbal Behavior, 9,* 143-148.

Cavanaugh, J.C. (1984). Effects of presentation format on adults' retention of television programs. *Experimental Aging Research, 10,* 51-53.

Cohen, G., & Faulkner, D. (1989). The effects of aging on perceived and generated memories. In L.W. Poon, D.C. Rubin, & B. Wilson (Eds.), *Everyday cognition in adulthood and late life.* New York: Cambridge University Press.

Colsher, P.L, & Wallace, R.B. (1991). Longitudinal application of cognitive function measures in a defined population of community-dwelling elders. *Annals of Epidemiology, 1,* 215-230.

Dixon, R.A., & von Eye, A. (1983). Depth processing and text recall in adulthood. *Journal of Reading Behavior, 26,* 109-117.

Ekstrom, R.B., French, J.W., Harman, H., & Derman, D. (1976). *Kit of factor-referenced cognitive tests* (Rev. ed.). Princeton, NJ: Educational Testing Service.

Fritzgerald, J.M. (1988). Vivid memories and the reminiscence phenomenon. *Human Development, 31,*

260-270.

Glanzer, M., & Cunitz, A.R. (1966). Two storage mechanisms in free recall. *Journal of Verbal Learning and Verbal Behavior, 5, 351-360.*

Greene, R.L. (1986). A common basis for recency effects in immediate and delayed recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12,* 413-418.

Hultsch, D. (1975). Adult age differences in retrieval: Trace-dependent and cue-dependent forgetting. *Developmental Psychology, 11,* 197-201.

Hultsch, D.F., Hertzog, C., & Dixon, R.A. (1990). Ability correlates of memory performance in adulthood and aging. *Psychology and Aging, 5,* 356-368.

Hultsch, D.F., Hertzog, C., Small, B.J., McDonald-Miszczak, L., & Dixon, R.A. (1992). Short-term longitudinal change in cognitive performance in later life. *Psychology and Aging, 7,* 571-584.

Jöreskog, K.G., & Sörbom, D. (1989). *Lisrel VII User's Guide. Mooresville, IN: Scientific Software Inc.*

McGuire, L.C., Schaie, K.W., & Willis, S.L. (1994, August). *The course of verbal memory: A lifespan approach.* Paper presented at the meeting of the American Psychological Association, Los Angeles, CA.

Meyer, B.J.F. (1987). Reading comprehension and aging. In K.W. Schaie (Ed.), *Annual review of gerontology and geriatrics: Vol. 7* (pp.93-115). NY: Springer.

Nairne, J.S. (1991). Positional uncertainty in long-term memory. *Memory & Cognition, 19,* 332-340.

Paul, N. & Whissell, C. (1992). Memory for words in a serial list as a function of primacy-recency, frequency, length, order, and location in a two-dimensional emotional space. *Perceptual and Motor Skills,* 74, 427-432.

Pillemer, D.B., Goldsmith, L.R., Panter, A.T., & White, S.H. (1988). Very long-term memories of the first year in college. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 14,* 709-715.

Poon, L.W. (1985). Differences in human memory with aging: Nature, causes, and clinical implications. In J.E. Birren & K.W. Schaie (Eds), *Handbook of the psychology of aging (2nd ed.)* (pp. 427-462).

New York: Van Nostrand Reinhold.

Rybash, J.M., & Osborne, J.L. (1991). Implicit memory, the serial position effect, and test awareness. *Bulletin of the Psychonomic Society, 29,* 327-330.

Salthouse, T.A. (1985). Speed of behavior and its implications for cognition. In J.E. Birren & K.W. Schaie (Eds.), *Handbook of the psychology of aging(2nd ed.)* (pp. 39-58). New York: Van Nostrand Reinhold.

Schaie, K.W. (1983). The Seattle Longitudinal Study: A 21-year exploration of psychometric intelligence in adulthood. In K.W. Schaie (Ed.), *Longitudinal studies of adult psychological development* (pp. 64-135). New York: Guilford.

Schaie, K.W. (1989). Perceptual Speed in Adulthood: Cross-Sectional and Longitudinal Studies. *Psychology and Aging, 4,* 443-453.

Schaie, K.W. (1993). The Seattle Longitudinal Study: A thirty-five year inquiry of adult intellectual development. *Zeitschrift für Gerontologie, 26,* 126-137.

Schaie, K.W. (1994). The course of adult intellectual development. *American Psychologist, 49,* 304-313.

Schaie, K.W. (In Press). *Intellectual development in adulthood: The Seattle Longitudinal Study*. New York: Cambridge University Press.

Schaie, K.W., & Willis, S.L. (1993). Age difference patterns of psychometric intelligence in adulthood: Generalizability within and across ability domains. *Psychology and Aging, 8,* 44-55.

Schaie, K.W., Labouvie, G.V., & Barrett, T.J. (1973). Fourteen-year cohort-sequential analyses of adult intellectual development. *Developmental Psychology, 28,* 328-334.

Schmidt, J.P., Tombaugh, T.M., & Faulkner, P. (1992). Free-recall, cued-recall and recognition procedures with three verbal memory tests: Normative data from age 20 to 79. *The Clinical Neuropsychologist, 6,* 185-200.

Spilich, G.J. (1983). Life-span components of text processing: Structural and procedural differences. *Journal of Verbal Learning and Verbal Behavior, 22,* 231-244.

Taub, H.A. (1979). Comprehension and memory of prose materials by young and old adults. *Experimental Aging Research, 5,* 3-13.

Thapar, A., & Greene, R.L. (1993). Evidence against a short-term-store account of long-term recency effects. *Memory and Cognition, 21,* 329-337.

Thurstone, L.L., & Thurstone, T.G. (1949). *Examiner manual for the SRA Primary Mental Abilities Test (Form 10-14)*. Chicago: Science Research Associates.

Verhaeghen, P., & Marcoen, A. (1993). Memory aging as a general phenomenon: Episodic recall of older adults is a function of episodic recall of young adults. *Psychology and Aging, 8,* 380-388.

Verhaeghen, P., Marcoen, A., & Goossens, L. (1993). Facts and fiction about memory aging: A quantitative integration of research findings. *Journals of Gerontology: Psychological Sciences, 48,* 157-171.

Waugh, N.C., & Norman, D.A. (1965). Primary memory. *Psychological Review, 72,* 89-104.

Wright, A.A., Santiago, H.C., Sands, S.F., Kendrick, D.F., & Cook, R.G. (1985). Memory processing of serial lists by pigeons, monkeys, and people. *Science, 229,* 287-289.

Zelinski, E.M., Gilewski, M.J., & Schaie, K.W., (1979, August). *Age differences in memory for facts vs. inferences.* Paper presented at the Annual Meeting of the American Psychological Association, New York.

Zelinski, E.M., Gilewski, M.J., & Schaie, K.W. (1993). Individual differences in cross-sectional and 3-year longitudinal memory performance across the adult life span. *Psychology and Aging, 8,* 176-185.

Table 1

A Description of the Sample as a Function of Age Group and Gender.

	Middle-aged		Young-old		Old-old	
	Males	Females	Males	Females	Males	Females
n	135	163	245	288	81	99
Age						
M	39.47	40.18	61.27	60.49	75.16	75.04
SD	6.70	6.95	5.49	5.74	3.78	3.36
Range	25 - 49	22 - 49	50 - 70	50 - 70	71 - 86	71 - 85
Education						
M	15.91	14.94	15.17	14.09	13.49	13.65
SD	2.65	2.67	3.02	2.56	3.65	4.78
Range	5 - 20	4 - 20	4 - 20	7 - 20	7 - 20	8 - 20
Vocabulary						
M	51.83	51.70	50.77	50.20	44.81	46.47
SD	9.21	8.90	9.75	9.88	11.74	10.08
Range	20.08-64.77	15.78-64.12	14.41-66.13	21.23-64.91	12.34-64.48	17.23-62.53
Perceptual Speed						
M	56.70	58.73	47.96	50.08	38.26	41.12
SD	7.48	8.55	7.53	8.06	8.01	7.66
Range	43.07-80.71	37.11- 80.47	27.01-66.16	32.65-73.23	16.72-58.33	22.31-58.08

Table 2

Pearson Correlation Coefficients for Position Recall Scores, Vocabulary, and Perceptual Speed.

	Vocabulary	Perceptual Speed
1984 Immediate Primacy	0.224 ***	0.257 ***
1984 Delayed Primacy	0.191 ***	0.314 ***
1991 Immediate Primacy	0.198 ***	0.328 ***
1991 Delayed Primacy	0.229 ***	0.354 ***
1984 Immediate Center	0.381 ***	0.427 ***
1984 Delayed Center	0.386 ***	0.497 ***
1991 Immediate Center	0.400 ***	0.535 ***
1991 Delayed Center	0.389 ***	0.540 ***
1984 Immediate Recency	0.337 ***	0.397 ***
1984 Delayed Recency	0.351 ***	0.430 ***
1991 Immediate Recency	0.366 ***	0.467 ***
1991 Delayed Recency	0.369 ***	0.503 ***

Note.
*** $p \leq 0.001$

Table 3

Repeated Measures 3 (Age group) x 2 (Gender) x 2 (Occasion) x 2 (Task) x 3 (Position) ANOVA and ANCOVAs

	No Covariates			Vocabulary and Perceptual Speed Covaried		
	F	DF	*p*	*F*	DF	*p*
Age	190.75	2, 1005	.001	59.87	2, 1003	.001
Gender	43.19	1, 1005	.001	39.79	1, 1003	.001
Age x Gender		*ns*			*ns*	
Occasion		*ns*			*ns*	
Occasion x Age	9.63	2, 1005	.001	5.71	2, 1003	.003
Occasion x Gender		*ns*			*ns*	
Occasion x Age x Gender		*ns*			*ns*	
Task		*ns*			*ns*	
Task x Age	8.61	2, 1005	.001	3.55	2, 1003	.029
Task x Gender	4.1	1, 1005	.043		*ns*	
Task x Age x Gender		*ns*			*ns*	
Position		*ns*		31.24	2, 2006	.001
Position x Age	12.12	4, 2010	.001	2.62	4, 2006	.033
Position x Gender		*ns*			*ns*	
Position x Age x Gender	3.39	4, 2010	.001	3.54	4, 2006	.007
Occasion x Task		*ns*			*ns*	
Occasion x Task x Age	4.19	2, 1005	.015	3.42	2, 1003	.033

(Continued on next page)

Table 3 (Continued)

	No Covariates			Vocabulary and Perceptual Speed Covaried		
	F	DF	*p*	*F*	DF	*p*
Occasion x Task x Gender		*ns*			*ns*	
Occasion x Task x Age x Gender		*ns*			*ns*	
Occasion x Position		*ns*			*ns*	
Occasion x Position x Age		*ns*			*ns*	
Occasion x Position x Gender	5.35	2, 2010	.005	6.54	2, 2006	.015
Occasion x Position x Age x Gender		*ns*			*ns*	
Task x Position		*ns*			*ns*	
Task x Position x Age		*ns*			*ns*	
Task x Position x Gender		*ns*			*ns*	
Task x Position x Age x Gender		*ns*			*ns*	
Occasion x Task x Position		*ns*		3.1	2, 2006	.045
Occasion x Task x Position x Age		*ns*			*ns*	
Occasion x Task x Position x Gender		*ns*			*ns*	
Occasion x Task x Position x Age x Gender		*ns*			*ns*	

Table 4

Mean Position Recall Scores in T-score Units: No Covariates and Adjusted for Covariates

	Middle-aged		Young-old		Old-old	
	Males	Females	Males	Females	Males	Females
1984 Immediate Primacy	52.99[1] [51.97] [2]	52.96 [51.59]	48.76 [48.94]	49.66 [49.63]	46.23 [48.66]	48.17 [49.92]
1984 Delayed Primacy	52.82 [51.69]	54.59 [53.13]	48.00 [48.27]	50.73 [50.69]	43.62 [45.84]	46.63 [48.35]
1991 Immediate Primacy	53.93 [51.19]	54.36 [53.79]	44.96 [49.10]	50.83 [50.91]	40.42 [42.55]	46.81 [48.19]
1991 Delayed Primacy	53.08 [52.15]	55.41 [54.51]	47.03 [47.44]	51.47 [51.49]	41.41 [43.68]	46.32 [47.90]
1984 Immediate Center	53.57 [52.01]	56.25 [54.49]	47.91 [47.97]	50.23 [50.19]	41.09 [44.49]	46.66 [49.08]
1984 Delayed Center	54.50 [52.56]	56.85 [54.53]	47.20 [47.47]	50.56 [50.55]	40.86 [44.99]	45.33 [48.29]
1991 Immediate Center	55.26 [53.32]	55.43 [54.38]	47.58 [47.94]	50.60 [50.62]	39.85 [44.30]	44.78 [47.91]
1991 Delayed Center	55.44 [53.59]	57.47 [55.48]	47.11 [47.45]	50.51 [50.51]	39.89 [44.03]	44.23 [47.17]
1984 Immediate Recency	52.56 [50.87]	54.99 [53.03]	48.06 [48.23]	51.03 [50.97]	43.35 [46.69]	45.52 [48.07]
1984 Delayed Recency	52.99 [51.31]	55.74 [53.78]	47.76 [47.92]	51.39 [51.34]	42.63 [45.90]	43.96 [46.47]
1991 Immediate Recency	53.86 [52.14]	56.14 [54.33]	48.19 [48.56]	50.49 [50.71]	43.03 [47.01]	43.35 [46.12]
1991 Delayed Recency	54.23 [52.35]	57.11 [55.07]	47.53 [47.92]	50.49 [50.47]	42.04 [46.18]	43.73 [46.68]

Note.
[1] No Covariates
[2] Vocabulary and Perceptual Speed Covaried

Figure 1. Serial Position Curves by Age Group.

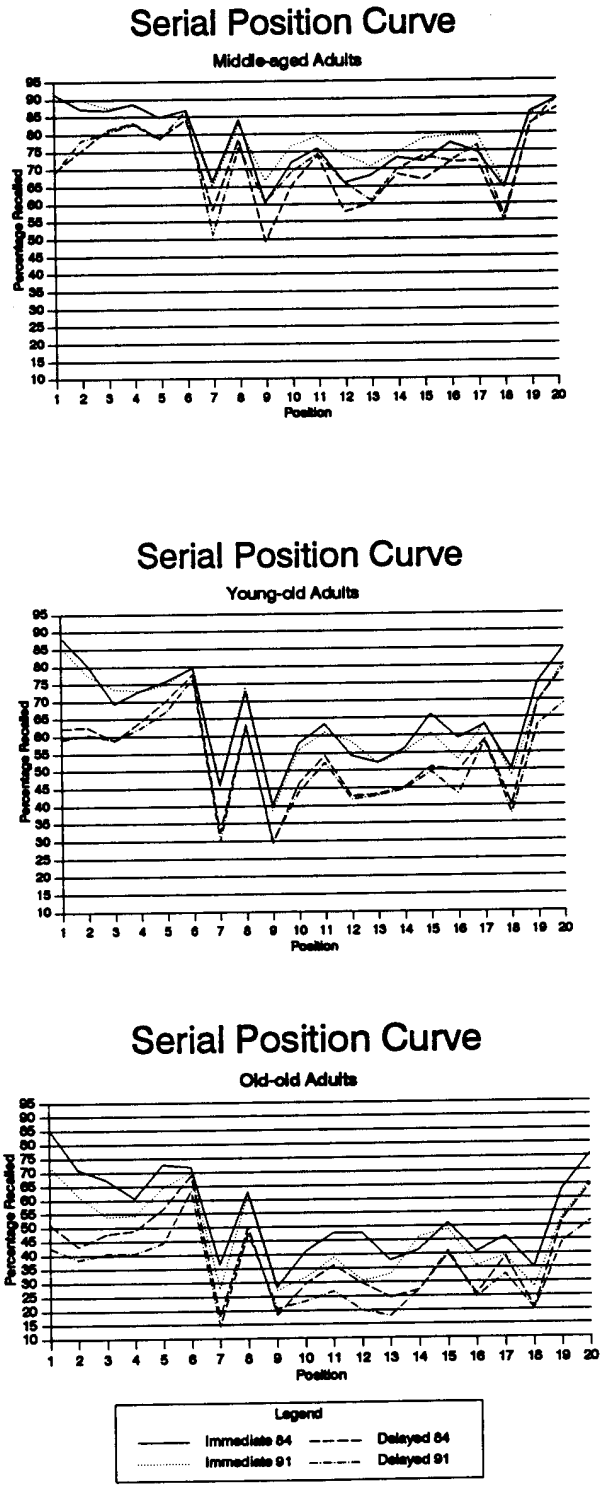

Figure 2. Recall Performance as a function of Position, Age Group, and Gender.

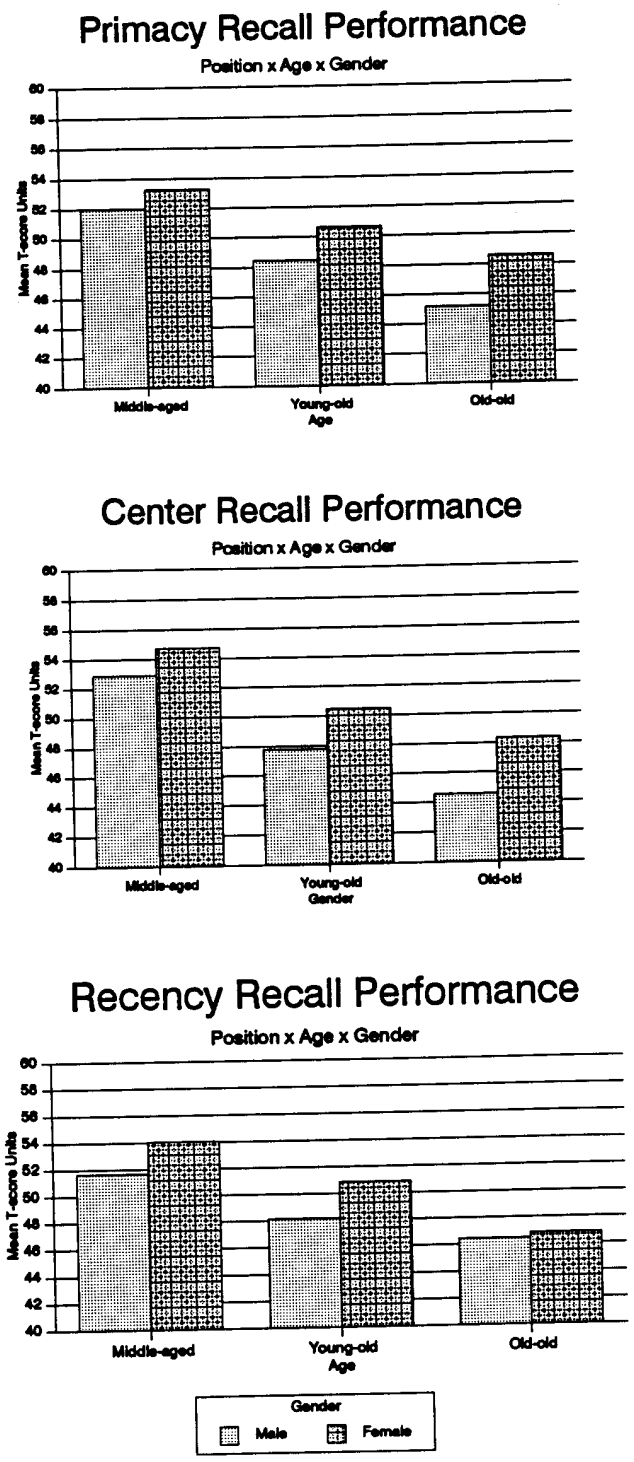

Figure 3. Recall Performance as a Function of Occasion, Talk and Age Group.