Influence of Cognitive Abilities and Age on Word Recall Performance Across Trials and List Segments

LACY E. KRUEGER
Texas A&M University–Commerce

TIMOTHY A. SALTHOUSE
University of Virginia

The influence of cognitive abilities and age on multitrial word recall performance was examined for different list segments (i.e., first, middle, and last) and across trials by having 2,497 participants ages 18–98 complete a multitrial word list test along with reference cognitive ability tests. As expected, higher episodic memory ability was associated with better recall on all list segments but with a smaller influence for the last items on the early trials. Performance improved across trials, but there were no relations of the fluid intelligence construct that might be postulated to be associated with effective strategy implementation with any of the recall measures. Advanced age was associated with lower levels of performance, but very few of the age relations were significant after the variation in the reference cognitive abilities was controlled for.

The serial position effect, characterized by greater recall from the first and last portions of a list than from the middle portions, is well established in word list learning tasks (Glanzer & Cunitz, 1966; Murdock, 1962; Rundus & Atkinson, 1970). The higher recall of early items in the list, the primacy effect, has been attributed to greater rehearsal of initial items (Bruce & Papay, 1970; Glanzer & Cunitz, 1966), whereas the higher recall of items at the end of list, the recency effect, has been postulated to occur because the last items are still available in short-term store (Glanzer & Cunitz, 1966) or focal attention (McElree, 2006). Although many experimental studies have investigated the serial position effect by, for example, manipulating the retention interval (Gershberg & Shimamura, 1994) or increasing the presentation rate (Wixted & McDowell, 1989), few studies have taken an individual difference approach to assess what it is about individuals that determines their level of recall at different serial positions and across successive trials.

To our knowledge, no study has examined the unique age relations and influence of multiple cognitive abilities including episodic memory, processing speed, vocabulary, and fluid intelligence (Gf) on recall performance across list segments and successive trials. An individual difference study by Crawford and Stankov (1983) included adults within a normal intelligence range to address which cognitive abili-

American Journal of Psychology
Fall 2011, Vol. 124, No. 3 pp. 291–300

ties are related to recall in the primacy and recency segments, and they found that the primacy effect was greater among individuals with higher processing speed, whereas higher levels of both crystallized and fluid intelligence were associated with better recall of the last items. However, this study did not examine the effects of these cognitive abilities on recall of items in the middle positions of the list. Because fewer items are recalled from the middle of a list, knowing which abilities are related to recall of these items may be informative about differences in learning and how to design techniques to improve performance. Unsworth, Spiller, and Brewer (2010) examined the association between working memory, reasoning skills (i.e., verbal analogies and number series), and SAT verbal and quantitative measures of performance on each item position in a word list. Working memory measures consisting of a reading span and operation span task were strongly associated with recall across all item positions, but only the prerecency portion of the list was associated with verbal SAT. Very few item positions were associated with reasoning skills and quantitative SAT scores. These studies therefore suggest that cognitive abilities may be differentially related to recall performance across item position. Furthermore, the influence of cognitive abilities may also change over successive trials with the same list of words; therefore, unlike in the aforementioned studies, a multitrial learning task was implemented in the current study. In addition, the current study sought to expand on previous individual difference studies by including a broad age range of adults in the sample to address how both cognitive abilities and age are related to recall performance across not only segments, again as was the case with the aforementioned studies, but also across trials.

We investigated the influence of cognitive abilities on recall performance on different list segments and across multiple trials with the Word List Recall test of the Wechsler Memory Scale (Wechsler, 1997b). The list consists of 12 words and can be divided into three segments: first (Items 1–3), middle (Items 4–9), and last (Items 10–12). Participants complete four study–recall trials of the same word list, and then they are presented with a new list of words. After attempting to recall words from the new list, participants are asked to recall the words from the original list. Performance therefore can be assessed after the initial trial (Trial 1 Recall), after repeated trials (Trial 4 Recall), and after intervening material (Trial 5 Recall).

The analytical procedure used to investigate the role of different cognitive abilities on different measures of word recall performance is portrayed in Figure 1. Several features of this approach should be noted. First, each cognitive ability is represented at the latent construct level, which corresponds to the variance that several variables have in common. The cognitive ability constructs in this analytical model therefore are more likely to reflect the theoretical construct of interest rather than task-specific influences that also contribute to scores on individual tasks. Second, several cognitive abilities are examined simultaneously, which allows their unique influences to be determined. When only a single cognitive ability is considered, all the influences it shares with other cognitive abilities are attributed to that ability, which could lead to inflated estimates of the role of that ability. Third age is included in the model with relations to each cognitive ability and to the target variable. This not only allows the influences of the cognitive abilities on the target variable to be determined after statistically controlling for influences of age on all variables but also provides an estimate of the strength of the unique influences of age on the target variable that are statistically independent of the influences on the cognitive abilities. The analytical procedure portrayed in Figure 1 has been called contextual analysis because it allows influences of age on individual variables to be determined in the context of age-related influences on other cognitive abilities (e.g., Salthouse, 2005; Salthouse, Pink, & Tucker-Drob, 2008; Salthouse, Siedlecki, & Krueger, 2006).

Our specific predictions were as follows. First, although episodic memory ability, as assessed by story recall and paired-associate measures, was expected to be related to most of the word recall measures, we predicted that the influence would be smallest for recency items because they may still be in a short-term buffer or currently attended to. Second, we expected that processing speed would be related to recall for primacy items, particularly on early trials in the task. Third, we predicted that fluid intelligence (Gf) would be related to recall performance, especially for middle items on early trials, because Gf abilities might be related to implementing effective strategies. Fourth, although advanced age was expected to be associated

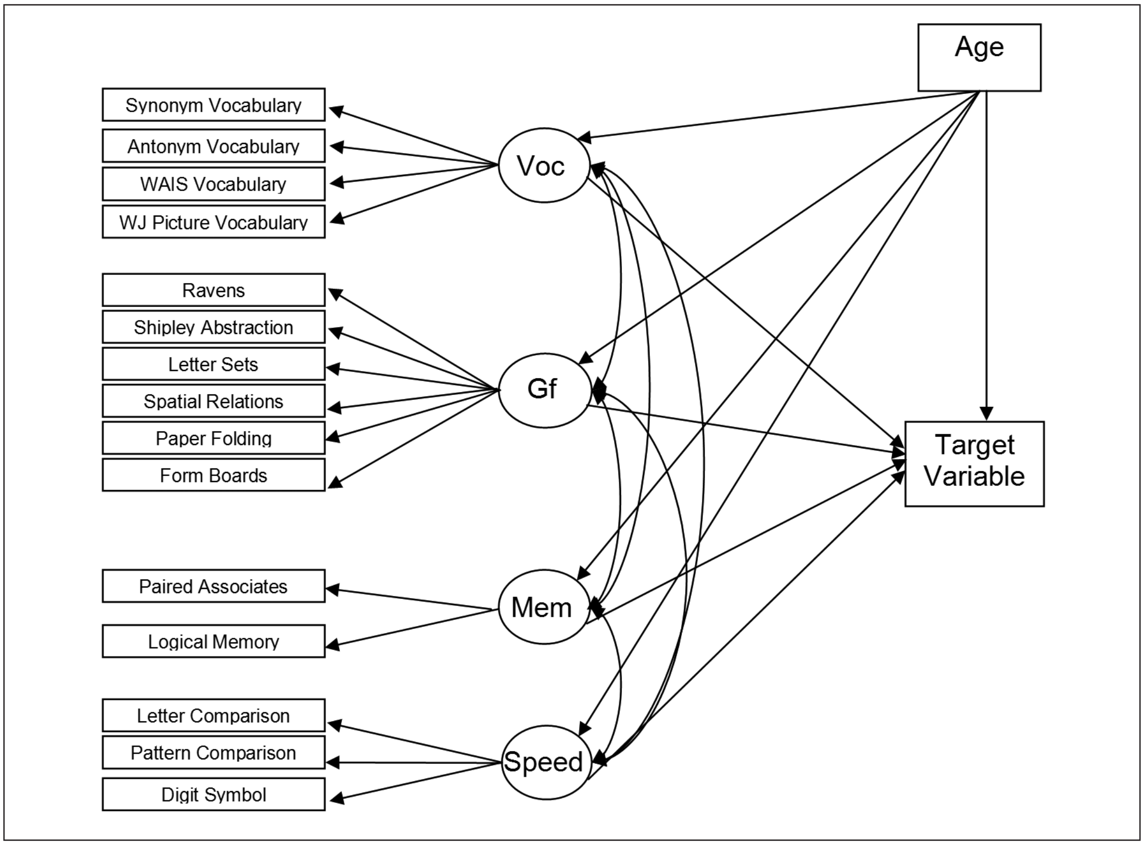

FIGURE 1. Contextual model that allows examination of the influence of the reference cognitive abilities and age on the target variable. Gf = fluid intelligence; Mem = episodic memory ability; Speed = processing speed; Voc = vocabulary ability; WAIS = Wechsler Adult Intelligence Scale; WJ = Woodcock & Johnson

with lower levels of performance on most of the recall measures, little or no relationship was predicted for recall of recency items on early trials because these items are thought to be largely unaffected by aging (Craik, 1968; Murphy, Craik, Li, & Schneider, 2000; see Kahana, Howard, Zaromb, & Wingfield, 2002, for an exception). And finally, because several previous studies with the contextual analysis procedure have found that there are very few statistically independent age-related influences on target variables after the variation in the reference cognitive abilities is controlled (e.g., Salthouse, 2005; Salthouse et al., 2006, 2008; Siedlecki, Salthouse, & Berish, 2005), we predicted that there would be no unique age relations on any of the recall measures. Such a finding would imply that the factors contributing to age-related influences on these multitrial verbal learning measures overlapped with the factors contributing to age-related influences on other types of cognitive variables.

EXPERIMENT

METHOD

Participants

The dataset included 2,497 participants ranging from 18 to 98 years of age from seven studies conducted in the Cognitive Aging Laboratory at the University of Virginia. Table 1 provides the descriptive characteristics of the sample, divided into three groups as used in some of the analyses. The age-adjusted scaled scores for four standardized tests from the Wechsler Adult Intelligence Scale–III (Wechsler, 1997a) and the Wechsler Memory Scale–III (Wechsler, 1997b) are reported to indicate the representativeness of the sample. Because the scaled scores have a mean of 10 and a standard deviation of 3, the sample can be inferred to consist of high-functioning participants, which is also apparent in the high average years of education. Advanced age was associated with some-what lower ratings of subjective health on a scale from 1 (*excellent*) to 5 (*poor*), $r = .16$, $p < .01$; however, all age groups rated themselves to be healthy.

Procedure

The participants completed the Word List Recall test of the Wechsler Memory Scale (1997b) along with 15 cognitive ability tests in a 2-hr session. The reference cognitive ability tests are briefly described in the Appendix. All variables have been found to have good reliability and moderate to high loadings on their respective cognitive ability factors (Salthouse, 2004a, 2005, 2007; Salthouse, Atkinson, & Berish, 2003; Salthouse, Berish, & Siedlecki, 2004; Salthouse & Ferrer-Caja, 2003; Salthouse et al., 2006).

The multitrial verbal learning task consisted of two lists, List 1 and List B, each comprised of 12 words. The words were read at a rate of approximately 1 s per word. On Trials 1 through 4 of List 1, the experimenter read aloud the words in the list, and immediately after each list the participants recalled as many words in any order from the list as they could remember. After the fourth recall trial, the experimenter read the distractor list, List B. After the participants recalled words from List B, they were asked to recall as many words from List 1 as they could remember. Unlike in Trials 1 through 4 of List 1, the experimenter did not read the words before participants attempted to recall the words on Trial 5.

TABLE 1. Descriptive Characteristics of Participants, Arbitrarily Divided Into Three Age Groups

	Age group				
	18–39 years	40–59 years	60–98 years	All	Age *r*
Number	732	948	817	2,497	
Age, years	26.7 (6.2)	50.1 (5.5)	71.3 (7.7)	50.2 (18.7)	
Proportion female	.64	.72	.59	.65	−.04
Health self-rating	1.8 (0.8)	1.9 (0.9)	2.1 (0.9)	1.9 (0.9)	.16*
Education, years	15.2 (2.4)	15.8 (2.6)	16.2 (2.9)	15.7 (2.7)	.17*
			Scaled scores		
Vocabulary	13.1 (3.2)	12.4 (2.9)	13.3 (2.7)	12.9 (3.0)	.03
Digit Symbol	11.6 (2.9)	11.4 (2.9)	11.7 (2.8)	11.5 (2.8)	.05
Word Recall	12.4 (3.1)	12.5 (3.3)	12.6 (3.2)	12.5 (3.2)	.02
Logical Memory	11.8 (2.7)	11.8 (2.8)	12.4 (2.8)	12.0 (2.8)	.10*

Note. *Standard deviations in parentheses.*
$^{*}p < .01$.

RESULTS[1]

Mean Recall Performance Across Trials and Segments by Age Groups

As shown in Figure 2, the classic *U*-shaped serial position function occurred on Trial 1, with proportionally more words recalled from positions at the beginning and the end of the list than from the middle of the list. The second panel reveals that recall performance improved across the trials for all list segments, and the third panel indicates that there was a decline in recall after the intervening list.

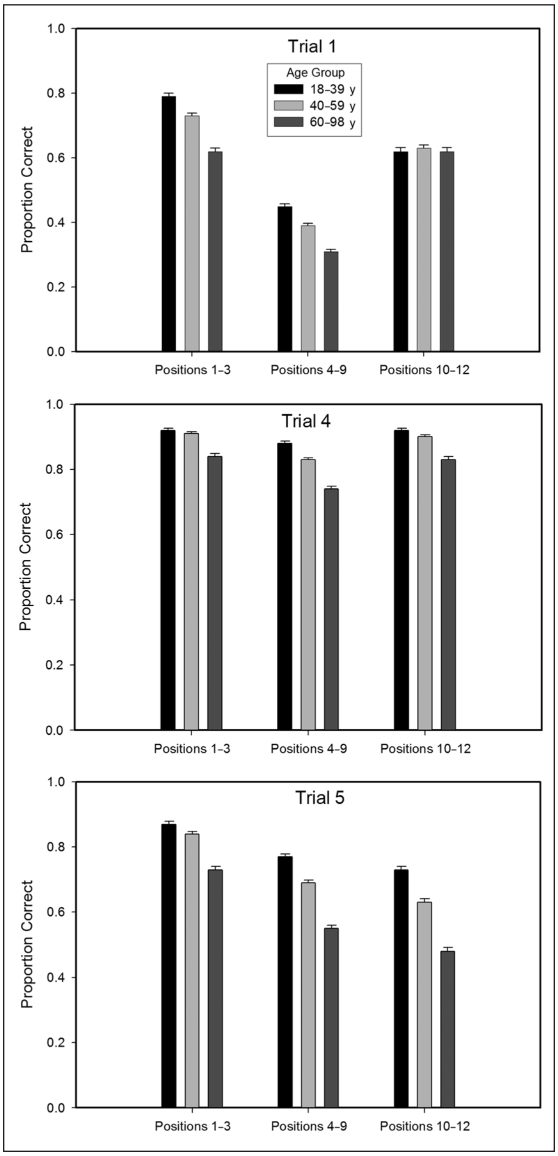

FIGURE 2. Mean proportion of words recalled on Trials 1, 4, and 5 for different list segments for 3 age groups

A 3 (age group: younger, middle, older) × 3 (trial: Trial 1, Trial 4, Trial 5) × 3 (segment: first, Items 1–3; middle, Items 4–9; last, Items 10–12) ANOVA on the proportion of items recalled revealed a main effect of age, $F(2, 2494) = 172.10$, $\eta_p^2 = .12$. A post hoc least significant difference test indicated that the younger group ($M = .77$) outperformed those in the middle ($M = .73$) and older ($M = .63$) groups, with participants in the middle group recalling more than the older group. There was also a main effect of trial, $F(2, 9976) = 3{,}373.83$, $\eta_p^2 = .58$, with individuals' performance increasing across trials and declining after the intervening distractor list ($M_{\text{Trial 1}} = .57$, $M_{\text{Trial 4}} = .87$, $M_{\text{Trial 5}} = .70$), and segment, $F(2, 9976) = 1{,}061.46$, $\eta_p^2 = .30$. Overall, participants recalled a higher proportion of items from the first part of the list ($M = .81$) than the last ($M = .71$) and middle ($M = .62$) portions, but the trial × segment interaction, $F(4, 9976) = 412.07$, $\eta_p^2 = .14$, indicates that differences between these portions of the list were less pronounced on Trial 4. Significant age interactions (segment × age group and trial × segment × age group) reflected the finding that recall of the last items is spared with increased age on the initial trial, Fs > 8.13, η_p^2s > .01.

TABLE 2. Contextual Analysis Results on Serial Position Data for Trials 1, 4, and 5

Variable	*M*	Total	Unique	Gf	Mem	Speed	Voc
			Trial 1 recall				
Items 1–3	.71 (.29)	–.26*	.03	–.08	.46*	.13*	–.12*
Items 4–9	.38 (.22)	–.29*	.12	–.17*	.75*	.13*	–.23*
Items 10–12	.62 (.33)	–.01	.15*	–.06	.22*	.10	–.04
			Trial 4 recall				
Items 1–3	.89 (.21)	–.18*	.06	–.10	.40*	.10	–.11*
Items 4–9	.81 (.21)	–.29*	.18*	–.10	.72*	.17*	–.27*
Items 10–12	.88 (.22)	–.18*	.03	–.06	.35*	.08	–.10
			Trial 5 recall				
Items 1–3	.81 (.27)	–.22*	.14*	–.08	.48*	.20*	–.16*
Items 4–9	.66 (.27)	–.34*	.11	–.10	.72*	.15*	–.25*
Items 10–12	.61 (.34)	–.32*	.02	–.13	.66*	.08	–.21*

Note. *Standard deviations in parentheses. Gf = fluid intelligence; Mem = episodic memory ability; Speed = processing speed; Voc = vocabulary ability*
*$p < .01$.

Contextual Analyses

Separate contextual analyses were performed for the three list segments on Trials 1, 4, and 5 to assess which cognitive abilities influenced recall. The analyses were conducted with the Amos (Arbuckle, 2003) structural equation modeling program. For the current purposes, the standardized regression coefficients relating the cognitive abilities and age to the target variables are the most relevant output information from the analyses. These coefficients are reported in Table 2.

On Trial 1, episodic memory ability was associated with recall performance at all list positions, especially for the middle items. As hypothesized, the influence of memory ability was the smallest for items located in the last positions. Consistent with research suggesting that the short-term buffer is spared by aging (Craik, 1968; Murphy et al., 2000), there were no age differences in recall performance for the last items on Trial 1 (see Figure 2, top panel).

An examination of the standardized regression coefficients on Trial 1 also revealed that although episodic memory ability had the strongest influences on the recall measures, as predicted, speed of processing was also related to better recall for early items. Overall, the results of the individual difference analyses in the current study are consistent with prior explanations of the serial position effect.

In addition to memory and processing speed, vocabulary ability was associated with recall. Unexpectedly, however, higher vocabulary ability was related to poorer recall. Furthermore, we expected that fluid intelligence would be associated with better recall performance, especially on the initial trial, with those higher in Gf being more likely to form a strategy to attempt to remember the items. Fluid intelligence was associated with recall performance on the first recall trial, but in this case the direction of the relationship between Gf and recall was opposite of our prediction.

Similar patterns of results were obtained across Trial 4 and Trial 5. Specifically, episodic memory ability was the most strongly associated with recall performance across list segments, and the influence of this ability was greatest on the final items on the retention trial (Trial 5). There was a tendency for better processing speed to be associated with better recall performance on the first and middle portions of the list (with the exception of Trial 4 recall, Items 1–3), and vocabulary was negatively associated with recall performance for the first and middle items. Interestingly, vocabulary ability was also associated with poorer performance on recalling the last items on the retention trial. Fluid intelligence was not related to recall performance on any portion of the list segments on Trial 4 and Trial 5.

In addition to examining which cognitive abilities were related to recall performance, we were also interested in whether there might be unique age relations on the word recall measures across Trials 1, 4, and 5 after we controlled for the variation in the reference cognitive abilities. However, the contextual analysis revealed that these age-related effects were mostly shared with the age-related effects on other cognitive abilities, as few of the direct effects of age on the target variables were significantly different from zero after we controlled the variation in reference cognitive abilities.

DISCUSSION

The major aim of the current study was to determine the influence of cognitive abilities and age on word recall performance on different list segments and across trials by using a contextual analysis approach. The benefit of using a contextual approach is that the unique influences of abilities and age can be examined along with several cognitive abilities simultaneously.

There has been some debate as to whether a dual-store representation of memory is needed to characterize recency effects. Specifically, although numerous researchers have posited that items at the end of the list are more likely to be recalled than those in the middle because later items are still available in the short-term buffer (e.g., Glanzer & Cunitz, 1966) and confirmatory factor analyses have found support for a distinction between primary memory–recency items and secondary memory–prerecency items (Bemelmans, Wolters, Zwinderman, ten Berge, & Goekoop, 2002; Carroll, 1993; Geiselman, Woodward, & Beatty, 1982; Unsworth et al., 2010), others have suggested that a single store exists (see Crowder, 1993, for a review). For example, an explanation of the single-store account posits that these later items are more distinctive, and therefore more likely to be recalled, because of their temporal location (e.g., Neath & Crowder, 1990). Likewise, the focal attention account, another single store account, suggests that the recency advantage occurs because the last item or chunks are currently being attended to rather than requiring a short-term buffer (McElree, 2006; see Jonides et al., 2008, for an excellent review of the focal attention and dual store accounts). Although the data in this study cannot be used to distinguish between these alternative accounts, our findings are consistent with the idea that recency recall relies less on episodic memory than other list segments because these items may still be available in short-term store (Glanzer & Cunitz, 1966) or focal attention (McElree, 2006). As predicted, the influence of episodic memory ability was the smallest for last items on the first recall trial. More telling were the age effects on the list portions. On the first recall trial the recency portion of the list was spared by aging, consistent with research that suggests that the recall of last items is not impaired with increased age in late adulthood (Craik, 1968; Graf & Utl, 1995; Murphy et al., 2000). However, there were age differences in recall of the last items on subsequent trials, with recency recall being poorer than primacy recall on the final trial. In fact, recall of the middle items was greater than the recall of the last items on the final recall trial. Because recall of these last items was reduced after the retention trial, it is possible that distinctiveness alone may not account for the initial recency recall. In other words, if items are recalled because they are more distinctive, one would expect that this memory advantage would remain after a retention trial. Instead, our findings indicated that after the retention trial the recency advantage is eliminated, possibly because these items are no longer in short-term store or focal attention.

Although there has been some support for the importance of a dual-store account for explaining serial position effects (e.g., Talmi, Grady, Goshen-Gottstein, & Moscovitch, 2005), more recently neuroimaging studies (Öztekin, Davachi, & McElree, 2010; Öztekin, McElree, Staresina, & Davachi, 2009) suggest that a single store account is more likely, with a contrast between items that are in focal attention and those that are not (i.e., items retrieved from memory). According to Öztekin et al. (2010), because all list positions except the final item required hippocampal activation, the notion of two stores is unlikely because some of the items that probably would be available in short-term store activated the hippocampus, an area needed for retrieval. In sum, according to these researchers the distinction is not whether there is a separate store but rather a difference between items that require retrieval (i.e., prerecency items) and those that are currently in focal attention (i.e., the last items).

Additional neuroimaging evidence has also indicated that different segments of the list activate different brain regions. According to Wiswede, Rüsseler, and Münte (2007), primacy effects are associated with activation in the frontal region, whereas recency effects were related to activation in the parietal region. They posited that these regional differences may be due to greater rehearsal in working memory for the primacy portions. Consistent with the idea that early items benefit from additional rehearsal (Bruce & Papay, 1970; Glanzer & Cunitz, 1966), we found that processing speed was related to recall of words in the primacy segment. Therefore, it can be posited that faster processing speed is related to more rehearsal of the initial items, contributing to better recall performance for this segment.

Although our predictions for the primacy and recency segments were confirmed, we did not find evidence to support our hypothesis that Gf is related to better recall performance for the middle items. There has been mixed evidence as to whether Gf is related to memory recall performance. Engle Tuholski, Laughlin, and Conway (1999) suggested that although working memory is related to Gf, secondary memory appears to be less strongly correlated with Gf. On the other hand, research studies by Unsworth (2009) and Beier and Ackerman (2004) revealed a strong correlation between recall and Gf. In order to understand the discrepancy between the findings in the current study and the results of the Unsworth study, follow-up analyses were conducted. In particular, we found that Gf was associated with better recall performance on middle items in Trial 4 and Trial 5 when the episodic memory factor was excluded from the analyses. These findings suggest that the inconsistency between the results of the current study and those of Unsworth may be due to the inclusion of episodic memory as a simultaneous predictor in the current study, which allows unique Gf influences to be identified, in contrast to the shared influences when other indicators of episodic memory are not included in the analysis. In sum, although it was posited that Gf might be related to strategy implementation, overall our results indicated that episodic memory ability rather than Gf is highly influential in recall performance.

Although there has been some evidence that vocabulary ability is associated with better word recall performance (e.g., Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Bolla-Wilson & Bleecker, 1986), in the current study better vocabulary ability was associated with poorer recall performance, particularly for early and middle items across trials, and also for last items in the retention trial (i.e., Trial 5). Similar to the results from the current study, Unsworth and Brewer (2010) found a negative correlation between intrusion rates and vocabulary performance. Previous studies indicated that advanced age is typically associated with better performance on vocabulary tests (e.g., Salthouse, 2004b), but interestingly, at least one study found that older adults were more likely to produce intrusions in word recall tests than younger adults (Kahana, Dolan, Saunder, & Wingfield, 2005). It is therefore possible that people with higher vocabulary ability have a greater number of semantic associates that can intrude in word recall tests. Because intrusion rates were not recorded in this study, a future direction of research would be to examine the number and types of intrusions (e.g., phonologically or semantically related) committed by individuals.

Finally, with regard to the age relations on recall performance, with the exception of the recency portion of the list on the first trial, advanced age was associated with poorer recall performance across trials and list segments. Nevertheless, controlling for the influence of other cognitive abilities reduced the age relations on recall performance on the majority of the trials and segments. Because the majority of the age relations on the recall variables were shared with age-related influences on other cognitive abilities, this suggests that an explanation that could account for influences of age on other cognitive abilities probably would also account for age-related influences on measures of multitrial verbal learning.

In conclusion, there were four main findings in this study. First, the influence of episodic memory ability was smallest for the last items on the first recall trial, and no age differences were observed for recall in this segment. Second, processing speed was related to recall of early items. A third finding was that improvement across trials was not related to Gf. Finally, the majority of the age relations on the recall variables were shared with age-related influences on other cognitive abilities. Overall, our findings are consistent with the explanation that greater rehearsal is related to the primacy advantage and that the recency effect occurs because the last items are still in the short-term buffer or in focal attention. In sum, the contextual analyses lend support to previous accounts of the serial position effect while also going beyond previous work by indicating the unique relations of age, episodic memory ability, Gf, processing speed, and vocabulary on recall performance across segments and trials.

NOTES

This research was supported by NIA Grants RO1AG019627 and R37AG024270 to T.A.S.

Address correspondence about this article to Lacy E. Krueger, Department of Psychology & Special Education, Texas A&M University–Commerce, P.O. Box 3011, Commerce, TX, 75428 (e-mail: lacy_krueger@tamu-commerce.edu).

1. Because of the large sample size, a $p < .01$ significance level was used in all statistical tests.

REFERENCES

Arbuckle, J. L. (2003). Amos (Version 5.0) [Computer program]. Chicago, IL: SPSS.

Beier, M. E., & Ackerman, P. L. (2004). A reappraisal of the relationship between span memory and intelligence via "best evidence synthesis." *Intelligence, 32,* 607–619. doi:10.1016/j.intell.2004.07.005

Bemelmans, K. J., Wolters, G., Zwinderman, K., ten Berge, J. M. F., & Goekoop, J. G. (2002). Evidence for two processes underlying the serial position curve of single- and multi-trial free recall in a heterogeneous group of psychiatric patients: A confirmatory factor analytic study. *Memory, 10*(2), 151–160. doi:10.1080/09658210143000290

Bennett, G. K., Seashore, H. G., & Wesman, A. G. (1997). *Differential Aptitude Test*. San Antonio, TX: The Psychological Corporation.

Bleecker, M. L., Bolla-Wilson, K., Agnew, J., & Meyers, D. A. (1988). Age-related sex differences in verbal memory. *Journal of Clinical Psychology, 44*(3), 403–411.

Bolla-Wilson, K., & Bleecker, M. L. (1986). Influence of verbal intelligence, sex, age, and education on the Rey Auditory Verbal Learning Test. *Developmental Neuropsychology, 2,* 203–211. doi:10.1080/87565648609540342

Bruce, D., & Papay, J. P. (1970). Primacy effect in single-trial free recall. *Journal of Verbal Learning & Verbal Behavior, 9*(5), 473–486.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor analytic studies.* New York, NY: Cambridge University Press.

Craik, F. I. M. (1968). Two components in free recall. *Journal of Verbal Learning and Verbal Behavior, 7*(6), 996–1004.

Crawford, J., & Stankov, L. (1983). Fluid and crystallized intelligence and primacy/recency components of short-term memory. *Intelligence, 7,* 227–252. doi:10.1016/0160-2896(83)90016-8

Crowder, R. G. (1993). Short-term memory: Where do we stand? *Memory & Cognition, 21*(2), 142–145.

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

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. A. (1999). Working memory, short-term memory, and general fluid intelligence: A latent-variable approach. *Journal of Experimental Psychology: General, 128*(3), 309–331.

Geiselman, R. E., Woodward, J. A., & Beatty, J. (1982). Individual differences in verbal memory performance: A test of alternative information-processing models. *Journal of Experimental Psychology: General, 111*(1), 109–134.

Gershberg, F. B., & Shimamura, A. P. (1994). Serial position effects in implicit and explicit tests of memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*(6), 1370–1378.

Glanzer, M., & Cunitz, A. R. (1966). Two storage mechanisms in free recall. *Journal of Verbal Learning and Verbal Behavior, 5*(4), 351–360.

Graf, P., & Utl, B. (1995). Component processes of memory: Changes across the adult lifespan. *Swiss Journal of Psychology, 54,* 113–130.

Jonides, J., Lewis, R. L., Nee, D. E., Lustig, C. A., Berman, M. G., & Moore, K. S. (2008). The mind and brain of short-term memory. *Annual Review of Psychology, 59,* 193–224.

Kahana, M. J., Dolan, E. D., Saunder, C. L., & Wingfield, A. (2005). Intrusions in episodic recall: Age differences in editing of overt responses. *Journal of Gerontology: Psychological Sciences, 60B*(2), 92–97. doi:10.1093/geronb/60.2.P92

Kahana, M. J., Howard, M. W., Zaromb, F., & Wingfield, A. (2002). Age dissociates recency and lag recency effects in free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*(3), 530–540. doi:10.1037//0278-7393.28.3.530

McElree, B. (2006). Accessing recent events. *Psychology of Learning and Motivation, 46,* 155–200. doi:10.1016/S0079-7421(06)46005-9

Murdock, B. B. (1962). The serial position effect of free recall. *Journal of Experimental Psychology, 64*(5), 482–488. doi:10.1037/h0045106

Murphy, D. R., Craik, F. I. M., Li, K. Z. H., & Schneider,

B. A. (2000). Comparing the effects of aging and background noise on short-term memory performance. *Psychology and Aging, 15*(2), 323–334. doi:10.1037//0882-7974.15.2.323
Neath, I., & Crowder, R. G. (1990). Schedules of presentation and temporal distinctiveness in human memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(2), 316–327.
Öztekin, I., Davachi, L., & McElree, B. (2010). Are representations in working memory distinct from representations in long-term memory? Neural evidence in support of a single store. *Psychological Science, 21*(8), 1123–1133. doi:10.1177/0956797610376651
Öztekin, I., McElree, B., Staresina, B., & Davachi, L. (2009). Working memory retrieval: Contributions of left prefrontal cortex, left posterior parietal cortex and hippocampus. *Journal of Cognitive Neuroscience, 21*(3), 581–593. doi:10.1162/jocn.2008.21016
Raven, J. (1962). *Advanced Progressive Matrices, Set II.* London, England: H. K. Lewis.
Rundus, D., & Atkinson, R. C. (1970). Rehearsal processes in free recall: A procedure for direct observation. *Journal of Verbal Learning and Verbal Behavior, 9*(1), 99–105.
Salthouse, T. A. (1993). Speed and knowledge as determinants of adult age differences in verbal tasks. *Journals of Gerontology: Psychological Sciences, 48,* 29–36.
Salthouse, T. A. (2004a). Localizing age-related individual differences in a hierarchical structure. *Intelligence, 32*(6), 541–561.
Salthouse, T. A. (2004b). What and when of cognitive aging. *Current Directions in Psychological Science, 13*(4), 140–144. doi:10.1111/j.0963-7214.2004.00293.x
Salthouse, T. A. (2005). Relations between cognitive abilities and measures of executive functioning. *Neuropsychology, 19*(4), 532–545.
Salthouse, T. A. (2007). Implications of within-person variability in cognitive and neuropsychological functioning on the interpretation of change. *Neuropsychology, 21*(4), 401–411.
Salthouse, T. A., Atkinson, T. M., & Berish, D. E. (2003). Executive functioning as a potential mediator of age-related cognitive decline in normal adults. *Journal of Experimental Psychology: General, 132*(4), 566–594. doi:10.1037/0096-3445.132.4.566
Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology,* 27(5), 763–776. doi:10.1037/0012-1649.27.5.763.
Salthouse, T. A., Berish, D. E., & Siedlecki, K. L. (2004). Construct validity and age sensitivity of prospective memory. *Memory & Cognition, 32,* 1133–1148.
Salthouse, T. A., & Ferrer-Caja, E. (2003). What needs to be explained to account for age-related effects on multiple cognitive variables? *Psychology and Aging, 18*(1), 91–110.
Salthouse, T. A., Fristoe, N., & Rhee, S. H. (1996). How localized are age-related effects on neuropsychological measures? *Neuropsychology, 10*(2), 272–285. doi:10.1037/0894-4105.10.2.272
Salthouse, T. A., Pink, J. E., & Tucker-Drob, E. M. (2008). Contextual analysis of fluid intelligence. *Intelligence, 36*(5), 464–468. doi:10.1016/j.intell.2007.10.003
Salthouse, T. A., Siedlecki, K. L., & Krueger, L. E. (2006). An individual differences analysis of memory control. *Journal of Memory and Language, 55*(1), 102–125.
Siedlecki, K. L., Salthouse, T. A., & Berish, D. E. (2005). Is there anything special about the aging of source memory? *Psychology and Aging, 20*(1), 19–32. doi:10.1037/0882-7974.20.1.19.
Talmi, D., Grady, C. L., Goshen-Gottstein, Y., & Moscovitch, M. (2005). Neuroimaging the serial position curve: A test of single-store versus dual-store models. *Psychological Science, 16,* 716–723. doi:10.1111/j.1467-9280.2005.01601.x
Unsworth, N. (2009). Variation in working memory capacity, fluid intelligence, and episodic recall: A latent variable examination of differences in the dynamics of free recall. *Memory & Cognition, 37*(6), 837–849. doi:10.3758/MC.37.6.837
Unsworth, N., & Brewer, G. A. (2010). Individual differences in false recall: A latent variable analysis. *Journal of Memory and Language, 62,* 19–34. doi:10.1016/j.jml.2009.08.002
Unsworth, N., Spiller, G. J., & Brewer, G. A. (2010). The contributions of primary and secondary memory to working memory capacity: An individual differences analysis of immediate free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*(1), 240–247. doi:10.1037/a0017739
Wechsler, D. (1997a). *Wechsler Adult Intelligence Scale* (3rd ed.). San Antonio, TX: The Psychological Corporation.
Wechsler, D. (1997b). *Wechsler Memory Scale* (3rd ed.). San Antonio, TX: The Psychological Corporation.
Wiswede, D., Rüsseler, J., & Münte, T. F. (2007). Serial position effects in free memory recall: An ERP-study. *Biological Psychology, 75*(2), 185–193.
Wixted, J. T., & McDowell, J. J. (1989). Contributions to the functional analysis of single-trial free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(4), 685–697.
Woodcock, R. W., & Johnson, M. B. (1990). *Woodcock–Johnson Psycho-Educational Battery—Revised.* Allen, TX: DLM.
Zachary, R. A. (1986). *Shipley Institute of Living Scale: Revised manual*. Los Angeles, CA: Western Psychological Services.

APPENDIX. DESCRIPTION OF THE REFERENCE TASKS AND THEIR SOURCES

Reference task	Description
Wechsler Adult Intelligence Scale Vocabulary (Wechsler, 1997a)	Provide definitions of words
Picture Vocabulary (Woodcock & Johnson, 1990)	Name the pictured object
Antonym Vocabulary (Salthouse, 1993)	Select the best antonym of the target word
Synonym Vocabulary (Salthouse, 1993)	Select the best synonym of the target word
Matrix Reasoning (Raven, 1962)	Determine which pattern best completes the missing cell in a matrix
Shipley Abstraction (Zachary, 1986)	Determine the words or numbers that are the best continuation of a sequence
Letter Sets (Ekstrom et al., 1976)	Identify which of five groups of letters is different from the others
Spatial Relations (Bennett et al., 1997)	Determine the correspondence between a 3-D figure and alternative 2-D figures
Paper Folding (Ekstrom et al., 1976)	Determine the pattern of holes that would result from a sequence of folds and a punch through folded paper
Form Boards (Ekstrom et al., 1976)	Determine which combinations of shapes are needed to fill a larger shape
Logical Memory (Wechsler, 1997b)	Number of idea units recalled across three stories
Paired Associates (Salthouse et al., 1996)	Number of response terms recalled when presented with a stimulus term
Digit Symbol (Wechsler, 1997a)	Use a code table to write the correct symbol below each digit
Letter Comparison (Salthouse & Babcock, 1991)	Same–different comparison of pairs of letter strings
Pattern Comparison (Salthouse & Babcock, 1991)	Same–different comparison of pairs of line patterns

Library Recommendation Form

THE American Journal OF Psychology

To: Librarian / Library Acquisition Committee

From: ______________________________

Position: ______________ **Dept:** __________

Email: ________________

Phone: _______________

I recommend that the library subscribe to *The American Journal of Psychology*. Please include this journal in your next serials review meeting with my recommendation to subscribe.

Signature: ____________________________

Date: ________

For subscription information please contact the University of Illinois Press online at http://www.press.uillinois.edu/journals/ajp.html