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Investigation of Student Status, Background Variables, and Feasibility of Standard Tasks in Cognitive Aging Research

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Data are reported on a variety of cognitive tasks from 62 college students and 362 nonstudent adults between 20 and 79 years of age. The goals of the project were as follows: (a) to investigate the validity of the practices of using college students and adults over age 65 in studies of cognitive aging, (b) to examine the influence of a variety of background variables on age trends in cognitive performance, and (c) to initiate the development of standard tasks to assist in the description of subject samples in cognitive aging research. The age trends in cognitive performance were relatively independent of an assortment of background variables, but because college students were atypical of their age group in several performance measures they may be suspect as the young-adult control subjects in investigations involving these types of measures. Adults over the age of about 65 appear to exhibit accelerated slowing of speeded performance, but in other respects perform about as one would expect on the basis of the age trends observed between the ages of 20 and 65.

The present studies were designed to investigate three issues considered important in research on cognitive aging. Two of the issues were related to the assessment of presumably normative cross-sectional age trends in cognitive functioning (student status of young subjects and the role of background variables on the relation between age and performance), and the third (standard tasks) was concerned with improving the description of subject samples in cognitive aging research.

One focus of the current studies was to examine the validity of the practices of using certain subject populations in research on cognitive aging. Specifically, college students were investigated because of the possibility that participation in school-related activities might provide them with an advantage in some cognitive tasks, and adults over age 65 were investigated because of the possibility that factors of retirement-associated activity disengagement and increased susceptibility to many diseases may lead to exaggerations of age-related effects on cognition. The means of investigation involved determining whether the performance of college students or adults over age 65 is predictable from the regression equations relating age to performance among nonstudent adults ranging in age from 20 to 65 years. If not, and the performance of college students or adults older than 65 is discontinuous from the functions of nonstudents of varying ages, then it might be inferred (a) that college students are not appropriate young-adult control subjects in studies designed to assess the effects of age on that type of cognitive functioning, or (b) that age-related effects beyond about age 65 involve somewhat different processes than those occurring at younger ages.

A second focus of the current studies was to determine the contribution of variables related to the individual's status or background (e.g., years of education; self-reported health; occupational status; and average number of hours per week spent reading, watching television, etc.) to observed age trends on measures of cognitive performance. Many of these variables are significantly related to age, and it is sometimes suggested that they might be responsible for the age trends frequently reported in various measures of cognitive functioning. We investigated this possibility by determining whether the correlations between age and cognitive performance are significantly altered by statistically controlling for these background variables.

The third and final goal of the current research was to initiate the development of standard tasks that might assist in describing and assessing the comparability of samples of participants in research on cognitive aging. A currently accepted practice in published studies in the area of cognitive aging is to report, in addition to ages of the participants, information about their demographic characteristics (e.g., average years of education) and summary statistics about their performance on certain psychometric tests (e.g., vocabulary or general information). This information is presumably provided for the purpose of describing relevant characteristics of the samples, but because there is seldom any evidence that these variables are related to performance on the task of interest, it is questionable whether such information can actually be used to assess the comparability of the samples for the experimental task being investigated.

It is useful to think of a continuum representing the purposes of information, other than performance on the tasks of primary interest, obtained from participants in studies of cognitive aging. At one end of the continuum is information simply intended to reflect the individual's global status. For example, noninstitutionalized living and ability to transport oneself to the research laboratory are sometimes considered indexes of relatively unimpaired functioning. At the other end of the continuum is information obtained for the purpose of statistical analysis in conjunction with the age and performance variables. That is, partial correlation or analysis of covariance techniques might be used to investigate the extent to which certain vari-

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ables moderate or mediate the relation between age and performance on the primary variable.

Intermediate between information used to establish that the research participants are not severely brain damaged and information used to analyze sources of individual differences is information that can help assess the comparability of the samples in each age group. That is, if variables could be obtained from each individual that were relevant to the activity under investigation, then samples from different studies could be examined to determine whether, for example, any discrepancies in results were attributable to procedural differences or to noncomparable samples.

Although measures of vocabulary and general information could conceivably be used for any of these purposes, frequent reports of a lack of statistical relation between these measures and performance on laboratory cognitive tasks has led many researchers to view them merely as instruments to detect gross cognitive impairments. Some researchers may consider measures of this type as also providing crude reflections of general intelligence, but because scores on tests of vocabulary and general information seem more dependent on previously acquired knowledge than on current processing efficiency, and increased age is often positively correlated with opportunity to acquire knowledge, it is questionable whether the measures reflect the same construct at different ages.

Salthouse (1985a) and Salthouse and Kausler (1985) have proposed that the intermediate goal of assessing comparability of subject samples might be appropriately assessed with measures of performance on a standard task specifically selected for its relevance to the activity domain under investigation. The appropriate standard task could be administered along with the experimental activities to specify the research populations along dimensions with known validity for the activity domain of interest (established by the correlations between performance on the standard and experimental tasks). Once this practice is widely adopted, the availability of multivariate data bases should also allow interesting analytical studies of the variables contributing to all types of individual differences on cognitive tasks, thereby addressing the third purpose of supplemental information in studies of cognitive aging. The major obstacle hampering implementation of this proposal in the past has been the absence of normative data on age trends for relatively simple tasks from a variety of different cognitive abilities. In the current article, we report data that can be used to initiate the development and evaluation of standard tasks for the purpose of further describing characteristics of subject samples in cognitive aging research.

Salthouse and Kausler (1985) discussed four criteria that might be used to evaluate candidate standard tasks: (a) at least moderate reliability (e.g., $r > .6$) to ensure that a reasonably stable and consistent aspect of behavior is being measured, (b) quick assessment to allow adequate time for the tasks of primary interest, (c) amenability to the acquisition of normative data from a broad spectrum of individuals having no specialized skills, and without the necessity of elaborate equipment, and (d) moderate relation with other measures within the same ability domain.

The last criterion is the most problematic because, although the task must be somewhat prototypical of a particular type of cognition in order to merit the designation standard, there is currently little consensus regarding types of cognition or domains of ability, and even less concerning tasks that are fundamental or central within each category. Eventually this criterion might be addressed with appropriate factor-analytic studies involving measures from as many different types of cognition as possible, but until that time, researchers will probably have to rely on intuitions and subjective assessments of face validity to make decisions about whether particular measures satisfy this criterion. Salthouse and Kausler (1985) used these types of judgments to propose that a reasonable candidate task in the domain of learning and memory is the learning of a short list of paired associates, and Salthouse (1985b) proposed that a digit symbol substitution task might serve as a standard task with activities emphasizing speed of performance.

These two tasks, along with a speeded number comparison task, assessments of immediate memory for verbal and spatial information, incidental memory for task order, intentional memory for word order and word frequency, and several tasks involving reasoning and spatial abilities, were included in the present studies. Reliability was assessed by presenting each task twice, with the second administration of a given task presented only after all other tasks had been presented at least once. (Salthouse, 1985a, p. 129, has argued that this method of assessing reliability provides a better assessment of strategic stability than alternative methods.) Each task required less than 10 min, and two administrations each of eight tasks, along with a ninth task and a background questionnaire, were administered in individual sessions averaging less than 2 hr each.

Two separate studies involving different combinations of experimental tasks were conducted, but the procedures and analyses were very similar and, hence, they are described together.

Method

Subjects

Participants in the project were drawn from two populations—college students and residents of rural and suburban communities from which the college draws the majority of its students. All of the 62 students participated to satisfy an introductory psychology course requirement, and the 362 community residents (or their designated groups) each received $10 for their participation. Recruitment of the nonstudent participants was achieved through acquaintances of the examiners, friends of participants, and contact with community groups. Further details about the participants are summarized in Tables 1 and 5.

Procedure

The experimental session began with a brief description of the activities to be performed, followed by completion of a background questionnaire and the administration of the tasks on a microcomputer.[1] The initial administration of each experimental task was preceded by instructions and several practice problems to ensure that the subjects thoroughly understood what they were supposed to be doing. The second administration of the tasks consisted of different stimulus items but the same procedure as the first administration. All of the subjects

[1] Copies of the programs, in Applesoft BASIC for the Apple-II series computers, are available from J. Scott Saults, Department of Psychology, University of Missouri, Columbia, MO 65211. Please enclose $5 to cover the cost of the diskettes and handling.

performed the tasks in the same sequence, but they were allowed brief rest periods between tasks as desired.

Different combinations of the tasks were used in the two studies in an attempt to sample as broad a range of abilities as possible. Tasks included in Study 1 were digit symbol substitution, number comparison, paper folding, paired associates, verbal memory, spatial memory, perceptual closure, temporal memory, and activity memory, followed by these tasks repeated again, but in reverse order. Tasks in Study 2 were digit symbol, number comparison, geometric analogies, paired associates, verbal memory, spatial memory, series completion, frequency judgment, and activity memory, followed by these tasks repeated again, but in reverse order.

The background questionnaire contained questions about the number of years of formal education completed; one's present or most recent job; the number of hours per week engaged in various activities; the number of prescription medicines taken per week; whether or not the individual had been treated in the last 5 years for heart trouble, high blood pressure, or diabetes; and self-assessments of level of social activity (1 = *extremely active,* 5 = *very limited*) and health status (1 = *excellent,* 5 = *poor*). In addition, all of the participants completed an 11-item version of the Need for Cognition Scale (Cacioppo & Petty, 1982), an instrument designed to measure the individual's desire for cognitive stimulation.

The digit symbol task was a yes/no version of the Digit Symbol Substitution subtest from the Wechsler Adult Intelligence Scale–Revised (Wechsler, 1981). A code table and 72 digit–symbol pairs were presented on the computer display monitor, with one half of the pairs correct according to the code table and one half incorrect. The task was to respond *yes* (by pressing the "/" key on the keyboard) or *no* (by pressing the *Z* key on the keyboard) to each pair, as rapidly and accurately as possible. The digit–symbol pairs were presented in four rows on the screen, with an arrow moving across the row after each response, to indicate the pair to be judged next. Performance was summarized by the percentage of correct responses and the median time per pair across the 72 digit–symbol pairs.

The number comparison task was an adaptation of the Number Comparison test from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963). A total of 48 pairs of digit strings containing from 4 to 13 digits each were sequentially displayed; subjects were instructed to respond *yes* ("/" key) or *no* (*Z* key) according to whether the digit strings in each pair were identical. One half of the pairs differed by one digit, and one half were identical. As in the digit symbol task, subjects were instructed to respond as accurately and rapidly as possible, and both percentage accuracy and median time per problem served as performance measures.

The paper-folding task was adapted from the Paper Folding test in the Kit of Reference Tests for Cognitive Factors (French et al., 1963). The current version consisted of 10 problems, each containing a display of a square piece of paper with two successive folds and a hole punched through the folded paper. The task was to decide whether, when unfolded, the paper would resemble the pattern of holes portrayed in another illustration on the display. Responses (yes—"/", no—Z) were to be made as accurately as possible, but without taking any more time than necessary. Both accuracy of the decisions (i.e., percentage correct responses) and the median time per problem were used as measures of performance.

The paired associates task consisted of two trials of eight word pairs (all words consisted of 4-letter nouns) in a study–test procedure. In the study phase, each word pair was displayed for 2 s, and in the test phase the first word from each pair was displayed until the subject named the word that had been paired with it in the study phase. This response was entered by the experimenter, at which time the next test word immediately appeared. A second study–test trial with the same word pairs in a rearranged sequence followed the last test word from the first trial. Performance in each test trial was represented by the percentage of correctly recalled associations.

The verbal memory task was based on a procedure used by Salthouse (1974, 1975), and consisted of the subject attempting to remember the identities of 7 target letters from a matrix of 25 letters. The letters were arranged in a 5 × 5 array, with 7 of them designated as targets by being displayed in reversed color (i.e., dark on light instead of light on dark). Immediately after the 3-s display of the matrix, the subject was to type the 7 target letters, guessing, if necessary, to produce seven responses. A total of four trials were presented in this task, with the average number of letters correctly recalled across these trials serving as the measure of performance.

The spatial memory task was also based on a procedure by Salthouse (1974, 1975), and consisted of the subject attempting to remember the positions of seven target cells from a 5 × 5 matrix. The target cells were again designated by being displayed in reverse color, and presentation of the stimulus display was again for 3 s. Target positions were reproduced by manipulating the arrow keys on the keyboard to move a flashing box to the appropriate cells in a blank 5 × 5 matrix. A total of seven responses were produced, guessing, if necessary, in each of the four trials; the average number of target positions correctly recalled across the four trials served as the measure of performance in this task.

In the perceptual closure task the subject attempted to identify incomplete versions of 12 line drawings of familiar objects. Each drawing, from the pool of stimuli described by Prill (1984), was made incomplete by randomly removing 90% of the dots composing the original picture. The incomplete picture was presented for 3 s, after which time the subject was instructed to select the name of the picture from a menu containing the 12 picture names. The percentage of trials with a correct response was the measure of performance in this task.

The temporal memory task consisted of successive 4-s presentations of 16 words (of varying length and parts of speech). Subjects were instructed to pay attention to the order in which the words appeared, and a simple arithmetic task was performed for 30 s after the last word. The entire set of 16 words was then displayed, and the subject was instructed to assign a number between 1 and 16 to indicate the order of appearance of each word in the previous list. Performance was summarized in terms of the correlation coefficient between the actual order and the recalled order of the items.

The activity memory task simply consisted of the subject rank ordering a list of the eight tasks just completed with respect to the order in which they had been presented. That is, the number *1* was to be assigned to the first task, the number *2* to the second task, and so forth. The correlation coefficient between actual and recalled order served as the index of performance.

The geometric analogies task contained 10 three-element analogy problems in the A:B::C:D format. The letters A, B, and C served as elements, with a transformation between each of the corresponding elements in the A:B or C:D terms consisting of either black or white reversal, size change, one-half deletion, or rotation. Instructions indicated that the subject was to decide as accurately as possible, but in no more time than necessary, whether the pattern of changes among elements in the first two terms was identical to the pattern of changes among elements in the second two terms. Decisions were communicated by pressing the "/" key for yes and the Z key for no, and task performance was summarized by both accuracy (i.e., percentage correct) and speed (i.e., median time per problem) of these decisions.

The series completion task consisted of 15 number series completion problems in which the task was to complete the series by typing the next number. Subjects were instructed to try to be as accurate as possible, but not to take any more time than necessary to produce a response. Both accuracy (i.e., percentage correct) and speed (i.e., median time per problem) were used as measures of performance.

The frequency judgment task involved from one to five 2-s presentations of each of 27 words (of varying length and parts of speech). At the conclusion of the acquisition list, 18 pairs of words were presented, and the subject was instructed to indicate whether the word on the left (left-arrow-key response) or the word on the right (right-arrow-key response)

Table 1
Summary Statistics for the Major Variables in Studies 1 and 2

	Study 1 age group				Study 2 age group			
Variable	Students	20–39	40–59	60–79	Students	20–39	40–59	60–79
Sample size	25	45	48	36	37	79	77	77
Women (%)	56	53	60	50	51	54	52	55
Age								
M	19.5	29.1	50.4	67.3	19.4	28.6	49.1	68.4
SD	1.9	6.2	5.8	6.0	1.4	6.0	5.8	5.2
Health								
M	1.9	1.9	2.0	1.8	1.8	1.9	2.0	2.1
SD	0.8	0.9	0.8	0.9	0.9	0.8	0.9	0.9
Education								
M	13.2	14.4	14.1	13.3	12.9	13.8	14.1	12.6
SD	1.4	2.1	2.7	2.7	1.3	2.1	2.7	3.1
Digit symbol								
Accuracy (% correct)								
M	96.4	97.1	94.9	93.8	96.1	96.9	97.2	95.5
SD	2.6	2.3	7.9	6.4	2.6	2.6	2.8	4.8
Est. rel.	.28	.13	.86	.27	.20	.53	.38	.53
Time (*mdn* s/item)								
M	1.39	1.49	1.93	2.28	1.29	1.55	1.79	2.22
SD	0.31	0.28	0.51	0.85	0.21	0.44	0.42	0.56
Est. rel.	.90	.94	.96	.94	.90	.96	.94	.94
Number comparison								
Accuracy (% correct)								
M	93.9	95.5	93.8	93.0	95.0	95.8	96.2	93.6
SD	4.0	3.2	4.6	5.9	4.5	3.3	3.7	5.1
Est. rel.	.67	.60	.66	.76	.54	.57	.50	.66
Time (*mdn* s/problem)								
M	3.65	3.64	4.48	5.24	3.68	4.29	4.39	5.22
SD	0.93	0.78	1.05	1.58	0.87	1.51	1.13	1.38
Est. rel.	.97	.93	.92	.92	.95	.95	.91	.89
Verbal memory (% correct)								
M	5.94	5.69	5.09	5.18	5.93	5.69	5.45	5.00
SD	0.48	0.76	0.81	0.75	0.53	0.81	0.77	0.70
Est. rel.	.65	.79	.74	.85	.66	.75	.81	.59
Spacial memory (% correct)								
M	4.46	4.23	3.53	3.50	4.63	4.10	3.83	3.30
SD	0.67	0.80	0.75	0.68	0.86	0.73	0.80	0.68
Est. rel.	.55	.60	.66	.55	.68	.49	.65	.66
Paired associates (% correct)								
Trial 1								
M	40.3	29.7	22.1	24.3	35.5	34.9	24.8	17.0
SD	23.1	21.0	19.5	23.8	20.8	21.6	17.8	18.4
Est. rel.	.59	.70	.76	.87	.55	.55	.54	.79
Trial 2								
M	73.5	54.9	43.8	38.9	66.0	61.8	45.3	33.8
SD	23.1	23.9	24.7	28.7	23.2	23.6	25.7	25.5
Est. rel.	.70	.59	.78	.89	.65	.73	.78	.84
Activity memory (corr. w/ true order)								
M	.91	.70	.64	.49	.86	.74	.64	.53
SD	.07	.43	.44	.51	.13	.23	.32	.31
Paper folding								
Accuracy (% correct)								
M	73.4	66.4	65.1	59.4				
SD	14.2	13.6	14.2	14.9				
Est. rel.	.58	.57	.61	.69				
Time (*mdn* s/problem)								
M	12.8	11.5	12.6	16.6				
SD	6.2	4.4	5.6	18.1				
Est. rel.	.92	.67	.67	.97				
Closure (% correct)								
M	81.7	84.4	78.8	79.4				
SD	8.7	8.0	10.8	13.8				
Est. rel.	.25	.14	.39	.69				
Temporal memory (corr. w/ true order)								
M	.64	.59	.45	.40				
SD	.20	.21	.31	.31				
Est. rel.	.44	.33	.78	.71				

Table 1 (*continued*)

Variable	Study 1 age group				Study 2 age group			
	Students	20–39	40–59	60–79	Students	20–39	40–59	60–79
Analogies								
Accuracy (% correct)								
M					97.0	93.9	88.7	76.7
SD					7.0	10.2	13.2	19.9
Est. rel.					.60	.74	.72	.80
Time (*mdn* s/problem)								
M					4.83	6.69	8.37	11.88
SD					1.31	2.46	2.94	4.25
Est. rel.					.69	.84	.57	.65
Series completion								
Accuracy (% correct)								
M					84.4	80.1	79.0	64.8
SD					11.9	14.1	22.3	26.8
Est. rel.					.85	.78	.91	.90
Time (*mdn* s/problem)								
M					11.0	16.3	18.4	22.5
SD					3.9	7.5	8.2	9.6
Est. rel.					.96	.84	.90	.82
Frequency judgment (% correct)								
M					87.8	84.7	83.7	80.3
SD					7.1	8.9	7.8	8.5
Est. rel.					.63	.54	.57	.43

Note. Est. rel. = estimated reliability; corr. = correlation.

had occurred more frequently in the list. The measure of performance was the percentage of judgments in which the more frequent word was correctly selected.

Results

Summary statistics for the major variables in the two studies are displayed in Table 1. The performance measures consist of the average of the scores across two administrations of each task, and the estimated reliability was obtained by boosting the correlation between the scores on the two administrations by the Spearman-Brown formula to predict the reliability of the composite score. Data have been collapsed across men and women, because a sex difference (i.e., women were faster than men in the number comparison task in the 60–79 group in Study 1) was significant ($p < .01$) for only one variable among the 108 contrasts (i.e., one for each performance variable in each subject sample in each study).

Both measures of time and accuracy are reported on tasks in which speed of performance was assessed. A positive ($r = .24$, $p < .01$) correlation between time and accuracy in the paper-folding task indicated that a speed–accuracy tradeoff may have been operating across individuals in this task because the faster individuals tended to be somewhat less accurate than the slower individuals. The only other significant ($p < .01$) correlations between time and accuracy measures in the same task were negative (i.e., digit symbol, Study 2, $r = -.24$; geometric analogies, Study 2, $r = -.35$; and series completion, Study 2, $r = -.36$), indicating that faster individuals were also more accurate than slower individuals. Statistical control of accuracy significantly attenuated, but did not eliminate, the correlation between age and time on the digit symbol task in Study 2 (from .56 to .54), on the geometric analogies task in Study 2 (from .59 to .51), and on the series completion task in Study 2 (from .32 to .24). These variations in the magnitude of the age trends point out the importance of considering both speed and accuracy of performance if the goal is to obtain a precise quantitative estimate of the effects of age on either aspect of performance.

Each trial of the paired associates task is represented by a separate measure because of the substantial improvements exhibited by most subjects from the first to the second trial (cf. Table 1). Reliability of a composite measure (i.e., Trial 1 plus Trial 2) was about the same as that for the measures on each trial, although the measure of performance combined across the two trials did exhibit slightly larger correlations with age.

Parameters of the linear regression equations relating age to performance in the nonstudent samples are presented in Table 2. The data were also examined to determine whether any quadratic trends were significant. A few of the 27 variables did have a significant ($p < .01$) quadratic trend (i.e., paper-folding time in Study 1, digit symbol time and accuracy in Study 2, number comparison accuracy in Study 2, and analogies time in Study 2), but the effects were small relative to the linear effects, and thus only the latter are reported.

To determine the continuity or discontinuity of the performance of the college students and the adults over age 65, data for the common variables in the two studies were combined to produce a sample of 294 nonstudent adults between age 20 and 65 years. Regression equations relating age to performance were then derived, and performance of the college students and adults over age 65 were predicted by substituting their mean ages (19.4 years and 71.8 years, respectively) in the equations. These predicted values were compared with the observed values by determining the number of standard errors from the distribution of observed scores separating the predicted and ob-

Table 2
Parameters of the Regression Equations Relating Age to Performance

Variable	r	Intercept	Slope
Digit Symbol Accuracy			
Study 1	−.22	99.28	−.083
Study 2	−.18*	97.57	−.015
Digit Symbol Time			
Study 1	.54*	0.875	.021
Study 2	.56*	0.979	.018
Number Comparison Accuracy			
Study 1	−.24*	97.58	−.073
Study 2	−.16	96.75	−.029
Number Comparison Time			
Study 1	.50*	2.512	.040
Study 2	.30*	3.450	.024
Verbal Memory			
Study 1	−.36*	6.169	−.018
Study 2	−.39*	6.295	−.019
Spatial Memory			
Study 1	−.47*	4.853	−.023
Study 2	−.42*	4.675	−.019
Paired Associates 1			
Study 1	−.15	34.26	−.187
Study 2	−.37*	48.02	−.469
Paired Associates 2			
Study 1	−.30*	68.35	−.461
Study 2	−.42*	80.30	−.693
Activity Memory			
Study 1	−.25*	0.955	−.007
Study 2	−.31*	0.882	−.005
Paper Folding Accuracy			
Study 1	−.28*	75.61	−.241
Paper Folding Time			
Study 1	.21	6.873	.137
Closure			
Study 1	−.20	87.57	−.139
Temporal Memory			
Study 1	−.29*	0.739	−.005
Analogies Accuracy			
Study 2	−.43*	106.58	−.414
Analogies Time			
Study 2	.59*	2.697	.128
Series Completion Accuracy			
Study 2	−.28*	92.06	−.356
Series Completion Time			
Study 2	.32*	11.15	.163
Frequency Judgment			
Study 2	−.19*	87.26	−.089

* $p < .05$.

served values. Deviation measures computed in this manner are illustrated in Table 3 for the nine performance variables common to the two studies. (Results from analyses based on the data in each study were more variable because of the smaller sample sizes, but the general patterns were very similar to those reported in Table 3.)

Because a deviation of two standard errors is more extreme than about 95% of the observations in a normal distribution, it is prudent to focus only on the variables with average deviations exceeding this value. Only two variables met this criterion in the over-age-65 group, both involving measures of speeded performance. Adults beyond the age of 65 were much slower in the digit symbol and number comparison tasks than the rate of speed expected from age groups between 20 and 65 years.

A more complicated pattern of differences was evident in the college student group, but the results seem interpretable in terms of two basic trends. The first is a tendency for the college students to be faster and less accurate than predicted in both the digit symbol and the number comparison tasks. The second trend is that the college students were considerably more accurate than predicted in memory for the order of recently performed activities.

To investigate the possible contribution of amount of education to these student-status effects, the regression analyses were repeated, with only the data from the nonstudent subjects with more than 12 years of education included. This smaller sample ($n = 171$, instead of $n = 294$) resulted in attenuated effects with the digit symbol and number comparison speed and accuracy measures (i.e., an average standard score of −1.54 compared with −3.07), but the deviation in the activity memory score was actually larger (6.60 vs. 4.53) in the sample with more than 12 years of education. (Controlling for education in this manner had no appreciable effects on the predictions for the over-age-65 group.)

Because several of the tasks had recently been administered to independent samples of college students and older adults in paper-and-pencil versions, it was possible to contrast the results of those studies with the present results to determine whether one age group was differentially affected by the computerized presentation. The relevant data are summarized in Table 4. Comparisons of absolute values in this table should be made cautiously because the assessments differed not only in manner of presentation but also in the number of items or trials for which the average is reported, the specific items or trials, and so on. Nevertheless, the results in Table 4 provide little indication that one age group is penalized more than the other by a particular mode of task administration, or by the context of other tasks within which the tasks were presented. The older adults were somewhat slower in the speeded tasks with computer presentation than with paper-and-pencil presentation, but these differences are slight in comparison to the overall age differences.

The data from the digit symbol task in Table 4 are particularly interesting because the computerized version involved only yes or no responses, whereas the paper-and-pencil version required writing the appropriate symbol, and yet the absolute times were quite similar in the two conditions. An implication of this finding is that most of the time in the traditional digit symbol task is apparently associated with processes other than those involved in writing the symbols.

The data were also examined to determine whether statistical control of any of the background variables would alter the age trends on the performance measures. Means and standard deviations of the background variables, and the correlations of each with age, are summarized in Table 5.

The only variable in Study 1 for which the age–performance correlation was significantly ($p < .01$) altered by statistical control of one of the variables in Table 5 was digit symbol time in which partialing out years of education reduced the correlation from .54 to .50. In contrast, a number of variables in Study 2 had significant alterations in the age–performance correlations by partialing out background variables. Control of years of education reduced the age correlations with digit symbol time (from .56 to .53), verbal memory (from −.39 to −.35), spatial

Table 3
Deviation (Observed − Predicted) in Standard Error of Observed Performance of Two Groups

Variable	College students			Over age 65		
	Observed	Predicted	Deviation	Observed	Predicted	Deviation
Digit symbol						
Accuracy	96.2	97.7	−4.41	95.1	94.8	0.60
Time	1.33	1.40	−2.33	2.45	2.08	4.11
Number comparison						
Accuracy	94.5	96.3	−3.27	93.9	93.5	0.76
Time	3.67	3.92	−2.27	5.65	4.76	4.94
Verbal memory	5.94	5.90	0.67	4.97	4.90	0.88
Spatial memory	4.56	4.36	2.00	3.29	3.20	1.13
Paired associate						
1	51.6	48.9	0.91	25.0	23.3	0.66
2	54.8	52.0	0.85	26.1	24.7	0.51
Activity memory	0.88	0.81	4.53	0.50	0.50	0.00

memory (from −.42 to −.38), and geometric analogies time (from .59 to .57). Statistical control of either number of medicines per week or positive responses to questions about recent treatment for heart or blood pressure problems attenuated the correlations with digit symbol time (from .56 to a minimum of .53), verbal memory (from −.39 to a minimum of −.35), spatial memory (from −.42 to a minimum of −.37), geometric analogies accuracy (from −.43 to a minimum of −.38), and geometric analogies time (from .59 to a minimum of .54). And finally, statistical control of the occupational status variable (derived by coding the individual's reported job along the Hollingshead scale, ranging from *high status* [1] to *low status* [7]) resulted in significant *increases* in the age correlations with digit symbol time (from .56 to .59), number comparison time (from .30 to .35), and verbal memory (from −.39 to −.43).

It is important to note that the failure to substantially alter the age relations by statistical control of the background variables is not simply attributable to a lack of an effect of these variables on absolute level of performance. Indeed, many of the correlations between the background variables listed in Table 5 and the performance variables listed in Table 2 were statistically significant, with most in the expected direction (e.g., higher education was associated with faster and more accurate performance, more reported medications was associated with slower and less accurate performance). Somewhat surprising was the absence of significant correlations between the variable of self-reported health status and any of the performance variables, despite a significant (i.e., $r = .35$, in both studies) correlation between the health measure and the reported number of medicines taken per week.

Table 4
Comparison of Results From Computerized and Paper-and-Pencil Administrations

Students (age 18 to 25)		Older adults (age 60 to 79)	
Computer	Paper-and-pencil	Computer	Paper-and-pencil
Digit symbol (s/item)			
1.39 (1)	1.32 (3)	2.28 (1)	2.10 (3)
1.29 (2)	1.29 (4)	2.22 (2)	2.00 (4)
	1.29 (5)		1.89 (5)
	1.33 (6)		1.89 (6)
Number comparison (s/item)			
3.65 (1)	3.45 (3)	5.24 (1)	4.31 (3)
3.68 (2)	3.38 (4)	5.22 (2)	4.11 (4)
Verbal memory (items correct)			
5.94 (1)	5.54 (4)	5.18 (1)	5.06 (4)
5.93 (2)		5.00 (2)	
Spatial memory (items correct)			
4.46 (1)	5.30 (4)	3.50 (1)	3.99 (4)
4.63 (2)	4.61 (5)	3.30 (2)	3.89 (5)
	4.68 (6)		3.76 (6)

Note. Sources for the data are (1) Study 1; (2) Study 2; (3) Salthouse (in press), $n = 20$ students, $n = 20$ older adults; (4) Salthouse (in press), $n = 100$ students, $n = 40$ older adults; (5) Salthouse (1987b), $n = 24$ students, $n = 24$ older adults; (6) Salthouse (1987a), $n = 20$ students, $n = 20$ older adults.

Discussion

A major focus of the current studies was to determine the appropriateness of college students as the young subjects and adults over the age of 65 as the older subjects in research on cognitive aging. The reasoning was that if the cognitive performance of either group was substantially discrepant from its predicted level of performance on the basis of the linear regression equations relating age (from 20 to 65 years) to performance in the nonstudent adults, then these groups may not form a good comparison group in studies of aging.

The results summarized in Table 3 indicate that college students are suspect as young-adult control subjects in only a few measures of cognitive performance. Students in the current studies were found to be considerably more accurate than was expected on the basis of the age trends among nonstudents in the activity memory task, in which subjects had to reconstruct the order in which they had performed previous activities. The college students also appeared to emphasize speed as opposed to accuracy, relative to the nonstudents, in the highly speeded

Table 5
Summary Statistics and Age Correlations for Background Variables

	Study 1 (n = 129)			Study 2 (n = 233)		
Variable	*M*	*SD*	*r*	*M*	*SD*	*r*
Years of formal education	14.0	2.5	−.25*	13.5	2.7	−.20*
Occupational status (1 = *high*, 7 = *low*)	3.6	1.5	−.02	3.7	1.5	−.25*
Health (1 = *excellent*, 5 = *poor*)	1.9	0.8	−.06	2.0	0.9	.08
Medicines/week	0.7	1.2	.28*	0.9	1.5	.31*
Treatment for						
Heart trouble (1 = *yes*)	0.2	0.3	.28*	0.1	0.3	.31*
High blood pressure (1 = *yes*)	0.2	0.4	.18	0.2	0.4	.31*
Diabetes (1 = *yes*)	0.1	0.2	.17	0.0	0.2	.10
Need for Cognition Scale	35.8	6.9	−.18	36.7	7.1	−.18*
Social activity (1 = *high*, 5 = *low*)	2.8	1.0	−.02	2.3	1.1	−.18*
Hours/week						
Watching TV	15.4	10.5	.09	15.9	11.0	.20*
Reading books or magazines	8.3	7.3	.20	9.0	9.1	.31*
Participating in hobbies	5.6	6.4	.22	7.2	9.9	.28*
Participating in sports	2.0	3.2	−.20	3.0	3.9	.15
Participating in clubs or other types of organizations	3.4	4.8	.24*	5.1	7.4	.06

* $p < .01$.

digit symbol and number comparison tasks. However, this latter effect may be attributable more to amount of education than to whether one is currently a student, because the prediction deviations were considerably smaller when the predictions were derived from data of subjects having more than 12 years of education.

It is conceivable that school-related activities somehow contributed to the student-status effect with the activity memory measure, but the mechanisms that might be involved were not yet obvious. Moreover, note that student status had very little effect on the presumably more school-relevant measures of paired-associate learning and verbal and spatial memory. These latter results, together with those of Parks, Mitchell, and Perlmutter (1986), in which groups of older students and older nonstudents were found to perform equivalently and at substantially lower levels than young students, seem to suggest that student status per se is probably not a major factor in age-related differences in most types of cognition.

Adults beyond the age of 65 produced levels of performance consistent with what one would expect on the basis of the trends of earlier ages, except for the measures of speeded performance. With these variables there appears to be an acceleration of the age-related effects beyond age 65, perhaps because of the operation of disease factors or secondary aging processes.

A second issue investigated in the current studies was the effect of statistically controlling the influence of a variety of background variables to determine whether they might be responsible for some of the age trends in the measures of cognitive performance. Although there were a number of significant alterations in the age correlations after partialing out the effect of the background variable, all were quite small and in no case did the statistical control render a significant age effect nonsignificant. The apparent implication, assuming that the present self-reported background variables are valid, is that the factors indexed by these variables are of relatively little importance for the age trends in the types of cognitive performance measures assessed in this study.

This conclusion has both practical and theoretical significance. It is important in practical terms because the fact that the age trends in the current measures are not modified by a variety of background variables bolsters the credibility of the tasks from which they were derived as standard tasks. That is, if standard tasks are to extend and supplement demographic information as descriptors of the research participants, then it is desirable that they should be relatively independent of these types of background variables.

The theoretical significance of the lack of appreciable alteration of the age trends by statistical control of a number of background variables is that these findings suggest that the age trends are apparently not simply a consequence of age differences in these variables. Although these results do not indicate what factors might be responsible for the observed age trends in cognitive functioning, the existence of highly significant age correlations after statistically controlling for variation in level of education, health status, frequency of various types of activities, and so forth, suggests that the bulk of the age effects are not directly mediated by variables such as these.

The third focus of the current studies was on the development of standard tasks for subject description in cognitive aging research. We envision that the current results might be used in the following manner in future studies. The initial step is to select one or more tasks that appear most related to the experimental tasks, and for which the available measures are reasonably reliable. Most of the time and memory measures summarized in Table 1 are at least moderately reliable, and thus nearly all of them might be appropriate in this respect. (Note that because all of the tasks were designed to be very brief and all were successfully administered to relatively large numbers of individuals, the other criteria for standard tasks, being quick to administer and amenable to collection of normative data, have also been satisfied.) The next step is to administer those tasks along with the task of primary interest to the samples of research participants in one's study. (Because the results are similar with computerized and paper-and-pencil administrations, the specific format in which the tasks are presented is apparently not too critical.)

Several options are then available for using the standard task data in assisting in the description of the subject samples. One option is to compare the absolute scores of the samples with those reported in Table 1, perhaps in terms of standard error units from the appropriate age groups, to determine whether the experimental samples are comparable to those in the present studies.

Another possibility is to make the comparisons on the basis of the relative differences between the samples in the experiment and the appropriate groups in the current studies. For example, if a group of 30-year-olds were compared with a group of 65-year-olds on the spatial memory task and the ratio of their performances differed substantially from the current ratios of between 1.20 and 1.25, then one might suspect that one or both samples may not be representative of their respective age group.

Still another means of using the current data to evaluate the comparability of the subject samples in future research is to use the regression parameters summarized in Table 2 to make the relevant comparisons. This could be done either by comparing regression parameters directly, or by determining the deviation of the predicted values of each sample from the observed values in a manner similar to that used in the present comparison of students and adults over age 65.

It is important to emphasize that we are proposing the current data as an initial effort in the development of suitable normative data for standard tasks. By no means do we intend that these efforts terminate with this study; additional data are clearly needed to obtain a truly representative normative sample, and more and different tasks should be evaluated as suitable standard task instruments. For example, other test batteries administered to relatively large samples of adults of widely varying ages (e.g., Dirken, 1972; Heron & Chown, 1967) may also be helpful in the selection of candidate standard tasks. Despite these qualifications, we believe that the use of standard tasks could be a valuable addition to cognitive aging research by allowing more precise description of subject samples than is currently the practice. The present results seem to represent an important step toward the attainment of this goal.

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Correction to Kosnik et al.

In the article, "Ocular Fixation Control as a Function of Age and Exposure Duration," by William Kosnik, Donald Kline, John Fikre, and Robert Sekular (*Psychology and Aging,* 1987, Vol. 2, No. 3, 302–305), the following corrections should be made:

1. The title of Table 1 should be changed to *Mean Bivariate Areas (min-arc^2) and Mean Horizontal and Vertical Standard Deviations (min-arc) of Fixations of Older and Younger Groups.*

2. The equation on page 304 should have used the natural log rather than the log base 10 and should read, $M = n * \ln(T) + k$, for T in milliseconds.