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Microcomputer Proficiency in Later-middle-aged and Older Adults: Teaching Old Dogs New Tricks

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ABSTRACT

Fifty-six later-middle-aged and older adults residing in commnunities in central Pennsylvania completed measures of fluid and crystallized intellectual abilities, received microcomputer training on the operation of Lotus 1-2-3 on an IBM personal computer, and were posttested on two microcomputer tasks. Participants as a whole successfully completed greater than 50 percent of the items on both microcomputer tests. No statistically significant sex or age differences were found on the intellectual ability measures. There were also no statistically significant sex or age differences in microcomputer proficiency. The fluid intellectual ability measures of Space and Letter Series were found to predict microcomputer proficiency. Level of education did not correlate significantly with microcomputer proficiency.

INTRODUCTION

Perhaps the most significant societal transformation directly affecting all of our lives is the shift from the industrial to information society (Naisbitt, 1982). This shift has been sparked by the explosion in the number of people engaged in the creation, processing, and distribution of information. Microcomputers have played a major role in this transformation.

The rate at which microcomputers are being received by society is more than five times the rate at which automobiles and telephones were adopted following their introductions (Gantz, 1985). In fact, a popular analogy holds that if the automobile industry had advanced at a pace equal to that of the microcomputer industry a Rolls Royce would cost $2.75 and get 3 million miles to the gallon (Caporael, 1984). Thus, in relation to older workers/learners, the question is not whether or not they will have to operate microcomputers, but how and when they will learn, if they intend to keep their skills current.

Moreover, it has been estimated that some workers may require formal retraining from five to eight times over the course of their careers due to changes in jobs and the requisite skills necessary to perform them (Office of Technology Assessment (OTA), 1985). Unfortunately, older workers are often the targets of

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negative stereotypes directed at their presumed diminished ability or resistance to learning new skills, reduced work capacity and efficiency, and slowed performance (Stagner, 1985). These stereotypes may in turn impact hiring practices and training or retraining opportunities for older workers, as well as leading the older individual to accept the stereotyped beliefs (Stagner, 1985).

It is in the context of the information society and microcomputer revolution that the current research examines whether or not later-middle-aged and older adults are capable of adapting to new information technologies by learning to operate microcomputers, thereby challenging negative stereotypes concerning older learners.

The present study is designed within a differential ageing paradigm to investigate microcomputer proficiency and relationships between intellectual functioning and microcomputer abilities. The theory of fluid and crystallized intelligence is adopted as a multidimensional model of intelligence to guide the formulation of hypothesized relationships between dimensions of intelligence and microcomputer proficiency.

The theory of fluid and crystallized intelligence is based on a hierarchical factor model of first- and second-order ability dimensions (Cattell, 1971; Horn, 1970, 1978; Horn and Cattell, 1967). Fluid and crystallized intelligence refer to second-stratum dimensions of psychometric intelligence. Fluid intelligence is characterized by natural ability which is relatively unbiased by educational or cultural experience. Operationally, it is measured by tasks involving figural or semantic content. Crystallized intelligence reflects mental abilities that depend on experience including, for example, the extent to which an individual profits from formal and informal learning. It is measured by tasks involving general information, vocabulary, and simple arithmetic.

This study has two specific objectives: to examine adults' ability to learn a specific microcomputer skill (spreadsheet design), and to examine what abilities are predictive of acquiring computer skills. In a larger context the objectives of the research are: (1) to demonstrate that later-middle-aged and older adults can contribute to society in meaningful and productive ways by training a representative group of adults to successfully operate microcomputers; (2) to provide descriptive information on the intellectual functioning and microcomputer abilities of this later-middle-aged sample; (3) to identifying predictive relationships between intellectual functioning and microcomputer abilities in later-middle adulthood; and (4) to put the project into a broader context by comparing the participants' intellectual abilities to gender specific norms.

METHOD

Participants

Sampling. Participants were recruited from three main sources targeted to represent a diverse sample of the workforce. The first source was several local hi-tech companies. The second source was the faculty and staff of the Pennsylvania State University. The final source included persons from the community from other than the aforementioned private organizations and the university.

Participants were recruited from 55–65-year-old full-time employees with no previous computer experience. Participants had to be in good health and not impaired in any way that would prevent them from operating a microcomputer (e.g. visual problems, hearing difficulties, diminished cognitive functioning, etc.).

Sample Characteristics. The final sample consisted of 56 community-dwelling later-middle-aged and older adults residing in central Pennsylvania. Their mean age was 57.9 years, ranging from 49 to 67 years (SD = 3.49). There were 25 males and 31 females. The participants were well educated (high school graduates = 24; completed college courses and/or graduated from college = 16; completed graduate courses and/or had graduate degrees = 16). There were no significant sex or age differences for education. The sample was quite heterogeneous in terms of the variety of jobs, including secretaries, lab. technicians, a farm manager, a corporate president and an automobile dealer. Only one participant failed to complete all tasks in the study.

Research design

The present study employed a pre-experimental research design similar to the one-shot case study (Campbell and Stanley, 1963). The treatment consisted of Lotus 1-2-3 training. Following the treatment, participants were tested on two microcomputer tasks. In a nonequivalent pretest, participants were tested on a battery of fluid and crystallized intelligence measures. Thus, the research design parallels that of an aptitude by treatment interaction study (Cronbach and Snow, 1977).

Procedure

The study involved two sessions. In the first session demographic information and the fluid and crystallized intellectual ability measures were administered, followed by 1½ hours of training. In the second session 1½ hours of training was given, for a total of 3 hours of training. The Lotus 1-2-3 criterion tasks were administered at the end of the second session.

The Lotus 1-2-3 training was conducted in a microcomputer lab. at The Pennsylvania State University. Each participant had his or her own IBM personal computer with either a monochrome or color monitor.

Training. Lotus 1-2-3 is one of the most popular and widely sold software programs on the market today. Lotus 1-2-3 is a sophisticated program, integrating spreadsheet, graphics and data management capabilities into one very powerful and easy-to-learn package. For the purposes of this project the training focused on the spreadsheet application. The training materials prepared and pilot-tested for this study were designed to provide participants with a general working knowledge of microcomputers and, more specifically, basic skills for operating Lotus 1-2-3.

A young white male instructor conducted the microcomputer training and administered the ability pretests and microcomputer posttests. Participants were taught in groups ranging from five to 11 individuals. Differential training group size (five to 11) was not considered an influence in the training outcome because participants worked individually on a computer, were provided ample time to complete each task, and competitiveness was de-emphasized in the training. During the first session, participants were given an introduction to the IBM

personal computer and the first four Lotus 1-2-3 lessons. In the second session, lessons five through eight were taught along with an integrated six-part review covering the previous lessons.

Participants were given a Quick Reference Guide, which contained a summary of the commands to be learned in the training. This guide was prepared to eliminate the need to take notes and to serve as a checklist to assure that the participants understood all of the commands.

Instructional Method. The primary instructional method consisted of direct instruction on how to complete the given lessons. The assignments were modeled for participants if instruction alone was not sufficient. Immediate feedback was provided as to the correctness of all work. Differential learning speed was considered by providing ample time ot practice the given assignments so that participants mastered each assignment before proceeding to subsequent lessons.

Measures

The measurement battery consisted of tests measuring three general dimensions: crystallized intelligence, fluid intelligence, and microcomputer proficiency related specifically to the operation of Lotus 1-2-3 and the IBM personal computer. The ability dimensions were measured by the SRA Primary Mental Abilities test (Thurstone, 1958), the Culture Fair test (Institute for Personality and Ability Testings (IPAT), 1973) and the Lotus 1-2-3 proficiency tests. Table 1 shows the conceptual framework for the measurement battery.

Table 1. Conceptual framework for the measurement battery: general dimension, primary factor, and measure

General dimension	Primary factor	Measure
Crystallized intelligence	Verbal	Verbal Meaning[a]
Crystallized intelligence	Numeric relations	Number[a]
Crystallized intelligence	Verbal recall	Word Fluency[a]
Fluid intelligence	Spatial orientation	Space[a]
Fluid intelligence	Inductive reasoning	Letter Series[a]
Fluid intelligence	Figural relations	Figure Series[b]
Fluid intelligence	Figural relations	Matrices[b]
Fluid intelligence	Figural relations	Topology[b]
Microcomputer abilities	Lotus 1-2-3 proficiency	General Ledger
Microcomputer abilities	Lotus 1-2-3 proficiency	Check Register

[a] From the SRA Primary Mental Abilities test (Thurstone, 1958).
[b] From the Culture Fair test (IPAT, 1973).

Because the intellectual ability measures are documented elsewhere (see, e.g., IPAT, 1973; Thurstone, 1938; Thurstone, 1958), only the Lotus 1-2-3 tests will be described. The Lotus 1-2-3 tests involved two measures: the ability to produce a simple general ledger and the ability to produce a check register (see Figure 1). Participants were allotted 20 minutes to work on each task, which required them to replicate the text, numeric information, and formulas quickly and accurately. The General Ledger was presented first. Following a brief break, the Check Register was administered.

TASK I

A	B	C	D	E	F	G
GENERAL LEDGER						
	JAN	FEB	MAR	APR	MAY	
SALES	7,159	6,578	9,723	2,644	14,862	
ACCTS						
PAYABLE	2,014	3,125	500	2,100	1,899	
SALARIES	3,600	3,600	4,500	4,500	4,500	
PROFIT	*	*	*	*	*	
TOTAL PROFIT					*	

TASK II

A	B	C	D	E	F	G
CHECK REGISTER						
NUMBER	DATE	DESCRIPTION		PAYMENT	DEPOSIT	BALANCE
		BEGINNING				
		BALANCE				200.00
	101 6/11	GROCERY STORE		90.35		*
	102 6/13	ELECTRIC COMPANY		105.99		*
	6/15	DEPOSIT			499.37	*
	6/17	CHARITY		25.00		*
		ENDING BALANCE				*

Figure 1. Lotus 1-2-3 proficiency tests: Check Register and General Ledger. Asterisk indicate where participants had to write formulas to perform the necessary calculations.

Microcomputer proficiency was assessed with six variables: Correct Formats (correctly formatted information); Correct Formulas; Correct Labels (non-numeric or character data); Correct Numbers (manually entered numbers); Correct Words (correctly spelled words); and an Overall Score. The former five variables are equal to the total number of correct attempts minus the total number of incorrect attempts. The Overall Scores is equal to a linear combination of the corresponding subscores.

RESULTS

The multivariate analyses of variance reported below follow a general $2 \times 2 \times n$ design with a 0.05 criterion significance level, where sex (male, female), and age of subject (49–57, 58–69) were the independent variables, and n intellectual ability or microcomputer proficiency variables were the dependent variables. The intellectual ability measures were separated into two groups for each analysis, according to whether they were of the fluid or crystallized type. The fluid intellectual abilities were assessed by three tests: Space, Letter Series, and Composite Figural Relations (Figure Series, Matrices, and Topology). The crystallized intellectual abilities were measured by three tests: Verbal Meaning, Number, and Word Fluency. The measures of microcomputer proficiency were also divided into two groups representing the General Ledger and Check Register. The performance on both microcomputer tasks was assessed by six variables: Correct Formats, Correct Formulas, Correct Labels, Correct Numbers, Correct Words, and Overall Performance. Thus there were three to six dependent variables in each multivariate analysis of variance.

Pretest Equivalence

Two multivariate analyses of variance conducted to determine the presence of differences within the sample group for (1) the three fluid intellectual abilities and (2) the three crystallized abilities did not yield any statistically significant effects. These within-group analyses assessed sex and age differences in intellectual abilities.

Univariate analyses of variance were further conducted for each of the six measures. No statistically significant sex or age differences were found. Test scores and standard deviations for the Primary Mental Abilities (Thurstone, 1938; Thurstone, 1958) are presented in Table 2 in the form of T-scores (M = 50, SD = 10). The T-scores were obtained from gender-specific published norms (Schaie, 1985). T-score norms for older adults were not available for the Culture Fair test

Table 2. Mean performance on primary mental abilities[a]

Subtest	Mean	SD
Females (n = 31)		
Verbal Meaning	45.97	10.57
Space	46.94	10.25
Letter Series	45.90	9.99
Number	49.39	8.30
Word Fluency	41.48	10.36
Males (n = 25)		
Verbal Meaning	46.92	8.55
Space	44.72	8.53
Letter Series	42.76	11.24
Number	51.28	7.59
Word Fluency	42.72	8.19
All subjects (n = 56)		
Verbal Meaning	46.39	9.73
Space	45.98	9.58
Letter Series	44.50	10.66
Number	50.23	8.05
Word Fluency	42.04	9.47

[a] Data presented as T-scores (M = 50, SD = 10).

Table 3. Mean performance on Culture Fair subtests

Subtest	Mean	SD
Females (n = 31)		
Figure Series	8.26	2.14
Matrices	2.29	1.16
Topology	2.71	1.62
Composite Figural Relations	13.26	3.25
Males (n = 25)		
Figure Series	8.32	2.67
Matrices	2.44	1.12
Topology	3.48	1.69
Composite Figural Relations	14.24	3.91
All subjects (n = 56)		
Figure Series	8.29	2.37
Matrices	2.36	1.13
Topology	3.05	1.68
Composite Figural Relations	13.70	3.56

(IPAT, 1973). Consequently, raw scores and standard deviations are presented in Table 3.

A systematic pattern was found across all of the primary mental abilities except Number. Participants placed below the norms (M = 50) for the majority of abilities. Men scored sufficiently high on Number (M = 51.28) to lift the combined mean score to an approximate normative level (M = 50.23). However, there were no consistent similarities or differences in intellectual abilities between men and women.

Again, no consistent similarities or differences were evident between groups on the Culture Fair subtests. Although men (M = 3.48) scored almost a point higher on Topology than women (M = 2.71), as noted earlier, this difference was minimal and not significant.

Table 4 shows the correlations among the measures of intellectual abilities. The intercorrelations among the primary mental abilities ranged from 0.15 to 0.54, each accounting for less than 30 per cent of the common variance. This lends support to the Thurstonian requirement of adequate factor separation for the ability measures (Schaie, 1985).

There were no significant intercorrelations among the Culture Fair subtests. However, as would be expected, the Composite Figural Relations score was highly correlated with its subscores. These correlations ranged from 0.50 to 0.83, and they all were statistically significant at the 0.001 level.

Several significant associations were found between the Culture Fair test (Composite score and subtests) and measures from the Primary Mental Abilities test. Topology was positively correlated with Space (0.39, $p < 0.01$) and Number (0.32, $p < 0.01$). Matrices correlated equally with Verbal Meaning (0.36, $p < 0.01$) and Word Fluency (0.36, $p < 0.01$). Figure Series was associated with all of the primary mental abilities with the exception of Word Fluency. In order of magnitude, Figure Series was positively correlated with Number (0.27, $p < 0.05$), Verbal Meaning (0.35, $p < 0.01$), Space (0.39, $p < 0.01$) and Letter Series (0.40, $p < 0.01$).

Table 4. Correlations among intellectual abilities (n = 56)

	Variable								
Variable	1	2	3	4	5	6	7	8	9
Fluid intellectual abilities									
1. CF Topology	—								
2. CF Matrices	0.03	—							
3. CF Figural Series	0.19	0.24	—						
4. CF Composite Figural series	0.61***	0.50***	0.83***	—					
5. PMA Letter Series	0.19	0.22	0.40**	0.43***	—				
6. PMA space	0.39**	0.25	0.39**	0.53***	0.27*	—			
Crystallized intellectual abilities									
7. PMA Number	0.32**	0.17	0.27*	0.34***	0.34**	0.37**	—		
8. PMA Verbal Meaning	0.19	0.36**	0.35**	0.44***	0.47**	0.38**	0.38**	—	
9. PMA Word Fluency	0.20	0.36**	0.15	0.33**	0.30*	0.29*	0.16	0.54***	—

CF = Culture Fair test, PMA = Primary Mental Abilities test.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The Composite Figural Relations score was correlated with all of the Primary Mental Ability subtests. In order of magnitude and significance, the Composite Figural Relations score was positively correlated with Word Fluency (0.33, $p < 0.01$), Number (0.34, $p < 0.001$), Letter Series (0.43, $p < 0.001$), Verbal Meaning (0.44, $p < 0.001$), and Space (0.53, $p > 0.001$).

Chi-square analyses by sex and age of data obtained from the demographic information sheet indicated a significant within-group difference on typing required on the job. Women were more likely than men to hold a job which required them to type, Chi-square (1, $n = 56$) = 10.68, $p < 0.001$. There were no significant within-group differences by sex or age for: (1) employment status, (2) educational level, (3) previous microcomputer experience, (4) if participants typed outside of work, and (5) how participants heard about the study.

The final pretest equivalence measure was composed of five questions about the operation of Lotus 1-2-3. No subject correctly answered any of the questions. This supported the requirement that participants not be familiar with Lotus 1-2-3 prior to the training. However, ten participants indicated that they had some previous computer experience, ranging from entering orders on their company computer to using LIAS, the Pennsylvania State University library system. It is argued that these computer experiences are qualitatively different from operating a microcomputer and Lotus 1-2-3. Consequently, these experiences were not expected to have an impact on the current study.

Microcomputer Proficiency Measures

Sex and Age Differences. Two multivariate analyses of variance conducted to assess sex and age differences for each microcomputer criterion task (General Ledger, Check Register) were not statistically significant. Univariate analyses of variance for both microcomputer tasks were conducted for each of the six measures. No significant age or gender differences were found for the General Ledger or Check Register total score or for the five subtests. This finding is consistent with the earlier multivariate analyses of variance for the intellectual abilities which did not identify significant group differences in intellectual functioning.

Training Effects. The means, standard deviations, percentage correct, and perfect scores for General Ledger and Check Register total scores and corresponding subscores are presented in Table 5. Perfect scores represent the maximum possible correct for each particular variable. The percentage correct values indicate the mean proportion of correct responses for each variable, and they are calculated by dividing each of the means by the overall Perfect Score for that subtask. The Task scores are linear combinations of the corresponding subscores (Task = Correct Formats + Correct Formulas + Correct Labels + Correct Numbers + Correct Words).

Participants completed correctly approximately half of the General Ledger items (52.36%). Although there were no significant sex differences in replicating the General Ledger either on the total score or subscores, there was a distinct pattern in the types of operations participants were most proficient at. Women were more accurate in operations requiring basic data entry and less cognitive

Table 5. Mean performance on Lotus 1-2-3 tasks

Score	Mean	SD	Perfect score	Percentage correct
Task I: General Ledger				
Females (n = 31)				
Task I	36.29	15.33	75	48.39
Correct Formats	0.32	1.25	5	6.40
Correct Formulas	1.32	1.80	6	22.00
Correct Labels	9.74	11.96	35	27.83
Correct Numbers	12.87	3.56	15	85.80
Correct Words	12.03	2.30	14	85.93
Males (n = 25)				
Task I	42.96	23.14	75	57.28
Correct Formats	0.40	3.80	5	8.00
Correct Formulas	2.40	2.52	6	40.00
Correct Labels	16.00	14.67	35	45.71
Correct Numbers	12.52	5.04	15	83.47
Correct Words	11.64	3.47	14	83.14
All subjects (n = 56)				
Task I	39.27	19.32	75	52.36
Correct Formats	0.36	2.67	5	7.20
Correct Formulas	1.80	2.19	6	30.00
Correct Labels	12.54	13.48	35	35.83
Correct Numbers	12.71	4.25	15	84.73
Correct Words	11.86	2.86	14	84.71
Task II: Check Register				
Females (n = 31)				
Task II	36.90	16.02	64	57.66
Correct Formats	0.23	0.56	2	11.50
Correct Formulas	0.48	1.15	5	9.60
Correct Labels	17.29	11.37	32	54.03
Correct Numbers	4.42	2.64	7	63.14
Correct Words	14.48	4.78	18	80.44
Males (n = 25)				
Task II	37.36	18.68	64	58.38
Correct Formats	−0.52	2.47	2	−26.00[a]
Correct Formulas	0.52	1.12	5	10.40
Correct Labels	18.00	13.66	32	56.25
Correct Numbers	4.92	2.74	7	70.29
Correct Words	14.44	4.27	18	80.22
All subjects (n = 56)				
Task II	37.11	17.10	64	57.98
Correct Formats	−0.11	1.72	2	−5.50[a]
Correct Formulas	0.50	1.13	5	10.00
Correct Labels	17.61	12.33	32	55.03
Correct Numbers	4.64	2.67	7	66.29
Correct Words	14.46	4.52	18	80.33

[a] A negative percentage correct score is possible if an individual commits more errors than the numb of items correctly completed. This may occur, for example, when an individual is unable to format tl designated items while simultaneously incorrectly formatting other undesignated information.

ability. They correctly entered and spelled 85.93 percent (m = 83.14%) of the words and 85.80 percent (m = 83.47%) of the numbers. On the other hand, men were more proficient in the more advanced operations of entering labels (m = 45.71%, w = 27.83%), creating formulas (m = 40.00%, w = 22.00%) and formatting information (m = 8.00%, w = 6.40%). In general, participants performed less well on the advanced operations (Formats = 7.20%, Formulas = 30.00%, and Labels 35.83%) than on the relatively straightforward data entry operations (Numbers = 84.73% and Words 84.71%).

Participants improved on the second microcomputer task, successfully completing 57.98 percent of the Check Register. The pattern of sex differences in microcompter proficiency identified for the General Ledger was not evident for the Check Register. Both men and women performed equally as well entering words (80.22 and 80.44%, respectively.) This time women were better at the more advanced operation of formatting information (11.50%). The negative percentage correct for the men on this subtask (−26.00%) reflects the poor performance of two particular men out of the 25 in the sample. Men remained more adept at the advanced operations of creating formulas (m = 10.40%, w = 9.60%) and entering lables (m = 56.25%, w = 54.03%), and they improved enough at entering numbers to surpass the women) m = 70.28%, w = 63.14%).

However, three consistent overall patterns in microcomputer proficiency were found between the Check Register and General Ledger. First, participants were more successful at the tasks (Words, Numbers, and Labels) which required less cognitive skill than the more complex tasks (Formulas and Formats) which often required considerable cognitive effort. Second, the ranking of performance (percentage correct) by subtasks was the same for both measures. The relative order listed from best to worst was Correct Words, Numbers, Labels, Formulas, and Formats. Note that, for the General Ledger, the Correct Numbers and Words were ranked approximately equally (84.73 and 84.71%, respectively). Third, the women exhibited less variation in microcomputer performance than the men across both measures, and these differences decreased between the first and second tasks.

Two additional multivariate analyses of variance were subsequently conducted to assess if participants who typed at work were more proficient microcomputer operators. For the purpose of this analysis it was assumed that participants who typed at work might be faster and more accurate typists than participants who did not type at work. The independent variable 'percentage of time participants typed at work' was dichotomized according to whether or not participants typed at work. The dependent variables were the General Ledger and Check Register overall and subscores. The multivariate and univariate F tests were not statistically significant for either task. Consequently, typing ability appeared to have no effect on microcompuetr proficiency.

Correlates of Microcomputer. Proficiency. The General Ledger and Check register both correlated 0.16 with level of education; these relationships were not statistically significant at the 0.05 level.

The correlation coefficients among the intellectual abilities, General Ledger, and Check Register variables are presented in Table 6. The fluid abilities of Topology,

Table 6. D Correlations among Intellectual Abilities, General Ledger, and Check Register variables (n = 56)

Variable	Fluid intellectual abilities			Crystallized intellectual abilities		
	Composite Figural Relations	PMA Letter Series	PMA Space	PMA Number	PMA Verbal Meaning	PMA Word Fluency
1. *General Ledger*	0.25	0.32**	0.40**	0.37**	0.16	0.04
2. Correct Formats	0.17	0.03	0.01	−0.06	0.02	0.04
3. Correct Formulas	0.23	0.20	0.30*	0.33**	0.13	0.14
4. Correct Labels	0.24	0.25	0.39**	0.33**	0.14	0.04
5. Correct Numbers	0.06	0.25	0.15	0.30*	0.05	−0.22
6. Correct Words	0.16	0.44***	0.44***	0.29*	0.26*	0.23
7. *Check Register*	0.36	0.40**	0.39**	0.40**	0.29*	0.29*
8. Correct Formats	0.00	−0.05	0.06	0.07	0.10	0.05
9. Correct Formulas	0.11	0.04	−0.01	0.14	0.06	0.07
10. Correct Labels	0.35***	0.29*	0.40**	0.31*	0.19	0.27*
11. Correct Numbers	0.30*	0.38**	0.35**	0.40**	0.30*	0.25
12. Correct Words	0.21	0.50***	0.16	0.37**	0.34**	0.17

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 7. Correlations among General Ledger and Check Register variables (n = 56)

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. *General Ledger*	—											
2. Correct Formats	0.39**	—										
3. Correct Formulas	0.52***	0.04	—									
4. Correct Labels	0.93***	0.31**	0.36**	—								
5. Correct Numbers	0.58***	0.03	0.38**	0.34**	—							
6. Correct Words	0.71***	0.14	0.44***	0.53**	0.55***	—						
7. *Check Register*	0.56***	0.20	0.36**	0.52**	0.29*	0.46***	—					
8. Correct Formats	−0.16	−0.01	−0.23	−0.16	−0.06	−0.06	0.19	—				
9. Correct Formulas	−0.12	−0.15	−0.02	−0.10	−0.04	−0.10	0.05	0.04	—			
10. Correct Labels	0.64***	0.28	0.40**	0.62***	0.24	0.46***	0.92	0.04	−0.05	—		
11. Correct Numbers	0.32***	0.03	0.29*	0.23	0.32**	0.37**	0.77***	0.14	−0.02	0.56	—	
12. Correct Words	0.30*	0.02	0.20	0.23	0.30*	0.32**	0.72***	0.12	0.08	0.44	0.76***	—

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Letter Series, Space, and the crystallized abilities of Number and Verbal Meaning accounted for all of the statistically significant correlations with the General Ledger subtask scores. These correlations ranged from 0.26 to 0.44, accounting for up to 19 percent of the common variance. The two fluid abilities Letter Series (0.32, $p < 0.01$) and Space (0.40, $p < 0.01$) and the crystallized ability Nubmer (0.37, $p < 0.01$) were moderately correlated with the General Ledger overall score.

A greater number of statistically significant correlations were found to occur between the intellectual abilities and the Check Register variables. All of the abilities correlated in the range of 0.27 to 0.50 with the Check Register subtask scores, accounting for up to 25 percent of the common variance. These intellectual measures also were significantly correlated with the Check Register overall score, ranging from 0.29 to 0.40.

Part–whole correlations for the General Ledger and Check Register variables are shown in Table 7. The part–whole correlations for the General Ledger ranged from 0.39 to 0.93, and they were all statistically significant. The part–whole correlations for the Check Register subscores of Correct Numbers and Words ranged from 0.72 to 0.77, and they were highly significant. Four out of the six correlations between microcomputer tasks were also marginally to moderately positively associated. The overall scores correlated 0.56, $p < 0.001$, Correct Labels correlated 0.62, $p < 0.001$, Correct Numbers correlated 0.32, $p < 0.01$, and Correct Words correlated 0.32, $p < 0.01$. Note also that there seems to be higher internal consistency among General Ledger subtasks than among Check Register subtasks.

Predictors of Microcomputer Proficiency. A multiple regression analysis, using the stepwise selection method (SAS, 1985), was conducted to identify significant predictors of microcomputer proficiency. The independent variables consisted of the six intellectual ability measures. A new dependent variable representing microcomputer proficiency was created for this analysis. The General Ledger and Check Register overall scores were summed, creating a new score representing microcomputer proficiency across both tasks.

The stepwise multiple regression analysis examining fluid and crystallized intellectual abilities identified two significant predictors of microcomputer proficiency. Table 8 shows the beta, partial R^2, model R^2, F and p values for the fluid abilities retained in the equation. Space accounted for 0.20 of the variance, and Letter Series accounted for 0.09 of the variance when added to the equation after Space. Together, Space and Letter Series accounted for 0.29 of the variance.

A subsequent stepwise multiple regression analysis was conducted which included level of education with Space and Letter Series as the independent variables. Level of education was not a significant predictor of microcomputer proficiency.

Table 8. Stepwise multiple regression analysis

Variables	Unstandardized coefficients	Partial R^2	Model R^2	F	p
Space	1.28	0.20	0.20	13.90	0.001
Letter Series	1.16	0.09	0.29	6.46	0.01

DISCUSSION

Training Effects

The microcomputer proficiency data suggest three points of interest. First, the failure to find significant sex or age differences in microcomputer proficiency indicates that these factors may not be of primary importance when training healthy older individuals. Second, the finding that participants improved on the second microcomputer task (recall that there was no training between microcomputer tasks) implies that older individuals can benefit from both formal educational experiences and individual trial and error. In this instance, improvement on the second microcomputer task (Check Register) resulted from individual experimentation and subsequent increases in microcomputer proficiency acquired while working through the first microcomputer task (General Ledger). Third, although norms are unavailable for the microcomputer tasks, the greater than 50 percent accuracy rate indicates that participants correctly completed a sizeable portion of both criterion tasks. Future analyses will address the issue of competency by exploring the intellectual functioning of the most and least proficient microcomputer users.

The finding of a pattern in the subscores of the microcomputer proficiency measures lends support to the construct validity of the instruments. Although the mean percentage correct differed for each microcomputer task, the rank order of the subscores was almost identical between both tasks. Moreover, there was a high positive correlation between both task total scores, which was supported by several high positive part–total correlations within each task. Given that the goal in developing the proficiency measures was to devise two independent tests, both of which measured microcomputer proficiency, the identification of structural consistency across measures suggests that both tests do reliably assess proficiency in Lotus 1-2-3.

Correlates and Predictors of Microcomputer Proficiency

The finding that level of education did not correlate significantly with either measure of microcomputer proficiency is important. It suggests that the ability to operate a microcomputer is also influenced by factors in addition to schooling (crystallized intelligence) such as culturally free ability (fluid intelligence) and, presumably, motivation to learn. The final stepwise regression analysis in which level of education did not predict microcomputer proficiency supports this finding. The absence of statistically significant associations between level of education and microcomputer proficiency suggests that the nature of the relationship between these variables is not yet clearly understood. It is reasonable to predict that well-educated individuals would be more proficient with computers than individuals with little or no formal education. The positive educational bias of the present sample, however, does not permit this question to be examined because less-educated individuals are under-represented.

The finding that performance on the two fluid intellectual measures of Space and Letter Series significantly predicted microcomputer proficiency suggests that the abstract reasoning aspects of fluid intelligence can influence the ability to learn to use a microcomputer. Recall that none of the crystallized intellectual measures remained in the final regression equation. The 'natural' fluid intellectual abilities as measured by Space and Letter Series were the two factors most closely associated with individual differences in microcomputer proficiency. This regression analysis lends support to the argument that factors other than education affect microcomputer proficiency in older individuals. For instance, as fluid intelligence presumably reflects the quality of one's brain – the speed signals enter and exit, and the quality of recognition and memory (Horn, 1982) – this form of intelligence is more susceptible to declines brought about by deterioration in the neural structures underlying intelligence.

Limitations and Suggestions for Future Research

A limitation of the present study may be a positive educational selection bias. However, when compared to gender-specific intellectual ability norms participants scored slightly below average.

The present research employed a cross-sectional design, limiting the generalizability of the findings to the current cohorts of healthy individuals examined. Only the most recent of older cohorts have even had a chance of being exposed to computer technology, as microcomputers were not introduced into the mainstream of society until the 1980s. As for future cohorts of older individuals, we can expect them to be much more knowledgeable of computers, as computers are continually integrated into home, educational, and workplace settings.

More comprehensive age-comparative research is needed, including younger cohorts of individuals, to examine the nature and magnitude of differences in microcomputer proficiency between older and younger age groups. For example, although there were no significant sex or age differences in microcomputer proficiency in the present sample, their performance may or may not be judged adequate to an employer when compared to the performance of younger workers. Answers to questions such as this can only be determined from age-comparative studies.

The cross-sectional nature of the current research also does not permit examination of two fundamental questions. First, did the training result in remediation of age-related declines? Second, did the training result in improvement in individuals experiencing no decline (see, e.g., Willis and Schaie, 1986)? A longitudinal component, including prior intellectual histories of participants, would be needed to address these questions, as well as incorporating a posttest intellectual ability measure into the research design. Additionally, the developmental trajectory of microcomputer proficiency over time could not be assessed, particularly in relation to intellectual abilities and other non-cognitive variables such as, for example, mental health, physical health, or motivation.

Another unknown has to do with speed of behavior. It is widely accepted that there is a reduction in speed of behavior with advancing age (Salthouse, 1985). The speed of behaviour question is one of accuracy and efficiency. An employer must know not only if an older individual can use a microcomputer, but also how he or she uses it in comparison to younger individuals. In some work settings the important aspect of performance is speed of data entry. In other work settings the emphasis is project-oriented, where the individual is responsible for completing an entire task, such as in researching and then writing a report. In all settings, however, the accuracy of the work is important, and in many instances errors are intolerable. One can resolve a mistake in a bank statement, but an error by an air

traffic controller or in the transfer of moneys at the stock exchange could lead to human or financial disasters.[1]

The final qualification concerns the hardware and software used in the training and testing. It is reasonable to expect that the training would generalize to other similar microcomputers and related software programs. Individuals who can use Lotus 1-2-3 on an IBM personal computer probably could adapt to another spreadsheet program on a different brand of microcomputer with ease. Although the specific commands may vary, the operational features are usually similar. It is like driving a car: if you learned to drive in a Chrysler, minimal effort is required to adapt to driving a Volkswagen. However, driving a Volkswagen does not readily generalize to operating an 18-wheel truck.

Implications for Older Learners

The findings that participants successfully completed over half of each microcomputer task, and that all participants were able to operate a microcomputer with varying degrees of proficiency after only two brief training sessions have important implications for older learners. It is clear that healthy and presumably well-motivated older individuals are fully capable of training to adapt to current and emerging technologies. The findings do not support some of the common negative stereotypes of older learners previously thought to be incapable of, and resistant to, retraining (Stagner, 1985) or possessing specific learning problems (OTA, 1985).

That performance on measures of two fluid intellectual abilities significantly predicts microcomputer proficiency suggests possible training targets. Given situations in which older individuals must learn to operate microcomputers, whether for work or pleasure, at least three strategies can be employed to facilitate the acquisition of microcomputer skills. First, within the work environment, older individuals could be screened for some predetermined levels of fluid intellectual competence in jobs requiring interaction with microcomputers. Second, microcomputer training could be preceded by cognitive training to improve fluid abilities. Third, fluid intellectual training could be incorporated into the microcomputer training. These latter two strategies would capitalize on the older individual's potential to benefit from fluid intellectual training (see, e.g., Willis and Schaie, 1986).

The microcomputer proficiency demonstrated after only two brief training sessions shows that older individuals can master new and emerging technologies. Participants successfully upgraded their skills and knowledge by learning to use Lotus 1-2-3 on an IBM personal computer, remaining technologically current (microcomputer proficient) and, therefore, valued assets at their respective organizations. Thus, the question typically asked by bureaucrats and corporations as to whether or not older individuals are capable of learning new skills, and even worse, the assumption that they are incapable of learning, are no longer valid. We must now work to determine how we are going to provide the resources to train and retrain older workers, and how this process can be most efficiently facilitated. The question changes from an expression of doubt (Are older workers capable of learning?) to a question of resource management (How do we ensure that effective training and retraining is provided?).

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NOTE

1. The literature on sociotechnical accidents, failures, and disasters shows that these are rarely due to human error alone. The goal of ergonomics, or human factors engineering, is to design the work environment to consider the capabilities and limitations of the human operator (Swain, 1977; Wickens and Kramer, 1985). This approach to the optimization of the interaction between human operator and the machines they operate acknowledges two sources of potential error: human reliability and machine reliability (Knowles, 1977). Thus, to prevent system failures from occurring or re-occurring, the work environment must be mechanically reliable and take into account the human component (e.g. motivation, attention, education). In reference to the air traffic controller example, system failures (aviation disasters) are averted through continued training, testing, and monitoring of controllers (human factor), in conjunction with the use of automated, well-designed air traffic tracking systems (machine factor).

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