Older Adults and Computer Technology:

The Role of Conventional Manuals, Multimedia, and the Effects of Practice

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David Kurzman

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Abstract

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David Kurzman, Ph.D.
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With the continuing absorption of computers into everyday life, it becomes important to determine the most effective methods for teaching older adults to use computers as well as the extent to which their ease of learning is affected by individual differences in ability and aptitude. In this study 48 older computer-naive women aged 51 to 78 years ($M = 65.8$, $SD = 6.0$) were trained in word processing using either a written, self-paced manual only (Text; $N = 24$) or the manual plus multimedia demonstrations (Multimedia; $N = 24$). In both conditions participants learned how to perform a task and then executed it on the computer. Individuals in the Text condition received two learning trials on the computer per command learned. Individuals in the Multimedia condition viewed and heard a demonstration of the steps required to complete the command and then received one learning trial. Following training the participants completed a quiz, and then repeated each command 10 times during the practice phase of each day's session. Half the individuals in each training condition were assigned to the Variable Practice condition in which they alternated between two methods to complete the practice items, while the other half were assigned to the Consistent Practice condition and used only a single method throughout the practice phase. On the final study day, participants completed exercises which integrated all they had learned, and additional exercises that measured the extent to which training on this word processing program could be transferred to a similar (near-transfer) program.

Neither type of training nor the type of practice had any effect on performance on any measure of word processing acquisition. As individuals practiced, their accuracy increased, while the number of errors, time required to complete the commands, and requests for help decreased. Path analyses examined the effects on performance of exogenous variables including age, education, factors based on cognitive abilities (memory, language, speed, visuospatial, and manual control), and attitudes towards computers. The discussion focuses on the implications of the findings for training older adults learning to use a word processor.

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The computer is incredibly fast, accurate, and stupid.
People are unbelievably slow, inaccurate and brilliant.
The marriage of the two is a force beyond calculation.

(Leo Cherne in M. J. Hillelsohn, 1984)

OLDER ADULTS AND COMPUTER TECHNOLOGY: THE ROLE OF CONVENTIONAL MANUALS, MULTIMEDIA, AND THE EFFECTS OF PRACTICE

Introduction, Background, and Rationale

The integration of computers in everyday life represents a significant technological change in our society. In the past two decades computers have been introduced into the workplace, the educational system, commercial enterprises, and the home and have rapidly become an integral part of the way we function in society. It has been estimated that more than half the members of the office labour force are required to use computer systems. Many individuals in a wide range of sales and service jobs are now faced with the need to master complex computer hardware and software. Many activities that were once performed exclusively by people are more frequently being conducted via computers. Furthermore, many individuals now use computers in their everyday lives for educational purposes, and for such activities as keeping track of personal finances, and word processing. As the cost of owning a computer continues to fall, owning one is no longer considered to be a luxury of the few. Rather the computer is quickly becoming a standard and essential household appliance. With technology continuing to advance, the ability to use a computer is increasing in importance. Given that older adults have tended not to adopt computers as quickly as do younger adults (Adler, 1996), nor to acquire spontaneously the skills needed for computer literacy (Zimmer & Chappell, 1993), it becomes important to understand how older adults can best make use of these technologies and to examine whether specific training methods are superior for older adults' acquisition of new technological skills. The objective of the present study was to examine the acquisition of word processing skills by older women in relation to training and practice conditions. In addition, the effects of practice and the relationship between various cognitive and background measures on the development of word processing skills were investigated.

Current trends in computer use by older adults

The demographic data of computer users have changed dramatically over the last decade. For example, in 1988, Schwartz (cited in Jay & Willis, 1992) estimated that in the United States, only 1% of persons aged 65 and older used a computer as compared with 9.5% of those aged 55-64 years, and 17.5% of those aged 45-54. The Canadian General Social Survey (GSS; 1989) indicated that only 6% of individuals over the age of 65 were able to use a computer, 5% reported having any formal computer training, and 3% stated that they had a computer in their home. In contrast, 22% of Canadians aged 55-64, 38% of Canadians aged 45-54, and 66% of Canadians aged 20-24 reported that they were able to use a computer (Lowe, 1990).

More recent demographic data present a radically different picture. According to Statistics Canada (1995), 24.4% of households in the 55-64 grouping indicated that they have a computer compared to the overall figure of 28.8% for all Canadian households. The 1994 version of the GSS survey reported that 36% of adults between 55 and 64, and 10% of adults over the age of 65 know how to use a computer (Frank, 1994). According to another recent American survey of 600 randomly-sampled seniors and 100 self-identified computer users, overall computer ownership among adults 55 to 75 is 29%, up from 21% in July 1994, representing an 8% increase in computer ownership in just 16 months (Adler, 1996). According to the Consumer Technology Survey, the largest survey of personal computer usage in the United States, between 1993 and 1995, computer purchases by adults between the ages of 50 and 59 grew by 36%, and it grew by 28% for those over the age of 60, indicating that more older adults now have a computer in their homes (CTI Survey, 1996). Education is a factor in computer ownership, with 53% of surveyed adults with a college degree indicating that they have a computer, as compared to 22% who reported some college and 7% with a high school diploma or less. Adults over the age of 55 make up the fastest growing sector of computer purchasers, accounting for 36% of all personal computers purchased in 1993 (Fisker, 1996). In fact, seniors spend more time during an average week ($\underline{M}$ = 12 hours per week) working on a personal computer in the home than individuals of any other age group (Fisker, 1996).

Older adults can benefit from computer technology in many of the same ways that younger adults benefit from this technology. It has been suggested that computers may add to older adults' quality of life (Czaja, 1988), work as memory aids (Morris, 1994; see Leirer, Morrow, Tanke, & Pariante, 1991 for the use of computers to improve elders' adherence to medication), and increase older adults' potential for socialization through the Internet, chat groups, or via digital video systems (Furlong, 1989; for a discussion of how these technologies can benefit older adults see Lawhorn, Ennis, & Lawhorn, 1996). In the case of older adults who have mobility problems and are restricted to their immediate environments, computers can provide an additional medium by which they can interact with the world. For example, computers can be used to help people with their banking, and to purchase groceries. In this type of system, one telephones a shopping network, selects a category of goods (e.g., canned vegetables) and, with the use of a mouse, searches for a specific product. The purchaser then views a picture of the item, receives additional information and the prices of the various brands available, and clicks on a button to add the item to his/her virtual 'grocery cart'. The item is then delivered to the individual by a mail delivery service.

As computers becomes even more prevalent in society, and as more activities are carried out by computers, computer literacy will be even more essential. Many activities that were once done manually now require the use of a computer. For example, bank machines, public library catalogue systems, and many home appliances are now computerized. This trend toward computerization will increase as the technology becomes less expensive to the consumer, and as more applications are produced. With data showing that people over the age of 65 now have more discretionary income than any other group (Dychtwald & Flower, in Ogozalek, 1991), it is quite possible that older adults will become the biggest technology consumers in the near future. It is also suggested that within a few years, prevalence of computer ownership and use among older adults will be identical to that of the general population (Adler, 1996). These data indicate that although older adults may not be the earliest adopters of such new technologies as computers, as the technology becomes more mature, they are willing to make use of it.

The effects of age on learning to use a computer

Early studies which examined older adults' abilities to use computers focussed mainly on teaching them how to play computer games. For example, Danowski and Sacks (1980) and Krauss, Florini and Bellos (1985) found that playing computer games led to more positive attitudes toward computers and increased self-esteem. Weisman (1983) taught nursing home residents to play computer games and found that participants were able to focus their attention and concentration on the computer and they benefited from their feelings of mastery over it. In a similar study, Hollander and Plummer's (1986) participants reported that they were most interested in software that made them think, and two thirds of the participants indicated that they were interested in being exposed to more innovative and challenging applications. Older adults quickly began to explore a wide range of computer activities, however the human-computer interaction researchers who study how older adults learn to use a computer were slow to respond to this trend.

Age as an individual difference variable predicting success at using a computer has only recently become a major focus of attention. Although it is possible to draw general conclusions from these studies, it is difficult to make direct comparisons between them because there is little consistency with respect to the software trained, the training methods used, and the method by which performance, errors, and time are measured. Appendix A lists the studies in which older adults were trained to use a computer, their respective sample sizes, the software trained, the number and average time per training session, and a brief description of the instructional material used.

Appendix B provides a summary of results of the research in which age was specifically examined. The following conclusions emerge from these studies: (a) older adults require significantly more time than younger adults to learn how to use a computer, to read the manuals, and to complete the practice exercises (Charness, Schumann, & Boritz, 1992, Experiments 1 & 2; Czaja, Hammond, Blascovich, & Swede, 1986, 1989; Czaja & Sharit, 1993; Echt & Morrell, 1995; Elias, Elias, Robbins, & Gage, 1987; Gomez, Egan, Wheeler, Sharma, & Gruchacz, 1983; Gomez, Egan, & Bowers, 1986, Experiments 1 & 2; Hartley & Hartley, 1988; Hartley, Hartley, & Johnson, 1984; Kelley, 1993; Kelly, Charness, Mottram, & Bosman., 1994; Kurzman & Arbuckle, 1994; Zandri & Charness, 1989); (b) older adults make significantly more errors during training, on multiple choice tests of trained material, and on performance evaluations after the training (Charness, et al., 1992, Experiments 1 & 2; Czaja et al., 1986, 1989; Czaja & Sharit, 1993; Echt & Morrell, 1995; Gomez et al., 1986, Experiments 1 & 2; Kelley, 1993; Kelly et al., 1994; Kurzman & Arbuckle, 1994); and (c) older adults ask more questions, and require more help when learning to use the computer (Charness, et al., 1992, Experiment 1; Echt & Morrell, 1995; Elias, et al., 1987; Hartley & Hartley, 1988; Hartley et al., 1984; Zandri & Charness, 1989). In fact, it has been suggested (Charness et al., 1992; Elias et al., 1987; Zandri & Charness, 1989) that older adults are between 1.2 and 2.5 times slower in acquiring word processing skills than younger adults.

The research generally reveals clear differences between younger and older adults in learning and using a computer. These effects have been found for a large variety of software tools including line editors, full screen text editors, word processors, spreadsheets, and graphics software. In addition, it should be noted that these conclusions generally remain similar across different training methods and performance measures. In contrast, the few studies which have yielded findings of no age differences in the acquisition of computer skills tended to include unusual methodology (Gomez et al., 1983; Gomez et al., 1986; Hartley & Hartley, 1988; Ogozalek & Von Praag, 1986), restricted age ranges (Garfein, Schaie, & Willis, 1988 a, b; Webster & Martocchio, 1993), or a very short quiz as a measure of learning (Ralls & Klein, 1992; Webster & Martocchio, 1993).

Garfein et al. (1988a, b), in a sample of novice middle-aged and older adults, aged 49 to 67 years, found that age was not associated with the ability to learn a spreadsheet application in the entire sample, or when the sample was divided into the most and least proficient participants. However, it is quite possible that the absence of a negative age effect for training performance was an artifact of the restricted age range. This restriction may have masked any age-related findings that would have been observed if a young control group was used (Salthouse, 1991). Furthermore, the authors used an ANOVA model to create dichotomous groups based on age; adults between the ages of 49 and 57 formed the middle-aged group, and adults between the ages of 58 and 69 formed the older group. If rather than use this arbitrary division, which could result in a loss of too much of the age-related data, they had kept age as a continuous variable and used regression techniques, it is possible that a trend toward an age effect may have arisen. Such an age trend was found by Kurzman and Arbuckle (1994) who also used a restricted age group. Webster and Martocchio (1993) also reported no age differences in a sample of 68 adults

(M = 41.3, SD = 11.6 years[1]) on a short multiple choice quiz that assessed training on the mail-merge feature of a word processor. In addition to the restricted age, the outcome measure consisted only of a 10-item multiple choice quiz, which may not have been sensitive enough to capture age-related changes. In the Ralls and Klein (1992) study, individuals who were trained in a classroom setting, either learned the fundamentals of the Disk Operating System (DOS; M = 41.90 years, SD = 10.69) or basic commands procedures for using a spreadsheet (M = 40.59 years, SD = 10.28). On a 12-item multiple choice quiz, they found a negative age effect for individuals in the spreadsheet condition, but no age effect in the DOS condition. The authors attributed this difference to the fact that individuals in the DOS condition received general computer information in a lecture format, whereas individuals in the spreadsheet condition were provided with hands-on training. Furthermore, the outcome variables did not include any hands-on performance tests, but was based on the short multiple choice quiz.

In a series of studies, Gomez et al. (1983; see also Gomez et al., 1986) reported inconsistent findings with respect to age in participants learning to use a line editor or screen editor. Their findings may be due, in part, to the outcome measures which they used. Although they included a single measure of accuracy (first-try errors), performance was generally measured as a function of speed (e.g., time spent reading the manuals and execution time per successful change) which are not measures of actual text editing, rather they measure one's performance when "they are preparing to solve editing problems" (Gomez

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1 The authors do not report the age range of their participants.

et al., 1983, p. 179). They reported that (a) age was significantly correlated to first try errors with older adults making more of these types of errors; (b) older adults required more time than younger adults to execute the commands which they had learned; (c) age was not correlated to the amount of time subjects spent reading the manuals which is consistent to previous research in which older adults do not read multiple-sentence text any more slowly than do younger adults during self-paced learning (Hartley, 1986, 1993, 1994; Meyer, Talbot, Puskar, Stubblefield, & Poon, 1996); and (d) older adults required more time than younger adults to execute the commands on a line editor, than on a screen editor which is consistent with previous research that showed that a line editor is more difficult to use than a screen editor (Gomez et al., 1983). Overall, these results are not surprising since the magnitude of age differences increases as a function of the difficulty or complexity of a task, and that increasingly complex tasks, in general, results in increasing reaction times for older individuals (Cerella, 1990; Cerella, Poon, & Williams, 1980; Salthouse, 1991).

Hartley and Hartley (1988) found no age related effects on the accuracy or efficiency with which editing operations were carried out. In fact, they stated that although older adults worked more slowly and completed fewer tasks in the allotted time, they acquired the information at the same rate as younger adults. This study differs from the others listed in Appendix B in that performance was based on a written recall of what the subjects had learned during the course of training. Similarly, Ogozalek and Von Praag (1986) reported no differences between younger and older adults in a study which examined age and method of computer input (standard keyboard versus simulated voice-recognition system). In this study, adults with at least 6 months of computer experience were asked to type or compose a letter. Performance was measured in terms of effectiveness of the letters, time to compose the letters, and grammatical errors. These performance measures, however, did not assess the ability to actually *use* the system and differ significantly from those traditionally used to measure performance.

Thus, the research shows that studies that have included a hands-on, accuracy-based, performance test have consistently yielded age effects in the acquisition of computer skills. These age effects are in keeping with those observed from the non-computer training literature in which younger and older adults learned new skills (e.g., Charness & Campbell, 1988; Kliegl, Smith, & Baltes, 1989; see also special section on training in later adulthood, Developmental Psychology, 26, 1990). In these studies, older adults required more time, asked for more help, made more errors, and performed at lower levels than younger adults who received the same amount of practice. Furthermore, although older adults' performance may be inferior to that of younger adults initially, it is possible that with additional practice the age effects may diminish. For example, Kelley, Charness, Mottram and Bosman (1994) examined how younger and older experienced computer users learned to use novel software. They demonstrated that prior computer experience enabled older adults to transfer their general knowledge about computers to learn to use new software, with results comparable to those achieved by younger computer users who had similar amounts of previous computer experience. In addition, when Czaja and Sharit (1993) controlled for amount of previous computer experience, although they still obtained an age effect on performance, this effect was drastically reduced. Sit (1996) in a study that examined how older adults used on-line library catalogue systems, concluded that experience, rather than age, was the critical determinant of search success.

Individual differences in computer literacy acquisition

There is a growing body of literature which has been examining the relationship between the acquisition of computer skills and individual differences in specific cognitive abilities and psychosocial dimensions. Spatial ability seems to be among the more important individual difference variables as this ability has generally been shown to be a significant predictor of performance on computer applications (Echt & Morrell, 1995; Garfein et al., 1988; Gomez et al., 1983, 1986; Kurzman & Arbuckle, 1994; Sein & Bostrom, 1989). Greater success in learning to use computers has also been shown to be associated with such verbal abilities as reading ability and text comprehension (Echt & Morrell, 1995; Gomez et al., 1983, 1986; Hartley & Hartley, 1988; Sebrechts, Deck, Wagner, & Black, 1984; Sein & Bostrom, 1989), vocabulary skills (Hartley & Hartley, 1988; Kurzman & Arbuckle, 1994), and verbal working memory (Echt & Morrell, 1995). In addition, inductive reasoning (Egan, 1988; Garfein et al., 1988a; Ralls & Klein, 1992) and logical reasoning (Gomez et al., 1983) seem to be important when learning computer skills. Psychomotor speed (Kelley et al., 1994; Kurzman & Arbuckle, 1995), and typing ability (Czaja et al., 1989; Gomez et al., 1983, 1986) have also been shown to be associated with better performance on tests of computer learning. Such psychosocial factors as learning style (Sein & Bostrom, 1989; Sein & Robey, 1991) and self-efficacy (Gallo, 1986; Ralls & Klein, 1992; Rosen, Sears, & Weil, 1987) have also proved to be significant predictors of success in learning how to use a computer. Appendix C presents the general findings of the studies which examined the relationship between various individual difference measures and learning to use a computer.

It is possible, however, that these relationships depend in part on the technology and interface used. For example, the observed relationships between the various individual difference variables and performance differed for a line editor, screen editor, and modern word processors, all of which are used to edit text. Furthermore, the method by which performance is measured (e.g., accuracy vs. time to completion) and the types of statistical analyses used can lead to different conclusions about relationships between individual difference variables and the acquisition of computer skills. For example, whereas many studies have demonstrated the importance of spatial abilities to learning to use a computer, Kelley et al. (1994; see also Sebrechts et al., 1984) using multiple regression, found that age, amount of computer experience (novice vs. experienced users), and a measure of perceptual speed (Digit-Symbol; CARNET version) were the best predictors of performance, errors, and time on a post-training exercise. Vocabulary scores and age were the best predictors of performance on a 40-item multiple choice quiz. In contrast, working memory and spatial abilities did not predict performance on a word processor or on the multiple choice quiz. They offered two suggestions to these findings. First, they stated that the measures they used to assess these abilities may not have been appropriate for their study. For example, the working memory measure was highly correlated with perceptual speed ($\underline{r}$ = .49), leaving little unique variance available to find a relationship. Second, unlike earlier studies in which line editors, or now-obsolete screen editors, were used they suggest that current word processing software may not place excessive stress on working memory and spatial abilities.

In contrast, Kurzman and Arbuckle (1994, 1995) used the same training materials as those used by Kelley et al. (1994) but administered a different battery of tests. The test battery included measures of perceptual speed, visuospatial ability, vocabulary, typing speed, text comprehension, and psychomotor speed. Kurzman and Arbuckle (1994, 1995) found age, spatial ability, and vocabulary scores significantly predicted accuracy on a post-training computer exercise and performance on a multiple choice quiz. None of the ability measures significantly predicted the number of errors made, requests for help, or time to complete the training, although age did predict the number of errors produced and the time required to complete the training. In support of the results found by Kelley et al. (1994), when age was partialled out, Kurzman and Arbuckle (1995) did find significant correlations, between perceptual speed and both accuracy (r = .47) and requests for help (r = -.66).

Hartley and Hartley (1988), controlled for age and identified reading comprehension as the best predictor of computer performance, items attempted, and efficiency (the number of operations per task divided by the actual number of operations). In addition, vocabulary and reading span showed significant correlations with the efficiency and items attempted measures. These results are not surprising given that one must be able to read and comprehend the manual or computer screen in order to learn how to use the software.

Echt and Morrell (1995) found that the relationship between specific abilities and performance changed as a function of training method. They examined whether interactive computer-based training would result in better performance than a written manual. They reported that spatial and verbal memory measures were significantly correlated with performance errors and interventions; however, the relationship was stronger for the computer-based training than for text-based training. Using a regression design in which age was entered first, followed by the cognitive variables, Echt and Morrel found that after entering age, a measure of spatial memory significantly predicted performance errors only for the computer-based training, and that text comprehension significantly predicted performance errors only for the text-based training. They concluded that the cognitive variables they examined played a greater role for the interactive computer training than for the text-based training.

With regard to psychosocial variables, Gist, Rosen, and Schwoerer (1988; see also Gist, Schwoerer, & Rosen, 1989) found that computer self-efficacy was significantly correlated with performance regardless of the type of training provided, with those participants with higher computer self-efficacy scores outperforming those with moderate or low scores. It had been suggested (e.g., Zuboff, 1988) that novices who tend to think abstractly are better able to construct an accurate mental model of a target system compared to those who tend have a concrete style of thinking and learning. Sein and Bostrom (1989) demonstrated the importance of one's preferred learning style on training in students who were trained to use an electronic mail filing system. Results from near and far transfer tasks supported this hypothesis. On transfer tasks that share few features to the training tasks (far transfer), abstract learners performed significantly better than concrete learners. A similar trend was found on tasks that were very similar to the ones performed during training (near transfer), and for a software comprehension test. In a follow-up study, Sein and Robey (1991) examined the relationship between training methods and learning style in a sample of novice undergraduate computer users learning to use a mainframe mailing system. They observed that Convergers and Assimilators, or those who prefer to combine active experimentation with abstract conceptualization, performed better when provided with an abstract model (i.e., a schematic diagram) than when given an analogical model (the mailing system was depicted as a filing system). The pattern was reversed for the Accommodator and Diverger groups, who prefered concrete experience. These studies therefore suggest that performance in using a computer application may be affected by the preferred style of learning, and that performance could be enhanced when the approach to training matches a person's learning style. These findings indicate that one's learning style is an important individual difference variable that should be examined further.

There are many other individual difference variables which have not yet been studied in the context of computer training but would be expected to be important predictors of success at learning how to use a computer. These include, for example, the ability to remember new verbal or visual information, solve problems, and focus attention. The following section examines how one's pre-training attitude towards computers predicts how the person performs during, and following, training.

Attitudes Towards Computers

The literature on attitudes towards computers is mixed. Lack of familiarity or experience with computers has generally been provided as the main reason why individuals have negative attitudes towards them. In addition, it is often assumed that older adults do not want to use computers and are afraid of them (Stagner, 1985). It has long been suggested that older adults are 'technophobic' (fear new technologies), and more specifically computer phobic. This stereotype is supported by the high technology industry which gears the software and hardware with children, teenagers, or young to middle-aged adults in mind (Zimmer & Chappell, 1993). In fact, most system designers still assume that older adults fear such new technologies as computers, or have limited opportunities to interact with them and thereby fail to consider older adults as a potential user group in the design process (Czaja, 1996). Brickfield (1984) found evidence to support this stereotypic view. In a sample of 750 adults over the age of 45, he reported that older adults who had never used a computer had less positive attitudes and were unlikely to incorporate computers into their personal lives. Krauss and Hoyer (1984) reported that, for both younger and older adults, experience with computers leads to more positive attitudes and that older adults reported fewer contacts with computers than younger adults. Using the same 10-item questionnaire as Krauss and Hoyer (1984), Meyer et al. (1996) found dramatic increases in recent years in the amount of contact with computers by both groups of adults, although the difference between them was still there.

Whether attitudes towards computers are directly related to contact with them is not yet clear. Arndt, Feltes and Hanak (1983) found, in a sample of 241 secretaries, that those secretaries who had never used a word processor were significantly more anxious about computers than secretaries who had previously used one. In contrast, according to Marcoulides' studies (e.g., Marcoulides, 1988, 1989, 1991; Marcoulides & Wang, 1990; see also Rosen et al., 1987; Weil, Rosen, & Wugalter, 1990) negative attitudes and anxiety about computers may be present regardless of prior computer exposure. It seems that the manner in which individuals perceive computers, and the manner in which computers are presented, are critical to the development of positive feelings towards them. One's attitude towards computers, however, probably does not directly affect one's ability to learn how to use them, rather it most likely affects one's motivation to learn. If individuals are not motivated, or feel that computers are not relevant to them, they will not be stimulated to learn. It is therefore reasonable to assume that attitude scales will be at least somewhat predictive of success at learning to use a computer. Equally, if a person does not know the potential benefits of computers then one's initial attitude need not be related to performance because discovery of the benefits may enhance motivation.

Overall, positive attitudes towards computers appear to be positively correlated with employment status, education level, amount of previous exposure, and one's general willingness to use computers and/or related technologies (Kerschner & Hart, 1984; Krauss & Hoyer, 1984). These findings have been consistently reported in students (Arndt, Clevenger, & Meiskey, 1985) and adults in the workplace (Arndt et al., 1983; Gattiker & Hlavka, 1992; Zoltan & Chapanis, 1982).

Attitude change as a function of training

The studies which have examined changes in attitudes over the course of training have yielded mixed results. Morris (1994, cited in Baldi, in press) found that exposure to computers resulted in positive attitude change in older adults. He trained his subjects to use publishing and spreadsheet software and found significant changes in attitudes over time. Specifically, after training, participants rated computer terminology as less confusing, their beliefs that computers would cause people to lose their jobs or rely on them too much were reduced, and they felt less apprehensive about using them in the future. In addition, Danowski and Sacks (1980) provided nursing home residents, who had never used a computer, the opportunity to interact with one. Those participants who reported positive ratings for their experience with the computer, also indicated more positive attitudes towards computers.

Other researchers, however reported no attitude change with computer use (e.g., Ansley & Erber, 1988; Czaja et al., 1986). Ansley and Erber (1988) suggested that single-session or short-term interaction opportunities may not be sufficient to induce attitude change. Danowski and Sacks (1980), for example, provided their participants with access to computers over a three week period, while Ansley and Erber (1988) provided subjects with only 10-minutes of exposure to a computer, and Czaja et al.'s (1986) study took place over the course of a single day. Jay and Willis (1992) also suggest that these mixed results may be due to the type of intervention (i.e., type of computer exposure, type of software trained) and to the attitude measure used. For example, Danowski and Sacks (1980) trained participants to use an interactive messaging system and to play games which the users may have found more interesting, fun, or relevant than the software taught by other researchers.

The effects of different training methods on computer attitudes, including the provision of support materials, self versus experimenter paced learning, and learning alone or with others, have also yielded mixed findings (e.g., Charness et al., 1992, Experiments 1 & 2; Czaja, 1989; Harrington, 1988; Harrington, McElroy, & Morrow, 1990; Jackson, Vollmer, & Stuurman, 1985; Martocchio, 1992; Zandri & Charness, 1989). Czaja (1989), for example, found no significant change in attitudes over the course of her study, no difference between age groups, and no effect of training condition on attitudes. Harrington et al. (1990; see also Harrington, 1988) found no differences in post-training anxiety between subjects who were taught to use a word processor using a lecture format and those who were taught through a written manual. In contrast, Martocchio (1992) demonstrated that trainees who had a manual that included positive (e.g, "working on computers is like playing a game"), controllable (e.g., "computers allow you to work more at your own pace"), and gain ("using computers provides greater job opportunities") aspects of microcomputer usage, reported less computer anxiety and performed better on a 10-item multiple choice quiz than those participants who were trained with a neutral manual. Jackson et al. (1985) reported that the performance of individuals with more negative attitudes prior to training became even lower over time when the text editor being taught was difficult to use. However, when the editor being taught was easier to use, attitudes were unrelated to performance.

Charness et al. (1992; Experiment 1) found no relationship between computer anxiety and training condition (advance organizer vs. no organizer) or age, but there was a significant decrease in computer anxiety following completion of the sessions. In Experiment 2, however, Charness et al. (1992) demonstrated that whereas young adults showed less anxiety in the self-paced condition, older adults showed less anxiety in the fixed-paced condition. In the Zandri and Charness (1989) study, post-training attitudes increased for all groups of subjects except for older adults who learned alone and who did not receive a pre-study jargon sheet. They concluded that the social support provided by partnering and the confidence fostered by the jargon sheet resulted in favourable attitudes towards computers. In contrast, Kurzman and Arbuckle (1995) found no difference in attitudes towards computers in older adults who were trained individually or in pairs, although they did demonstrate that attitudes for all participants improved over the course of the three days of training.

Relationship of attitudes to performance

In general, studies with both younger and older participants which have examined the relationships between pre-training attitudes and performance have yielded contradictory findings. Several studies have shown that negative attitudes or heightened computer anxiety are related to lower accuracy scores (Kurzman & Arbuckle, 1994; Zandri & Charness, 1989), greater number of errors during performance (Czaja et al., 1989; Paxton & Turner, 1984), increased times to complete computer tasks (Paxton & Turner, 1984; Zandri & Charness, 1989), and more questions asked during training sessions (Harrington et al., 1990; Zandri & Charness, 1989). In contrast, Gomez et al. (1986; Experiment 1) found that although older adults had less favourable attitudes towards computers, attitudes did not correlate reliably with any performance measure. However, in Experiment 2, Gomez et al. used an extended version of their attitudes questionnaire from their first experiment and found that people with more positive attitudes towards computers required *more* time to execute a command. Charness et al. (1992) found significant but weak correlations between anxiety and performance in Experiment 2 but no such effect in Experiment 1. Charness et al. (1992), Gomez et al. (1986; Experiment 2) and Kurzman and Arbuckle (1995) observed no relationship between computer attitudes and requests for help. With respect to the relationship between attitudes and errors on computer tasks, no relationship was observed by Gomez et al. (1986), Ansley and Erber (1988), Harrington et al. (1990), Jackson et al. (1985), and Kurzman and Arbuckle (1994).

Attitudes Towards Computers: Exploring the inconsistencies

There are numerous possible reasons for the inconsistencies described above. First, all of the older participants who participated in these studies were volunteers who wanted to learn how to use a computer. It is likely that volunteers would have a generally positive attitude towards computers, and that, in consequence, the range of attitudes in the sample would be restricted. Restriction of range can lead to an underestimate of the true relationships among attitudes, anxiety, and performance. The restricted range also can make it difficult to observe statistically significant changes in means over time. Second, the measurement instruments used to assess attitudes and anxiety towards computers differ greatly across studies, and the reliability and validity of the attitude measures are rarely reported or have not been adequately assessed (e.g., Ansley & Erber, 1988; Czaja et al., 1986, Danowski & Sacks, 1980), thereby making it difficult to fully evaluate the findings from the studies. Third, given the extent to which computer technology and its applications have been changing over the years, the dimensions of attitudes and anxiety towards computers must be constantly reexamined. Any reliability or factor analytic study of a measure grows quickly obsolete, because computers themselves have experienced rapid change, and because people's understanding and appreciation of computers have also been changing. For example, in a questionnaire devised by Zoltan and Chapanis (1982), many questions appear to be dated. Such questions as "proficiency in computer work requires mastering a special computer language" and "the computer's capacity for artificial intelligence is frightening" demonstrate how the technology has advanced in just the last decade. Lee's (1970) study on attitudes towards computers did not even ask about computers, rather about “electronic brain machines”. Fourth, many researchers assume that attitude scales tap a single unidimensional structure. Research focussing on younger adults have found that multiple dimensions underlie computer attitudes, including such factors as interest, comfort, and dehumanization (Richards, Johnson, & Johnson, 1986; see also Arndt et al., 1985; Igbaria & Parasuraman, 1991), yet many of the computer training studies in the literature have failed to use measures that contain these dimensions.

Jay and Willis (1992) reviewed the computer attitudes literature on students and adults and created, based on confirmatory factor analyses, a 35-item, 7-dimension, attitudes-towards-computers questionnaire geared towards the elderly. They demonstrated, in a sample of 101 older adults that with training, significant attitude change in the positive direction was observed for 5 of the 7 dimensions, namely, computer comfort, efficacy, gender equality, interest and dehumanization. Training consisted of a supervised, lecture-format in which participants learned how to use a simple graphics package (Printshop). The attitudes were assessed prior to training, immediately following the final training session, and 2 weeks after the participant's completion of the study. The significant positive changes in attitudes took place between the first and second administration of the measure, with no difference between the second administration and the 2-week delayed administration, suggesting that the positive changes were the result of direct computer experience, and that these changes remained stable for at least a 2-week period. Kurzman and Arbuckle (1994) used the Jay and Willis measure and demonstrated more positive attitudes both for individuals trained alone or in pairs, in the comfort and efficacy dimensions after participants learned to use a word processor during a 3 day training study. Furthermore, Morrell, Park, Mayhorn, and Echt (1996) used a modified version of the Jay and Willis measure in two training studies. In both studies, the participants reported more positive feelings of self-efficacy using computers, noted more interest in their use, felt that they were less dehumanizing, and were more comfortable using them after completing the training.

Training Methods

Age by Training Interactions

A number of studies have been conducted in which different types of training methods have been used to teach novice older adults to use a computer (Caplan & Schooler, 1990a; Charness et al., 1992, Experiments 1 & 2; Czaja et al., 1986, 1989; Echt & Morrell, 1995; Gist et al., 1988, 1989; Gomez et al., 1983; Gomez et al., 1986, Experiment 2; Kelley, 1993; Kelley et al., 1994; Kurzman & Arbuckle, 1995; Martocchio, 1992, Experiment 2; Ogozalek & Von Praag, 1986; Webster & Martocchio, 1993; Zandri & Charness, 1989). The goal of these studies has been to isolate a technique that fits the learning needs of older adults. Appendix D provides a summary of the research in which different training modalities were examined, including the conclusions from these studies. The research suggests that there is little reason to suspect that specific methods of training are more suitable for older adults. Except for three studies (Caplan & Schooler, 1990a; Webster & Martocchio, 1993; Zandri & Charness, 1990), the research has failed to demonstrate any Age x Training methods interaction, suggesting that there is no *optimal* method for older adults, rather methods that are beneficial for younger adults are also beneficial for older adults. As expected, the research generally shows that older adults have a harder time learning how to use a computer than do younger adults. Morrel and Echt (1996) proposed that the general failure to find Age x Training methods interactions may be due to a selection bias; the participants in the computer training studies are volunteers who are generally in good health, are educated, and most likely have high levels of cognitive functioning. Thus, there is little cognitive decline to be mediated by the different training methods. They speculate that if older adults (i.e., older than 75 years) were examined, there is a greater likelihood that Age x Training method interactions would be observed.

Two of the three studies (Caplan & Schooler, 1990a; Webster & Martocchio, 1993) that found Age x Training Method interactions used methodology that differed from those used in the other training studies. Caplan and Schooler (1990a) examined whether using an analogical model, which involves identifying a novel domain by explicitly comparing it to a familiar one, enhances performance of younger and older adults when learning to use a computer. They hypothesized that such a model would encourage people to encode learning experiences in terms of rules and concepts, while the absence of a model would encourage people to encode their experiences as individual problems and solutions (Caplan & Schooler, 1990b). They trained their participants in the use of a simple graphics program and provided a model to half the subjects. The model was established by providing participants with a picture of a desktop with containers of the program's 'tools' which were labelled accordingly. The picture was accompanied by the printed sentence "You can think of the tools you will learn on the Macintosh as tools you might find on your desk". They found an Age x Training method interaction in which older adults performed significantly worse than younger adults in the analogical model condition but no age differences were observed when no model was provided. The authors suggest that older adults have greater difficulty than younger adults using elaborative strategies to learn new material. Their performance measure, however, was a flexibility test in which the subjects were required to solve, on the computer, each of three problems in 8 different ways.

This type of measure does not adequately measure the efficacy of the training condition as it is based on one's ability to be flexible. It is quite possible that the use of an analogical model created a mental set for older adults, which in turn may have hindered their ability to perform successfully of a measure of flexibility. Previous research has demonstrated a progressive age-related decline in performance on standardized tests of mental flexibility, hypothesis generation, and conceptualization (e.g., Axelrod & Henry, 1992; Fristoe, Salthouse, & Woodard, 1997, see Lezak, 1995 for a discussion of age-related changes to frontal lobe functions). However, further research would be required to test the hypothesis that the creation of a mental set would in turn negatively affect older adult's ability to perform tests of mental flexibility.

Webster and Martocchio (1993) trained individuals to use the mail merge feature of a word processor. Individuals received training that was either labelled as play and included terms associated with playfulness and with having fun, or training that included terms associated with work. Although they observed no main effect for age, they found an Age x Training method interaction. The authors used the American ADEA (Age Discrimination in Employment Act) definition of an older employee which defines an older employee as a person over the age of 40. They found that younger individuals (i.e., under 40 years of age) scored higher on a multiple choice quiz in the play condition than older individuals (over the age of 40 years) but no differences were observed between individuals in the work condition. Although the authors do not elaborate on the reasons for this finding, they suggest that labelling training as play may have positive effects only for younger adults because "older adults have more years of work experience than younger adults and may see less ambiguity in their jobs" (p. 138).

Zandri and Charness (1990) trained subjects individually or in pairs and provided half the subjects in both groups with a jargon sheet 3 days before the first training session. The jargon sheet included information about the computer system, and computer terminology. It was based on a suggestion by Elias et al. (1987) who had proposed that it would be helpful to provide take home information when teaching word processing. With respect to the percentage of tasks correctly completed, Zandri and Charness found a significant Age x Jargon interaction, as well as a significant three way Age x Jargon x Group Size interaction. For older adults, having the jargon sheet in advance of training resulted in better performance for individuals working alone ($\underline{M}$ = 94.7% vs. 85.6% correct responses; jargon vs. no jargon, respectively), but did not make any difference for those who worked in pairs ($\underline{M}$ = 87.3%, 91.3%). For young adults, having the jargon sheet resulted in worse performance for those working alone ($\underline{M}$ = 80.8%, 99.3%), but not for those who worked in pairs ($\underline{M}$ = 100%, 98.0%). These interactions, however, must be interpreted with caution given the small and unequal sample sizes within the cells. Kurzman and Arbuckle (1995) examined performance in participants who were trained either alone or in pairs and found no effect of training group size on a subsequent performance evaluation task in which each participant was tested alone. They concluded that although individuals who were trained in pairs took more time and made more errors than those trained alone, their final performance level was similar to those who were trained alone. These findings were consistent with those obtained in younger adults (e.g., Carrier & Sales, 1987).

Elements of Successful Training

Research has consistently demonstrated that passive learning conditions are inferior to active learning conditions (e.g., Czaja, 1996; Czaja et al., 1986, 1989, 1993; Frese et al., 1988; Gist et al., 1988, 1989; Harrington, 1988; Harrington et al., 1990; see Deck & Sebrechts, 1984 for a discussion of forms of active learning). On-line tutorials, which are computer-based self-paced learning tools that use a simulation of the software as a form of training, can be described as a passive learning tool. Czaja et al. (1986, 1989, 1993) hypothesized that trainees passively follow along with the exercise without developing any real understanding of the operation of the computer system. Similar results have been obtained when trainees are given a manual to read but are unable to practice while reading the manual (Charney & Reder, 1986). Meyer et al. (1996), in a study on reading strategies of younger and older adults, examined different modes of presenting text to their participants. They demonstrated that, whereas younger adults are as comfortable when reading text from either a manual or a computer screen, older adults prefer to read from printed text. In addition, when reading from a computer screen, both younger and older adults prefer self-paced reading of information.

The most successful training programs elicit active participation on the part of the trainee by incorporating problem solving exercises (Czaja, 1996; Czaja et al., 1986, 1989, 1993; Gist et al., 1988, 1989; Harrington et al., 1990). This technique, which is known as the 'Discovery Method', has been found to be superior to other training methods in studies that did not involve computers. Discovery learning is typically characterized by having features such as self-paced learning, active participation, rapid feedback, reduced emphasis on verbal instruction, and the omission of irrelevant information (Belbin, 1965; Belbin, 1969). Self-paced learning is an important consideration for older adults who tend to learn more slowly and need more trials than younger adults in order to retain the material which they are learning (e.g., Charness et al., 1992). One feature of the discovery method is that the task to be learned is usually divided into smaller meaningful problems. The trainee then learns how to complete a task by successfully mastering each of the smaller problems. The advantage of discovery learning is that it gets trainees to understand what they are doing rather than having them simply memorize sequences of responses. Each new step builds on what has already been learned, so that trainees can use what they already know to help them master new material. The use of small steps reduces the memory demands of the task. This is an important consideration for older adults, who tend to remember new material less readily than do younger adults. In addition, adults of any age tend to perform better when training techniques emphasize meaningfulness rather than memorization.

Another feature of the Discovery Method is that because the trainee is supposed to be learning on his/her own, assistance and elaboration are only provided to trainees as required. Pridemore and Klein (1991) demonstrated that individuals who are provided with feedback that includes elaboration perform better than those who are simply told whether or not they are correctly completing the task. In addition, Martocchio and Webster (1992) demonstrated that positive feedback results in higher test performance than negative feedback in adults who were trained to use a word processor.

In the computer training literature, those studies which demonstrated the most success used training materials that supported active learning. The training manuals are referred to as Minimal Manuals and are based on the suggestions of Carroll, Smith-Kerker, Ford, & Mazur-Rimetz (1987; see also Carroll, 1990). These manuals are oriented towards user goals and, consistent with the Discovery Method, are designed so as to enable recognition of, and recovery from, errors (Frese, Brodbeck, Heinbokel, Mooser, Schleiffenbaum, & Thiemann, 1991). The manuals expose the trainee to a wide range of possible commands and encourage the understanding of the general procedures common to many tasks (Charney & Reder, 1986; Charney, Reder, & Kusbit, 1990). In addition, trainees are given the opportunity to practice on a computer while using these manuals. Because trainees have the opportunity to use the computer freely in order to learn the software, they assume an active role in the learning process. In addition, training procedures that include extensive use of the computer have been shown to reduce anxiety and to promote the idea that it is a valuable instrument (Arndt et al., 1983).

Animated Demonstrations

Computer technology is always changing. Many computers now include inexpensive sound cards and high quality video cards which allow the computer to incorporate digital quality sound and render full screen animated videos. Furthermore, many applications now include on-line animated and spoken demonstrations which show the user how to complete various tasks. In fact, the use of multimedia for educational and training purposes is increasing rapidly. Many computer users prefer to have multimedia in their educational situations, and many people believe that multimedia improves learning (Baldi, Plude, &

Schwartz, in press; Fletcher, 1989; Morrel & Echt, 1996; Ogozalek, 1994; see Kotlas, 1997 for a bibliography of the use of multimedia technologies in education). These animations are meant to be analogous to going to an expert and asking him/her to demonstrate the sequences required to perform a task (MacLachlan, 1986). Although many applications currently include these animated demonstrations, very little research has been conducted to examine whether animated instructions result in faster learning, better retention, and transfer of knowledge to similar tasks when compared to written instructions (Palmiter, Elkerton, & Baggett, 1991; Palmiter & Elkerton, 1993).

Animated demonstrations allow the trainee to see the motoric sequences necessary to complete a task. In addition, they allow the user to "experience in concrete visual terms how each procedural step contributes to the overall task goal" (Palmiter et al., 1991 p. 698). According to Palmiter at al. (1991), these demonstrations allow users to rehearse and plan visually while watching instructions. Conversely, there is the possibility that the trainees will passively watch the sequences and blindly mimic the procedures without processing or encoding them. It is suggested that multimedia demonstrations may be beneficial for older adults because they may reduce the demands on working memory (Morrel & Echt, 1996). According to Fletcher (1990), multimedia demonstrations should improve information retention because "people retain 10% of what they see, 30% of what they hear, 50% of what they see and hear, and 80% of what they see, hear, and do" (cited in Ogozalek, 1994, p. 66).

Najjar (1995, 1996a, 1997) reviewed the education literature on the effects of multimedia on learning, and reported that the results of the research are inconsistent. In his review, Najjar defined multimedia training to include one or more multiple combinations of a text manual, text with illustrations, video-based training, computer-based tutorials, animated demonstrations, and audio-based training. He concluded that: (a) multimedia information appears to be most effective for learners who have little prior knowledge in the domain being learned, (b) presentation of redundant information using simultaneous multimedia, (e.g., text with video demonstrations), produces better learning than when the same information is presented using a single medium or when the two media are separated by significant amounts of time, (c) the information presented by different media should be closely related, otherwise the information may have a negative impact on learning, (d) the information from different media should not interfere with each other, otherwise learners may focus their attention on one medium and fail to process the others, (e) improvements in learning seem to be especially strong when the multimedia includes both verbal and pictorial stimuli, (f) adding animated pictures to text appears to improve learning more than does adding static pictures, and (g) visual-verbal information (i.e., text) is learned better than auditory-verbal information (i.e., voice).

Najjar (1995, 1996a) also reported that a significant number of studies illustrate that multimedia learning may not help people to learn. He suggested that multimedia that encourages the learner to process information elaboratively may improve learning compared to multimedia that does not encourage elaborative encoding. For example, presenting new information through different modalities is likely to increase the number of ways in which it can be related to prior knowledge, and thereby make it easier to recall than information that has been presented in a single modality (e.g., Beagles-Roos & Gat, 1983; Hayes, Kelly, & Mandel, 1986; Mayer & Anderson, 1991; Paivio, 1991; Paivio & Csapo, 1973). When Najjar (1996a) re-examined the studies which failed to show that multimedia encourages learning, he discovered that many of these studies did not encourage elaborative encoding. Rather, these studies used two versions of verbal information (e.g., text and audio), or presented different information to different modalities (e.g., visual information which was different from textual, or auditory information).

In one of the few studies to examine the effects of animated multimedia demonstrations as a form of computer training in adults of any age, Palmiter et al. (1991) provided individuals with either written instructions or animated demonstrations for completing various tasks. Participants who used demonstrations performed approximately 50% faster during training than those who used text alone. However, when participants later performed the same tasks from memory, the participants who were given step-by-step instructions with a manual were quicker and more accurate than those who were trained only with animated demonstrations. They explained their findings by suggesting that whereas users exposed to written instructions encoded the material verbally, visually (i.e., they could visualize the instructions as they read them), and motorically, individuals in the animated demonstration group did not elaboratively encode the information to the same degree because the material was presented only visually and motorically. In addition, those who were trained via demonstrations appeared to mimic and passively perform the demonstrated procedures.

In a follow-up study, Palmiter and Elkerton (1993) replicated the first study and added a third condition which consisted of a combination of text-only and demonstration-only conditions. In this group, identical spoken text was provided simultaneously with the demonstrations, with the intention that the combination of modalities would minimize competition for attentional resources. Participants were trained to use a HyperCard authoring tool and the training focussed specifically on procedural information. The participants performed tasks on the computer immediately during training and again 1-week later. Overall, individuals in the demonstration groups were 16% more accurate in their performance than the text-only group immediately after training. However, one week later the demonstration groups' performance had decreased but the text-only group's performance had improved, with the result that the performance of all three groups was equivalent. In addition, whereas the text-group required significantly more time than the demonstration groups during training, the pattern was reversed one week later. These data suggest that the demonstration groups did not maintain their superior performance over time. The authors proposed that individuals in the text condition may have spent more time during training interpreting the instructions, and this additional time helped them perform more effectively later. No differences were observed between the demonstration-only and the combined demonstration and text groups. It is worth noting that the manuals used in the text condition did not include any illustrations and it is possible that the authors still failed to create a condition that minimized competition for attentional resources. The authors concluded that the addition of textual material may not be sufficient to remedy the usability problems associated with animated demonstrations, and the demonstrations may be an attention-grabbing medium that must be carefully used in combination with text.

Overall, the use of multimedia demonstration within software will continue to flourish as the cost of the technology continues to decline. In fact, it is becoming more cost effective for industry to use on-line multimedia training than it is to provide written manuals because: (a) learning takes less time when multimedia instruction is used (e.g., Kulik, Kulik, & Cohen, 1980; Kulik, Kulik, & Shwalb, 1986; Kulik & Kulik, 1991; Najjar, 1992, 1996b), (b) trainees are more inclined to complete the training because they tend to enjoy multimedia learning materials and prefer using them over conventional materials (Najjar, 1996b), and (c) multimedia instruction allows the learner to set the pace of learning, thereby providing them with the opportunity to review or move on to new material when they are ready. Few studies, however, have examined whether multimedia demonstrations as a method of training adults to use a computer yields better performance than when adults are trained with a conventional manual, and no study has yet been conducted to examine their efficacy in teaching older adults to use a computer.

Transfer of Training

A major focus within the skill acquisition literature is whether one can generalize or transfer the skills and knowledge obtained during training to other domains. Transfer is very relevant to the use of computers as the interfaces used within software change with almost every new version of the application. Most studies of the acquisition of computer skills, however, fail to examine whether users can transfer what they have learned to other commands, or to other computer applications. It is important to determine not only whether one training method is better than another for a given application, but also which methods, if any, yield better transfer. In fact, not one study has examined whether older novices learning to use a computer can transfer what they have learned during training. Kelley et al. (1994), however, in a sample of experienced older computer users who learned a novel word processor found that those individuals who used more types of computer applications made fewer errors and took less time than those participants who used fewer applications. The authors concluded that positive transfer may be a function of general knowledge about computers, rather than specific knowledge about word processors.

One's ability to transfer newly learned computer information has been shown to be affected by such factors as type of interface used (e.g., Foltz, Davies, Polson & Kieras, 1988; Polson, Bovair, & Kieras, 1987), by the method of training (e.g., Kamouri, Kamouri, & Smith, 1986), and by individual differences (e.g., Sein & Bostrom, 1989). Foltz et al. (1988) examined whether novices trained to use menus on one word processor system would be able to transfer their knowledge to a second system in which the menu structure had been altered. For example, the menu structure was modified by renaming menus with lexically equivalent commands (e.g., Delete vs. Discard), and the number of levels within the menu structure was modified such that it increased or decreased the number of steps required to complete a task. Foltz et al. (1988) found that whereas adding or deleting menu steps had no detrimental effect on performance, changes to the lexical system negatively affected performance, and required the users to learn new rules in order to use the system. Polson et al. (1987) examined whether users could transfer knowledge between text editors. In their study, subjects were trained on 5 editing commands either on a screen editor or a line editor. On the second day of the study, the participant performed the commands either on the same editor or on the second one. Overall, performance (which was based on time to complete the tasks) increased over days, but no Day x Editor interaction was observed, indicating that the participants were able to transfer what they had learned on one editor to the second one.

Kamouri et al. (1986) investigated whether training method would affect people's ability to transfer what they had learned. They examined whether there was a difference between individuals who received exploration-based versus instruction-based training, and whether this would have an effect on a transfer task. The participants in the exploration-based group learned the various devices by simply interacting with the system until they were able to complete the required tasks accurately. The instruction-based group also interacted with the computer, but were presented with a written manual during training. In the transfer task, which was administered two days later, the participants either worked on a novel application which required them to use the same procedures as those used during training (analogous condition), or they worked on a novel task for which the procedures differed from the ones they were trained on (disanalogous condition). Overall, individuals in the exploration-based training condition were able to transfer their knowledge to the analogous device and they performed significantly better than those who received similar training but were required to transfer their knowledge to a disanalogous task. The performance of individuals in the instruction-based condition was equally poor in both transfer conditions.

Sein and Bostrom (1989) determined that one's ability to transfer can be related to individual differences. For example, they demonstrated that individuals with higher spatial abilities and more abstract learning styles performed better on both near-transfer tasks (very similar to the tasks performed during training) and far-transfer tasks (tasks which require more complex sequences of commands that must be inferred).

Transfer is an important concept for the acquisition of novel skills yet it has not been adequately assessed within the computer training literature. Furthermore, transfer has not been examined for older adults learning to use a computer. It is possible that, even in the absence of Age x Training method interactions on acquisition of a computer task, training method could have an effect on one's ability to transfer the knowledge to the learning of similar tasks.

Research Questions and Hypotheses

The aim of the present study is to examine whether, in a sample of older subjects who are learning to use a word processor, there is a difference in performance between individuals trained via a conventional text manual and those trained with the addition of multimedia demonstrations. Learning to use a word processor was chosen to be the focus of this study because it is the most common activity carried out by individuals of any age when using a computer. For example, 69% of computer users (GSS, 1994), and between 84 and 89% of older users reported that they most commonly use a word processor when they used the computer (Adler, 1996; Cole, 1996; Software Publishers

Association, April 22, 1996)[2]. This study also examined the influence of extended practice, the effect of using single versus multiple methods to execute a command, the impact of individual difference variables on performance, and one's ability to transfer knowledge to a different word processor. The following is a list of the major research questions that this study strives to answer and the hypotheses related to those questions.

1. Does the addition of animated demonstrations provide any additional benefits to individuals who are learning to use a word processor over those benefits that are obtained through the use of a conventional manual?

Animated demonstrations are becoming increasingly popular as software manufacturers include them in new versions of applications. Palmiter et al. (1991, 1993) found that individuals who were given step-by-step instructions with a manual were quicker and more accurate than those who were trained only with animated demonstrations. Najjar (1996a) suggested that elaborative encoding using multimedia training facilitates one's ability to encode, and therefore, recall information. Whereas Palmiter et al. (1991) did not supply their participants in the animated demonstration group with written instructions, and individuals in the combined text and demonstration group received both forms of information simultaneously, in this study the participants were provided with written instructions which included illustrations prior to viewing the animated demonstrations. In addition, the animated demonstrations used in this study

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2 Software Publishers Association (SPA) surveys represent 90 percent of all packaged software sales in the United States and are considered to be extremely reliable. For more information see their World Wide Web Site (HTTP://www.spa.org).

include verbal instructions about the steps required to complete a command and visual information which allows the person to see how to execute the command and the outcome of performing it. Furthermore, whereas Palmiter et al. (1991, 1993) focussed primarily on procedural information, the manuals and demonstrations used here follow the guidelines of the Discovery Method of learning and are based on the design of Minimal Manuals which expose the trainee to a wide range of commands, and encourage the understanding of the general procedures common to many tasks.

It is hypothesized that these animated demonstrations will benefit older adults, and therefore the participants in the multimedia group will outperform those in the text group. Individuals in the text group may encode the material verbally, visually (by imagining it), and motorically. The individuals in the multimedia condition can encode the material verbally, auditorily, and they are able to directly view the visual and motoric components through examples. However, this hypothesis assumes that older adults are able to process the additional information in the multimedia presentation. Because of age-related limitations on processing speed (Salthouse, 1991), an alternative possibility is that the older adults may be unable to take advantage of the additional stimulus information. Thus, although it is hypothesized that the multimedia group will outperform the text group, if the older adults cannot make use of the additional information then no group differences will be observed.

2. <u>What are the effects of practice?</u>

Most studies in the human computer literature provide the participants with only a few trials for each of the commands which they are taught. In this study, after the participants complete the training, they are provided with 10 additional practice trials for each of the commands they learn. Although this amount of practice does not compare with the thousands of trials given to subjects in the skill acquisition literature, it is still possible to examine changes in performance with practice and to assess whether the amount of change differs between the text and multimedia groups. It is hypothesized that with practice, the participants in both groups will take less time, require less help, and make fewer errors. In addition, even if group differences appear initially, the performance of both groups should be about the same following sufficient practice.

3. What is the relationship of the individual difference variables to performance?

Ackerman (1986, 1988, 1990, 1992) demonstrated that the correlation between measures of individual differences and performance changes as a function of training. As a skill is acquired, the following pattern of correlations is obtained: (a) correlations between general abilities and performance start high and then attenuate; (b) correlations between perceptual speed ability and task performance increase and then decrease in magnitude; and (c) correlations between psychomotor ability and task performance increase as the skill becomes automatized. In this study, the relationship between performance and individual difference variables is examined within a series of path analyses. It is hypothesized that whereas specific abilities (e.g., spatial skills) will predict initial performance, performance on previous lessons will be the best predictor of subsequent sessions.

4. Does performance differ when commands are consistently executed using a single method or varied between two methods?

In general, there are several methods by which an individual may execute a single command. In fact, most training tutorials include multiple methods for every command trained. It is therefore important to determine whether the performance of individuals who always execute command using a single method differ from those who alternate between different methods. It is hypothesized that due to working memory limitations, the initial performance of individuals alternating between methods would be inferior to that of individuals who use only a single method. However, with practice it is hypothesized, that the performance of those individuals who alternate between methods will converge with those who use only a single method.

5. Can individuals transfer what they learn to a different word processor?

An important aspect of any training study is whether the trainees can transfer what they had learned. In this study, transfer is examined by having the participants work on a second word processor to which they had never before been exposed. It is hypothesized that with practice individuals will be able to successfully complete the transfer tasks. Furthermore it is expected that relative to their final performance on a post-training task, in which the participants used all of the commands that they had learned, there will be a decline in performance. In addition, because it is hypothesized that practice is more relevant to overall learning than is training method, no group differences are expected.

6. Do attitudes change with training and do the changes remain stable over time?

Previous research has demonstrated that when a multidimensional attitude scale is administered, attitude change can occur as a function of training. Furthermore, the change in attitude can remain stable over time (e.g., Jay & Willis, 1992). Using the Jay and Willis Attitudes Towards Computers Questionnaire, it is hypothesized that positive change will occur in at least a few of the dimensions and the changes will remain stable over time. Previous research (e.g., Baldi et al., in press; Najjar, 1995, 1997) has demonstrated that individuals who are exposed to multimedia demonstrations enjoy them and think that they will have a positive effect on learning. It is therefore possible that individuals in the multimedia condition will report more positive attitudes towards computers after training.

Method

Participants

Fifty-nine community-dwelling women between the ages of 50 and 80 (M = 66.39, SD = 5.90) were recruited on a voluntary basis through letters to Concordia senior students and flyers placed throughout the community. All participants were required to meet the following criteria at the time of testing: (a) they were between 50 and 80 years of age, (b) they were in self-reported good health, with no neurological or psychiatric disturbances, and no problems with vision, hearing or motor coordination that could affect their performance in this study, and (c) they were computer novices. Computer novices were defined as individuals who had less than 10 hours of experience on *any* type of computer over the last year, had *no* experience with any Microsoft Windows[tm] application, and had *never* used a word processor, text editor, or graphics package. Preliminary screening of these inclusion conditions was conducted over the telephone at the time of initial contact.

Only women were tested in this study for the following reasons. First, gender differences in exposure to, and use of, computers have been reported in the literature. For example, the research has demonstrated that male and female children (Bernhard, 1992; Collis & Ollila, 1986; Hawkins, 1985; Wilder, Mackie, & Cooper, 1985), university students (Arch & Cummins, 1989; Gattiker & Hlavka, 1992; Igbaria and Chakrabarti, 1990; Temple & Lips, 1989) and adults (Massoud, 1991) have different attitudes towards computers, with women more frequently reporting more negative attitudes than men (for a review see Whitely, 1997). In addition, Vernon-Gerstenfeld (1989, see also Gutek & Bikson, 1985) demonstrated that men and women adopt computers for different reasons and that women may in fact adopt computers sooner than men when applications, rather than programming, are stressed. With respect to older adults, Adler (1996) reported the following: (a) men over the age of 55 are 1.5 times more likely to own a computer than are women, and the gender gap widens to 2.2 times more likely among those over the age of 75 years; (b) older women prefer to learn how to use a computer by taking classes or learning from friends while men prefer to teach themselves; (c) women report using a computer primarily for writing whereas males reported that managing personal finances was most important for them. Kelley (1993) examined gender differences after training and found that in general there was a tendency for both younger and older women to achieve higher scores than men.

Second, gender differences have been described for a variety of skills and for a number of cognitive abilities which are thought to be associated with computing skill. These include, for example, visuospatial abilities (Halpern, 1986; Willis & Schaie, 1988; Voyer, Voyer, & Bryden, 1995), verbal abilities (Huyck, 1990), manual dexterity (Dodrill, 1979), and motor performance (Thomas & French, 1985). Because sex differences have been demonstrated in areas related to computer skills, inclusion of both men and women in the study would require examination of sex as a factor, and therefore an increase in the size of the sample in order for adequate power.

Apparatus

Hardware. Two identical computer systems were set up in different rooms in order to allow concurrent training sessions. Participants were trained and tested on a 386DX33 IBM desktop clone with a 14" video graphics adapter

(VGA) colour monitor set at a resolution of 640 x 480 pixels. Each computer had 8Mb of Random Access Memory, a 420Mb hard drive, a 3½ and a 5¼ inch floppy drive, a Microsoft standard sized serial mouse, and a Soundblaster 16 bit sound card with speakers. Both computers used the most current disk operating system (Microsoft DOS version 6.2) available at the time the study was conducted.

Because a device is needed to convert the video signal between most computers and National Television System Committee (NTSC) video sources, a VGA to NTSC video card connected to a video cassette recorder (VCR) was used in order to record the participant's interactions with the computer during both the training and performance evaluation sessions. When connected to the VCR, these video cards make it possible to record in real time and on standard videotape every interaction that a user has with the computer, thus providing a document of the participant's session with the computer (i.e, everything that the participant sees on the monitor in front of her is recorded). In addition, the subject's voice, the sound of the keystrokes, and the sound of the mouse clicks were all recorded onto videotape via a microphone that was placed next to the computer.

Software. A number of software packages were used in the present study. First, all of the software described below works within Microsoft Windows™ version 3.1 (hereafter referred to as Windows). Windows provides a graphical user interface which allows the user to see on the monitor the fonts, appearance, and layout of the document that would appear when it is printed on paper.

The participants were trained on the Microsoft Word for Windows™

(version 6.0a; from hereafter referred to as Word) word processing system. Version 6.0a was the most current version of the program available at the time the study was conducted. Word was chosen over other word processing systems to keep the software consistent with that used in our previous research (Kurzman & Arbuckle, 1994, 1995). In addition, Word is one of the most popular word processors currently available for the IBM computer system (PC Magazine, October 1996; Software Publisher's Association, 1996). The software used in the current study was modified in a number of ways to suit the needs of this study. These modifications were designed to minimize the number of serious errors that a participant could make and from which she would be unable to recover. They were also designed to prevent the participant from executing commands which were not being trained or which were beyond her current level of skill.

Word uses a combination of pull-down menus, icons, and accelerator keys (i.e., using only the keyboard to enter commands) to execute various word processing commands. It provides the user with at least three methods of accessing a single command. In this study, access to commands was based solely on the use of pull-down menus, because this method appeared to be the easiest one for older adults. For example, Kelley (1993) demonstrated that across all ages, novice computer users using keystrokes had significantly more difficulty completing the word processing tasks than did users of pull-down menus and a combination of menus and icons. Also, other researchers (e.g., Gittins, 1986) revealed that even experienced computer users have trouble interpreting abstract icons and remembering what each icon is used for.

As previously stated, a number of modifications were made to the software. First, access to commands through keystrokes (e.g., ALT-F6 for center align) was disabled. In addition, all of the icon bars and tool bars were turned off. Second, some of the menus were edited. For example, access to the Word on-line help facility was disabled. If a subject attempted to access Help, the message "This menu is currently unavailable!" would appear. The menus which the participants were not using during the study were also disabled with this message. In addition, Word has 9 default menus with each menu having between 4 and 16 ($\underline{M}$ = 12.56) associated commands. In order to reduce the possible confusion associated with such a large number of commands, the number of commands per menu was reduced to include the set of commands trained and tested plus a second set which were not trained during the study and which were included to provide interference. Third, based on previous research (Kelley, 1993), the mouse clicks and drag speeds were set to their slowest speeds in order to help the participants more easily use the mouse. With the exception of the changes mentioned above, participants were able to explore the software as they wished.

WordPerfect™ for Windows version 6.0a was used to test generalization of word processing skills to a different word processor. This software was chosen because it uses commands similar to those used by Word. In addition, it was possible to edit menus and commands in the same way that they were edited in Word. Although the names of the WordPerfect menus were not modified, those which the participants were not required to use were turned off using the same method described for Word. The dialog boxes used by WordPerfect were not modified in any way. Dialog boxes are boxes that appears on the screen in response to a command, and allow you to communicate with an application in order to direct the way it will execute the command.

On-screen multimedia demonstrations were created and displayed through the use of Lotus Screencam (1994, Version 1.1). With the addition of a sound card, Screencam allows the user to both view, and listen to, pre-recorded material. Macros were written to enable the participant to access these demonstrations directly from Word by pressing a pre-defined sequence of keys (e.g., Alt-Q). Each demonstration had an associated key stroke which was clearly indicated in the training manual. All macros were written using the Microsoft Word Basic programming language, which allows the user to customize various aspects of the Word interface.

The Windows 3.1 Mouse Tutorial Program (Microsoft, 1993), which is part of the Windows Help facility, was used as part of the Mouse training provided to the participants. In this tutorial, the user is provided with a 5 to 10 minute on-line lesson on the three basic skills (i.e., clicking, double-clicking, and dragging) required to use a mouse.

An on-screen timer, written using the CMM basic programming language (Cenvi version 1.009), was positioned in the right hand corner of the screen. The timer was reset to zero prior to both the training and practice phase of each day's session. In addition, the timer covered, and thereby prevented the use of, the Windows minimize and maximize buttons which, when activated, change the way the information on the screen is displayed.

Design

This study was designed to provide participants with the opportunity to learn how to use a word processor and to allow them to practice the various commands trained on a particular day. Thus, during each session, the participants completed the training phase where they learned new commands according to the training condition in which they were assigned, followed by the practice phase where they practiced what they had learned according to the practice condition to which they were assigned. The following sections describe these conditions.

Training Conditions

The participants were randomly assigned to one of two training conditions. In the first condition, Text, the participants received a tutorial manual which was written for this experiment. The manuals were designed such that there was first an explanation of each command followed by a description of the steps required to access the command. Graphic images of the screen were integrated into these manuals in order to help the participants. The participants were then given two chances to practice the commands in a section labelled Your Turn. Across the four training sessions, the manual progressed in a logical manner, from very basic skills to more complicated skills. Table 1 presents a detailed listing of all of the commands taught to the participants across the four days of training.

In the second condition, Multimedia, the same manuals were used with a

Table 1. Topics and Commands Trained during each of the Four Training Days.

Day 1 Introductory Session	Day 2 Lesson 1	Day 3 Lesson 2	Day 4 Lesson 3
Introduction	Basic Commands	The Scroll Bars	Character Formatting
Computer Terms	Starting Word	Selecting Text	Tab Stops
What is Windows	The Word Screen	Cutting and Pasting	Finding & Replacing Text
What is Word Processing	Creating a New Document	Copying and Pasting	
What is the Mouse	Moving Around in Word	Aligning Text	
The Mouse Pointer	The Enter Key	Line Spacing	
The Mouse Buttons	Moving the Insertion Point		
Mouse Tutorial[a]	The Backspace Key		
(Viewing a Demonstration)[b]	The Delete Key		
Positioning the Mouse	What is a Menu		
Clicking	What is a Dialog Box		
Double Clicking	Saving a Document		
Dragging	Closing a Document		
	Opening a Document		

[a] This interactive tutorial was given on the computer.
[b] This one page section was provided only to those participants who were in the multimedia condition.

single exception. Whereas the participants in the text condition were given two chances to practice each of the commands, participants in the multimedia condition were given only one. The first practice opportunity in the Text condition was replaced in the multimedia condition by an animated demonstration on the computer. Following the animated demonstration, the participants were given a chance to practice the command. The animated demonstrations included visual and auditory information so that the participants could both see the steps required to complete the task and hear a voice explaining these steps. The two conditions did not differ in any other way.

Practice Conditions

The practice was designed so that the participants would have multiple trials to practice each of the commands that they had learned. The goal of this additional practice was to develop a better understanding of the processes involved when executing a command, and to be able to recall more effectively the steps required to complete it. Although this practice does not compare with the thousands of trials that participants perform in skill acquisition studies (Anderson, 1981), no other study on computer skill acquisition has yet included as many trials as has been included here.

Each day's practice consisted of 10 trials per command taught. The total trials (10 x the number of commands taught) were broken down into 5 practice blocks, with each block containing 2 trials per command. Within each block of trials, the length of the documents used and the number of characters that the participant was required to type were equivalent so that in theory, no block of trials should have been more difficult than any other block. Within each block of trials, the order of the items was randomly assigned with the single provision that the same command was not repeated twice in a row. The order of the five blocks of trials was also randomly constructed with the same order being used for all participants.

As previously noted, there are multiple methods available to execute a single command. In fact, most training tutorials include multiple methods for every command trained. It is therefore important to observe whether focusing on a single method to execute a command would result in a different level of performance than would shifting between alternating methods.

Participants were assigned to one of two practice conditions. In the first condition, Variable Practice, the participants alternated between two methods for completing some of the commands which they learned. For example, the participants in this condition alternated between using the Delete key to erase and then change a word in a document, and using the Backspace key to do the same thing. Overall, the participants completed the command 10 times, but they used each unique method for a total of 5 times. It is important to note that on each day only a subset of the commands that involved multiple methods was trained. Table 2 lists the commands that the participants practiced for each of the practice conditions.

In the second condition, Consistent Practice, the participants completed the practice trials using only one of the two methods. This condition was designed such that half of the participants used one method to complete a command during the practice, while the other half used a second method during the practice. Thus, in the example presented above, half of the participants in the Consistent Practice condition used only the Backspace key while the other

Table 2. Commands Practiced by the Participants in Each of the Practice Conditions.

Lesson	One Method	Two Methods		
		Consistent Practice (Type 1)	**Consistent Practice (Type 2)**	**Variable Practice**
1	Create New Document Open Document Saving Document Close Document (Save As) Close Document (Confirm Save) Close Document (No Confirm)	Backspace	Delete	Backspace Delete
2	Cutting Text Copying Text	Line Spacing (Insertion Point)	Line Spacing (Text Selection)	Line Spacing (Insertion Point) Line Spacing (Text Selection)
		Aligning Text (Insertion Point)	Aligning Text (Text Selection)	Aligning Text (Insertion Point) Aligning Text (Text Selection)
3	Fonts	Tabs (Paragraph Dialog)	Tabs (Menu Choice)	Tabs (Paragraph Dialog) Tabs (Menu Choice)
		Replace (All Instances)	Replace (Specific Instances)	Replace (All Instances) Replace (Specific Instances)

Note. During the Introductory Session, all participants practiced Clicking, Double Clicking, and Dragging. One Method refers to practice items that were completed by all participants through a single method.

half used only the Delete key. With this format, it is possible to examine whether (a) one method is in fact easier than the other, and (b) by combining these two conditions, to directly compare performance to the participants' performance in the Variable condition. Across study days, the methods required to complete a command were randomly assigned to the conditions. It is important to note that the participants in both practice conditions received identical treatment in the training phase, that is, everyone learned the multiple methods to complete the various commands. The difference between practice conditions is whether they later practiced one method or two methods.

Individual Difference Measures

Demographic and Psychosocial Measures

The purpose of the demographic and psychosocial measures was to establish the equivalence of the treatment groups prior to the commencement of training. These measures included a personal demographics questionnaire, a health questionnaire, a measure of current mood and well-being (Memorial University of Newfoundland Scale of Happiness, MUNSH; Kozma & Stones, 1980), a measure of the personality traits of extraversion and neuroticism (Eysenck Personality Inventory, EPI; Eysenck & Eysenck, 1968), a measure of learning style (Kolb Learning Style Measure; Kolb, 1984, 1985), a measure of circadian rhythms (Morningness-Eveningness Questionnaire, MEQ; Smith, Reilly, & Midkiff, 1989), and a measure of one's desire to engage in elaborative thought (Need for Cognition Questionnaire; Tanaka, Panter, & Winborne, 1988). The following is a description of these tests and their psychometric properties.

Demographic/Health Questionnaire. This short questionnaire queried the participants about basic demographic information (e.g., age, education, marital status, work history), as well as their experience and knowledge of computers. Three questions were also included to screen participants for the presence of a computer phobia. In addition, a series of questions examined the participant's health status.

Eysenck Personality Inventory (EPI). The EPI (Eysenck & Eysenck, 1968) is a widely used standardized measure of two central dimensions of personality, extroversion-introversion and neuroticism. Each trait is measured by means of 24 questions, which were selected on the basis of item and factor analyses (for more information see Eysenck & Eysenck, 1968). In addition, the EPI includes a 9-item lie scale which measures the tendency for individuals to present themselves in a socially desirable way. Test-retest reliability after several months ranged between .84 and .94 for each of the three scales. Split-half reliability was between .74 and .91 (Eysenck & Eysenck, 1968). Eysenck and Eysenck (1968) report that the EPI demonstrates both construct validity and concurrent validity.

Learning Styles Inventory. Kolb's Learning Styles Inventory (Kolb, 1984, 1985) consists of 12 items of four words each. Respondents rank the words in order of their perceived correspondence to their own learning style. The instructions advise the respondent that there are no right or wrong answers and that the questionnaire is one of preference, not ability. According to Kolb's model, there are two separate and independent continua that reflect four basic styles of learning. One continuum, Concrete Experience, characterizes the degree to which people view each situation as a discrete event to be evaluated separately from other situations, versus Abstract Conceptualization, a situation to be fit into a theoretical framework already developed. These approaches comprise two of the basic approaches people may apply to new situations. The other continuum characterizes the degree to which people begin by actively involving themselves in a new situation or event, referred to as Active Experimentation, versus reflecting on the situation, referred to as Reflective Observation. The Learning Styles Inventory determines a score along each of these continua.

Based on two score combinations for the two continua, individuals can be classified into one of four following learning styles: (a) Accommodators, or individuals whose combined relative preference is for actively engaging in new experiences, which they see as discrete entities, not as part of theoretical frameworks, (b) Divergers, or individuals whose combined relative preference is to evaluate situations as discrete events and also to observe and reflect about the events rather than actively engage in them, (c) Assimilators, or individuals who prefer to observe and reflect upon new situations, and then conceptualize the situations according to theories developed from other similar events, or (d) Convergers, individuals who tend to think abstractly but who like to test out theories that they develop.

Memorial University of Newfoundland Scale of Happiness (MUNSH). The Memorial University of Newfoundland Scale of Happiness (MUNSH; Kozma & Stones, 1980, 1983) consists of 24 items. Items are presented in writing to the subject and scored as "yes", "no", "don't know", or "no response". According to Kozma and Stones (1980), the MUNSH measures the emotional state of an individual. It consists of two scales measuring positive and negative current affect and two scales measuring positive and negative experiences over the previous 12 months. High scores on the two subscales of affect and experience indicate a state of well-being; low scores indicate depression. Test-retest reliability has been reported to be between .70 and .79, with an internal consistency coefficient of .85 (Kozma & Stones, 1980).

Morningness-Eveningness Questionnaire (MEQ). Research on circadian rhythms and cognition suggest that the general effect of time of day is moderated by individual differences in optimal performance periods, with best performance occurring at an individual's peak time during the day (May, Hasher, & Stolzfus, 1993). May et al. (1993) and May, Hasher, and Bhatt (1994) used the MEQ (Smith et al., 1989) to investigate the effects of optimal periods and time of testing in younger and older adults. They found that in general, while younger adults reported being evening types, older adults are morning types. In addition, older adults performed better on tests of recognition memory and their ability to detect misinformation when tested in the morning (i.e., at their optimal time) than when tested in the afternoon. The reverse was found for younger adults.

The MEQ is a 13-item questionnaire which examines whether an individual is a morning person (i.e., prefers day activity), an evening person (i.e., prefers night activity), or somewhere in between. Each item on the MEQ involves a question pertaining to an activity or how one feels at a certain time. Four choices are available for each item, corresponding to a definite morning type, moderate morning type, moderate evening type, and definite evening type. The MEQ is a composite scale as it was developed by taking the items with the best internal measurement properties from the Horne and Östberg (1976) and the Torsvall and Åkerstedt (1980) scales. The internal consistency of the MEQ is .87 and it possesses external measurement properties comparable with, or slightly better than, the two scales from which it was formed.

Need for Cognition survey (NFC). The NFC survey (Cacioppo & Petty, 1982) consists of a series of true-false questions which assess the desire to engage in elaborative thought. The version used in this study was the 18-item abbreviated version (Cacioppo, Petty, & Kao, 1984) of the original 25-item scale. On the 25-item version of the scale, Tanaka et al. (1988) found no education effect, but they did report a significant gender difference, with women having a higher score then men.

Cognitive and Motor Measures

A number of tests of cognitive abilities that are potentially related to the acquisition of word processing skills were also administered to all of the participants. As previously discussed, individual differences in cognitive abilities are correlated with age and age-related declines in cognitive abilities may explain some of the reasons why older adults have more difficulty than younger adults learning to use computers. The tests selected for this study provide measures of vocabulary (Advanced Vocabulary Test; Ekstrom, French, Harman, & Derman, 1976), reading abilities (NAART; Blair & Spreen, 1989), word fluency (CFL; Benton & Hamsher, 1983), verbal learning (California Verbal Learning Test, CVLT; Delis, Kramer, Kaplan, & Ober, 1987), non-verbal learning (Biber Figure Learning Test; Glosser, Goodglass, & Biber, 1989), visuospatial conceptualization (Weschler Adult Intelligence Scale, WAIS-R Block Design; Wechsler, 1981), ability to shift attentional focus (Trail Making Test (Forms A and B); Reitan & Wolfson, 1985), and sustained attention (VIGIL Sustained Attention Test; Computer Version). In addition, measures of motor abilities were also administered. A measure of psychomotor processing speed (WAIS-R Digit Symbol), a measure of motor speed (Finger Tapping Test; Halstead, 1947), and a measure of typing abilities were also included. Although normative data exist for many of the following tests, raw scores were used, as the examination of norms is not relevant to the focus of this study.

Advanced Vocabulary Test. A 44-item multiple-choice paper and pencil vocabulary test (Ekstrom et al., 1976) was given to all of the participants as a control measure. An underlined target word was followed by six possible choices. The participant was simply required to circle the word that had the same meaning, or nearly the same meaning as the target. There was no time limit for this task.

Block Design. The Block Design subtest is one of the five performance subtests of the Wechsler Adult Intelligence Scale - Revised (WAIS-R). Specifically, it is a construction test in which the subject is required to use blocks to construct a replica of a design that is presented to the subject by the experimenter. Block design is thought to tap such abilities as visuospatial conceptualization, visuospatial organization, and non-verbal problem solving (Lezak, 1983). The test was administered and scored using the standard WAIS-R procedures (Wechsler, 1981).

California Verbal Learning Test (CVLT). The CVLT (Delis et al., 1987) involves oral presentation of a list of 16 words (List A) over 5 learning trials at a rate of 1 word per second. The list contains 4 words from each of four semantic categories and the items are presented as a shopping list in order to increase the relevance for the participant. Adjacent words on the lists are from different categories, which allows for the evaluation of the degree to which an individual uses an active learning strategy of recalling word in semantic clusters. After each presentation, the participants are asked to recall as many of the words as they can remember. Participants are not told how many items are on the lists. They are told that they can recall the words in any order and they are encouraged to guess if unsure of a word. Immediately after the participants complete the fifth learning trial of List A, an interference list of 16 words (List B), which they must then recall, is presented once. The free recall of List B is then followed by free and category-cued (short delay) recall of the first list (List A). After a 20-minute interval (long delay) in which non-verbal testing occurs, free recall, category-cued recall, and recognition of List A are evaluated. Recognition memory for the list is assessed by presenting a list of 44 items (16 from List A, 8 from List B, and 20 new distractor items) and having the participant indicate which items are from List A. Scoring of the CVLT was conducted using the IBM scoring software for the CVLT (Fridlund & Delis, 1987).

The CVLT was designed to quantify and provide normative data on the different strategies, processes and errors an individual may display when learning new unstructured information. In addition to assessing correct recall and recognition, the CVLT quantifies such variables as semantic and serial learning strategies, serial position effects, learning rate across trials, consistency of item recall across trials, degree of vulnerability to proactive and retroactive interference, retention of information over short and long delays, as well as perseverative responses and intrusions during recall and false positives during recognition. Delis, Freeland, Kramer, & Kaplan (1988) demonstrated that a number of orthogonal factors underlie verbal memory performance on the CVLT and that its assessment of learning processes, strategies, and errors categorizes performance in ways that are not captured by the global scores used in most memory tests. Delis et al. (1987) reported a split-half reliability of .92 for the total score over five trials, and internal consistency values of .69 for items recalled across the 5 learning trials (for more detailed reliability information see Delis et al., 1987, Tables 2 through 5).

Biber Figure Learning Test - Extended version (BFLT). The BFLT (Glosser et al., 1989; Glosser, 1994) was developed as a nonverbal analogue to the supra-span word list paradigm (e.g., CVLT). In the BFLT participants are presented with a list, List A, of 15 simple geometric designs (at the rate of one design every 3 seconds) over five learning trials. After each presentation, the participants are asked to draw as many of the designs as they can remember on an answer sheet. The answer sheets (one per trial) consist of 16 squares of equal size in which participants draw their responses. Participants are not told how many items are on the lists. They are told that they can draw the designs in any order and they are encouraged to guess if unsure of a design. Following the five learning trials, a second "interference" list (List B) of 15 items is presented for one trial, which the participants must then draw on an answer sheet. The participants are then given a new answer sheet and is asked to draw as many of the designs as they can remember from the first list (short delay). After a 20-minute delay (long delay), the participants are again asked to draw as many of the designs as they can remember. Recognition memory for the list is assessed by presenting a list of 45 items (15 from List A, 7 from List

B, and 23 new distractor items) and having the participant indicate which items are from List A.

The BFLT allows for the examination of (a) the rate and pattern of acquisition of new visuospatial information; (b) the difference between short-term and long-term visual memory; (c) the difference between learning and retention; and (d) a comparison of free recall and recognition. The original BFLT has been extended (Glosser, 1994) from its original 10 designs to 15 designs, with each design being constructed by combining two simple geometric forms. In addition, an interference list was created for the extended version so that the administration would be consistent to that of the California Verbal Learning Test. On the original BFLT, results demonstrate that it is relatively insensitive to the effects of age, and performance is not related to educational level (Glosser et al., 1989). In addition, test-retest reliabilities are high ranging between .79 for immediate reproduction, and .91 for delayed recall. Furthermore, no significant differences were observed between initial testing and retesting on any of the BFLT measures.

Scoring is based on a three point system for each recalled item (for a maximum score of 45 per trial). One point is given for the accuracy of reproduction of *each* of the two component shapes and an additional point is given for correctly recalling the relationship between the two component shapes. Scoring is based on a liberal criterion in that there is no penalty for drawings that include distortions in size, graphomotor distortions, and any other idiosyncratic response. Responses that cannot be matched to any stimulus figure are scored as extraneous, and responses that are highly similar to a previous response, or an identical repetition, are scored as perseverative. On the recognition test, the number of hits, false alarms, and the total number of correct responses (hits plus correct rejections) are scored.

Digit Symbol. The Digit Symbol subtest of the WAIS-R is a test of psychomotor speed and processing speed (Salthouse, 1988; Salthouse, Kausler, & Saults, 1988). Motor persistence, sustained attention, response speed, and visuomotor coordination play important roles in the normal person's performance. Although some perceptual organization components do show up in the performance of older adults, the natural response slowing that comes with age seems to be the most important variable contributing to age differences in this test. Performance on this test is relatively unaffected by intellectual competence, memory, or learning (Erber, Botwinick, & Storandt, 1981). In addition, age-related declines in digit-symbol performance are independent of both years of education and self-reported health status, and are characterized by a gradual shift in the entire distribution of scores with little age-related increase in variance (Salthouse, 1992)

In this study, administration of the Digit Symbol subtest was based on the method described by Kaplan, Fein, Morris, and Delis (1991). In this procedure, although performance is noted after 90 seconds as per standardized administration, participants complete all four rows of the test. Upon completing the fourth row, the participants are handed a sheet of paper containing 9 small blank squares, with each square paired with a number ranging between one and nine. The participants are then asked to pair, without looking at the key, as many of the symbols as they can recall. This modification acts as a measure of incidental memory.

Finger Tapping Test. The Finger-Tapping Test, which is also known as the Finger Oscillation Test (Halstead, 1947), is the most widely used test of manual dexterity (Lezak, 1983). It is a measure of motor speed of the index finger of each hand (Spreen & Strauss, 1991). Using a specially adapted tapper, the subject is instructed to tap as fast as possible first with the index finger of the preferred hand, and then with the non-preferred hand. The subject is told to move only the index finger while keeping the whole hand and arm at rest, and is provided with a practice trial. In this study, three 10-second trials were given for each hand, with a brief rest period after each trial. The finger tapping score is computed separately for each hand and is the mean of the three consecutive trials.

Performance with each hand is quite stable over time, even with test-retest intervals of two years (Dodrill & Troupin, 1975; Spreen & Strauss, 1991). Reliability coefficients ranging from .58 to .93 have been reported with both normal and neurologically impaired adults. Slowing occurs with age, tending to show up in the fifth to sixth decades and increasing significantly thereafter (Bak & Greene, 1980). In general, better performance is associated with the preferred hand, male gender, younger age, and more years of education (Bornstein, 1985).

North American Adult Reading Test (NAART). The NAART (Blair & Spreen, 1989), a North American version of the British National Adult Reading Test (NART; Nelson, 1982), is a reading test of 45 irregularly spelled words (e.g., syncope, worsted) that must be read aloud by the participants. It is considered to be one of the best estimates of WAIS-R verbal IQ (Spreen & Strauss, 1991). In addition, the NAART has high internal and test-retest reliabilities.

Trail-Making Test (Forms A & B). The Trail-Making Test (Reitan & Davison, 1974) is a test of speed for visuomotor tracking and mental flexibility. Whereas Form A requires the connection, by making pencil lines, of 25 randomly arranged numbers in numeric order, Form B requires the connection of randomly arranged numbers and letters in sequence by alternating between the two sequences. Scoring is based on the time required to complete the task. If an individual makes an error, the experimenter points it out as it occurs. Although diminished reliability may be a consequence of this action (because the time includes the speed with which the participant corrects it), Snow, Tierney, Zozitto, Fisher, and Reid (1988) reported one-year test-retest reliabilities in older subjects of .64 for Form A and .72 for Form B. Similar findings have been reported by Gold and Arbuckle (1995). Age and education level affect the scores.

Typing Test. Because typing is inherent in the use of any word processor, typing skill is an important individual difference that needs to be examined. Typing skill was measured using a computer-administered typing test. The participant was given a warm-up passage to type and was then asked to type as much of a one page document as she could in two minutes. The document consisted of 24 sentences (307 words), and the participants were told that no one was expected to be able to type all of it within the given time limit. The number of correctly typed words was used as an estimate of typing speed. In addition, the number of characters typed and words containing errors were also included. Initially, pilot subjects were required to complete two typing test trials; however, when preliminary analyses indicated that the two trials were highly correlated (correlations of .92 and .98 for number of typed words and number of correctly typed characters respectively) and mean performance on both measures did not change significantly over trials, the test was shortened to one trial in order to reduce the duration of the test session.

Vigil (Computer-Administered Continuous Performance Test). Vigil (Vigil, 1991) is a computerized test of attention which incorporates a version of the Continuous Performance Test (CPT; Orzack & Kornetsky, 1956). The CPT is among the most frequently used tests of attention and its use in research has been well documented. Attention is viewed as a complex set of processes, so any test of attention can in fact only assess specific forms or processes of attention. Vigil is designed to examine that part of attention which deals with one's ability to concentrate or one's maintenance of attention over time.

Vigil allows the experimenter to modify or create new version of the test to suit ones needs. The version of the CPT used in this study, involved three trials in which a series of white upper-case letters (against a black background) were presented to the participant. The participant's task was to respond to the presence of a target letter by pressing the space bar. All instructions appeared on the screen and were read aloud by the experimenter. The participants were first given a practice trial where they were told to press the space bar on the keyboard as quickly as possible whenever the target letter 'X' appeared on the screen in front of them. The practice trial involved a single block of 10 stimuli, 5 of which were targets. For this trial, the stimulus duration was set at 250 ms with an inter-stimulus duration of 1500 ms. After the practice trial was completed, two test trials were given. For these trials, the stimulus duration was set at 100 ms with an inter-stimulus duration of 900 ms. Each test trial was divided into 4 blocks, with each block composed of 36 stimuli in which 9 were targets. From the participant's point of view, the four blocks constituted one continuous trial, that is, there were no interblock intervals. In the first test trial, participants were required to press the space bar as quickly as possible whenever the letter 'K' appeared. In the second trial, participants were required to press the space bar whenever they saw the letter 'K' but only after it appeared immediately after the letter 'A'. The measures of performance were the number of correct and incorrect responses, the hit rate, false alarm rate, number of errors of commission and omission, and the average reaction time. All data were saved on the computer. The summary statistics included totals for each test trial, as well as, subtotals for each of the test trials 4 blocks. By looking at each block separately, it is possible to examine changes in performance over time.

For normal adults, internal consistency, split-half reliability and test-retest reliabilities ranged between .67 and .96 for all of the outcome variables listed above (Vigil, 1991), indicating that VIGIL normed tests are highly reliable within a given subtest as well as over time. Construct validity of Vigil has also been ascertained. It demonstrates both convergent and discriminant validities and it is related to tests that are face valid instruments assessing attentional processes. In addition, in an analogous 'AX' version of the original CPT, Halperin, Sharma, Greenblatt, and Schwartz (1991), found that the test was reliable, correlated with age, and resistant to learning effects.

Word Fluency Test. This test, also known as the Controlled Oral Word Association test, was developed by Benton and Hamsher (1976) as part of the Multilingual Aphasia Examination. It is a sensitive measure of verbal associative fluency (Spreen & Strauss, 1991) which is often impaired in patients with diffuse or focal brain disease. Factor-analytic studies (e.g., desRosiers & Kavanagh, 1987) have shown that this test loads mainly on a Verbal Knowledge factor along with tests of vocabulary. The subject is given three word naming trials and is asked to produce, in a limited period of time, as many words as possible that begin with the letters C, F, and L. They are timed via a stopwatch and are given one minute for each letter. A subjects raw score is the sum of all acceptable words for all three letters. Inadmissible words (i.e., proper nouns, repetitions, variations, wrong words, and numbers) are not counted as correct.

One year test-retest reliability coefficients of .70 have been reported in normal elderly adults, and a test-retest reliability of .88 after a period of 19 - 42 days (desRosiers & Kavanagh, 1987). Relationships to other letters (e.g., PRW, FAS) was found to be high, ranging between .82 (Benton & Hamsher, 1976) and .93 (Lacy, Gore, Pliskin, Henry, Heilbronner, & Hamer, 1996). Correlations with age ranges between -.14 (Mittenberg, Seidenberg, O'Leary, & DiGiulio, 1989) and -.19 (Yeudall, Fromm, Reddon, & Stefanyk, 1986). Yeudall et al. (1986) showed correlations of .21 with education. Lacy et al. (1996) showed correlations ranging between .49 and .59 between verbal fluency and WAIS-R full scale, verbal, and performance scaled scores. Overall, this test is a sensitive measure of individual word production under a restricted search condition.

Computer-Related Measures

Two attitudes towards computers surveys (Attitudes Towards Computers Questionnaire (ATCQ), Jay & Willis, 1992; Feelings for Computers Questionnaire (FCQ), Igbaria & Charkrabarti, 1990) were also administered in order to examine whether any changes in attitudes occurred over time.

Whereas the former was administered three times (pre-training, post-training, follow-up) over the course of the study, the latter was administered twice (pre-training, follow-up). In addition, a Mouse Test was given to the participants on both the first study day and on the final study day in order to examine how one's ability to use the mouse changes with practice.

Attitudes Towards Computers Questionnaire (ATCQ). The ATCQ (Jay & Willis, 1992) is a 35-item multidimensional questionnaire which assesses seven dimensions of attitudes towards computers that were identified in prior research on students and adults (See Appendix E). The ATCQ includes the following dimension: (a) Comfort, which assesses feelings of comfort with the computer and its use; (b) Efficacy, which taps feelings of competence with the computer; (c) Gender Equality, which assesses the belief that computers are important to both men and women; (d) Control, which assesses the belief that people control computers; (e) Interest, which assesses the extent to which an individual is interested in learning about and using computers; (f) Dehumanization, which assesses the belief that computers are dehumanizing; and (g) Utility, which assesses the belief that computers are useful. All items are based on a 5-point Likert scale, with response options ranging from 'Strongly Disagree' to 'Strongly Agree'. In a sample of 420 elderly adults, Jay (1989; cited in Jay & Willis, 1992) reported adequate LISREL factor loadings for the seven dimensions, and internal consistency coefficients ranging between .54 (control) and .82 (dehumanization).

Feelings for Computers Questionnaire (FCQ). The FCQ (Igbaria & Charkrabarti, 1990) is a 9-item true or false attitude subscale (see Appendix F) which was modified from the computer anxiety subscale of a longer computer attitudes and microcomputer usage questionnaire. The questionnaire was originally designed to examine the use of computers in work organizations. The FCQ examines cognitive, behavioural, and affective elements of computer use and has been shown to have an internal consistency coefficient of .80).

Mouse Test. Charness, Bosman, and Elliott (1995) reported that the mouse is difficult to control for both young and old novice computer users, but older adults generally commit significantly more mouse-related errors than do younger adults. The purpose of the Mouse Test was to examine the degree to which one's ability to use the mouse increased with practice. The mouse test examines three skills which were thought to be required in order to effectively use a mouse. These include clicking the mouse button, moving or manipulating the mouse, and combining the two. The Mouse Test is based on computerized, but modified versions of the Finger Tapping test (Halstead, 1947) and the Trail Making test (Reitan & Davison, 1974).

In order to assess the ability to click the mouse button, the participants were asked to click on the mouse button as quickly as they could, for a period of 10 seconds. After a brief practice trial, three trials were given per hand, with the hands tested alternating across trials. The number of clicks the participant made during each 10 second trial was recorded by the computer. To assess the ability to manipulate the mouse, a task similar to Form A of the Trail Making Test was used. In this test, 25 circles, each containing a number from 1 to 25, appeared on the screen. The participant was asked to use the mouse to move the mouse pointer around the screen so that the pointer would roll over the numbers in their proper sequence. As the participant rolled the pointer over the number, the circle changed colour. If the participant made an error, the experimenter immediately pointed it out. The computer recorded the time it took for the participant to complete the task. The final task examined the participant's ability to move the mouse and click the mouse button to achieve a specific goal. Again, a series of numbers from 1 to 25 within circles appeared on the screen. In this task, however as the participant rolled the mouse so that the pointer appeared on a number, she was required to click on the mouse button so that the circle changed colour. If the participant failed to position the mouse within the circle while clicking, it failed to change colour. The participant was required to click on all 25 circles in their proper sequence. The computer kept track of the time it took for the participant to complete the task and the number of errors the participant made.

Procedure

The study took place on five consecutive mornings or five consecutive afternoons. Testing of all participants took place at the Loyola Campus of Concordia University. Participants worked with the same experimenter during each day of the study. The five days included one day of cognitive testing and an introductory computer lesson, three days of word processing training lessons, and one day of testing. Each day's session was designed to take about three hours to complete. Rest periods were supplied as needed.

There were three experimenters, each of whom received extensive training with the word processor in order to enable them to resolve any problem or provide a solution to any question that the participant had while working on the computer. In addition, the experimenters were trained in the administration of the tests used during the first session. Experimenter A, an advanced undergraduate psychology student, trained 8 participants, and Experimenter B, a Bachelor of Arts level research assistant in the adult development and aging laboratory trained 6 participants in the Multimedia condition. Experimenter C, the author of this thesis, trained the remaining participants. Experimenter effects are discussed in the Results section.

Day 1: Preliminary testing and introductory lesson

Ethical approval for the present study was given by the Human Research Ethics committee at Concordia University. During the first session the participants were introduced to the study, informed of their rights as research participants, and asked to sign a general consent form. The purpose of the study and the facts that the data are being used for research purposes and that confidentiality would be maintained, were explained to the participant both orally and in writing at the start of the first session. The participants were told that everything they saw on the computer, every action that they made on the keyboard, and everything they said, was going to be recorded onto videotape. In addition, they were told that each videotape was going to be given a code number in order to ensure confidentiality. In addition, informed consent statements authorizing the use of the data for research purposes were signed by the participants. The participants were told that they could withdraw from the study at any time and that if they should wish, they would be informed about the outcome of the study at a later date. The participants received an honorarium ($10 per session) for a total of $50 if they completed all five sessions of the study.

The participants were then asked to complete the individual difference measures described above. The individual difference measures were administered in the same order to all of the participants. Following the completion of these tests, the participants were given an introductory training session on the computer concerning the mouse and how to use it.

All of the training was administered via the manuals described above with the exception of the Mouse Tutorial, which was administered on the computer during this session. All participants received this tutorial, which trained them on some of the basic skills required to use a mouse. Because using the mouse is a skill that is inherent in using any Windows application, this lesson involved overlearning in the sense that the mouse tutorial and the manual were repetitive.

The animated demonstrations presented to individuals in the Multimedia training condition included a 2-minute introductory animated demonstration which showed them what the demonstrations looked like and how to access them. In addition, four demonstrations, moving the mouse, clicking, double clicking, and dragging, were integrated into the manual. These demonstrations lasted between 19 and 55 seconds ($\underline{M}$ = 32.2 seconds).

All participants were instructed to go through the manual in the order in which it was written without skipping any sections. Both groups were told, however, that they were permitted to review earlier pages as necessary. Although individuals in the multimedia condition were not given any instructions concerning multiple viewings of the animated demonstrations, none of the participants viewed them more than once. There was no time limit imposed on the participants; rather they were able to complete the tutorials at their own pace. They were told, however, that the second part of each day's session (i.e., the practice phase), would require about 90 minutes to complete. In addition, although accuracy was stressed over time to completion, the subjects were told that the day's session, including breaks, could not extend over a period of 4 hours. This time restriction was implemented simply because of time restraints with respect to testing 2 participants in a single day. The time required to complete each day's session was recorded. An experimenter was in the same room as the participant throughout the sessions and was available when help was required. Breaks were given to the participants as needed and were not included in the measure of time required to complete the training.

Upon completing the mouse tutorial, the participants were given a 10-item multiple choice quiz which tested their immediate comprehension and retention of the lesson. Specifically, the quiz assessed the participant's knowledge of the concepts and commands, and their recollection of how to execute them. Each question had four choices as a response.

Upon completing the quiz, the participants began the practice phase in which they received extended practice on the commands trained in the mouse tutorial. The practice phase was completed without referring to the manual or the animated demonstrations. For the Introductory session, the practice consisted of three tasks associated with using a mouse, namely, clicking, double clicking, and dragging. The participants practiced each of these three tasks 10 times, for a total of 30 practice items, or 6 items per block.

Requests for Help

When required, help was available to the participants during both the training phase and during the practice phase. The following guidelines were adhered to by the experimenters when responding to questions. During the training phase, the participants were asked to explain the problem they were having and to indicate the place in the manual that was causing the problem. The participants were then asked to recount the steps that they performed to reach the current point and to review what they were trying to achieve. Next, the participants were told to attempt the particular command again while the experimenter watched. If required, the experimenter worked through the problem with the participant. During the practice phase, the participants were provided with the minimal amount of information required to allow them to complete the task. In the case where participants made an error that dramatically changed a document, the experimenter intervened and fixed the problem. The participants were then told to continue working on the item from the point where they had difficulty. In previous studies, (e.g., Kelley, 1993), help during practice was not given except when absolutely required and participants were simply told to look in the manual whenever they had a question. Under these conditions, novice older participants became very upset (some even began to cry), and reported negative feelings about the training process (C. Kelley, personal communication, July 1996). The approach taken here was different in that requests for help were answered, with the goal being to minimize the need for human assistance and to increase the participant's understanding of the system and the steps required to complete a command.

Day 2

On Day 2, the participants began their actual training on the word processor which continued until the end of Day 4. During these sessions, the participants were trained exclusively on Word. Each day's session was similar to that described for the Introductory training session on Day 1. Specifically, the participants completed the training phase followed by a multiple choice quiz and then the practice phase. During the Day 2 session, individuals in the Multimedia condition viewed a total of seven animated demonstrations which lasted between 37 and 283 seconds (M = 91.1 seconds). As previously mentioned, Table 1 lists the commands in the order in which they were trained, and Table 2 describes the commands practiced by the participants in each of the practice conditions. During Day 2, 1 of the 5 commands practiced was included in the variable/consistent manipulation. Individuals in the Variable practice condition shifted between using the Backspace and Delete keys in order to change a single word of text while those in the Consistent condition practiced one or the other method only. Because of the nature of the items practiced (i.e., opening and saving files), one command (closing a document) was practiced by all participants using each of three different methods (save the document and give it a name while closing it, confirm save by clicking on OK dialog box while closing file, and closing file with no confirmation). The practice consisted of a total of 55 trials (2 trials per block for each of 4 commands, and 3 trials per block for the close command).

Days 3 and 4

On Day 3, individuals in the Multimedia condition viewed a total of six animated demonstrations which lasted between 86 and 133 seconds (M = 115.2 seconds). In this lesson, 2 of the 4 commands practiced were included in the variable/consistent manipulation. During this session, individuals in the

Variable practice condition shifted between selecting text or placing the insertion point anywhere in a paragraph when attempting to change either the alignment or line spacing of a single paragraph. In addition, at the start of every block of trials, the participants were required to open a new file which they would edit, and upon completion of the block they would close (and save) it. The practice therefore consisted of a total of 50 trials (2 trials per block for each of 4 commands, and 1 trial per block for each of the open and close commands).

On Day 4, individuals in the Multimedia condition viewed a total of three animated demonstrations which lasted between 309 and 398 seconds (M = 362.3 seconds). In this lesson, 2 of the 4 commands practiced were included in the variable/consistent manipulation. During this session, individuals in the Variable practice condition shifted between replacing all or selected instances of a word via the Replace function as well as either invoking the Tabs function via the menu, or through the Paragraph dialog box. As in the previous session, at the start of every block of trials, the participants were required to open a file which they would edit, and upon completion of the block they would close (and save) it. The practice therefore consisted of a total of 40 trials (2 trials per block for each of 3 commands, and 1 trial per block for each of the open and close commands).

Day 5: Performance evaluation

During the final session, the participants completed a variety of exercises beginning with the Word Processor Integration exercise in which the participants, while editing a single document, were required to use all of the commands that they had learned.

The participants were then given a 54-item multiple choice quiz (See Appendix G). The quiz consisted of the 40 items presented on Days 1 through 4 plus an additional 14 questions which were specifically designed to examine procedural ('how to') versus declarative ('why') knowledge. These questions were designed to test seven items of knowledge about what had been taught about word processing from both a procedural and declarative standpoint. The results from the procedural versus declarative questions were examined in another study (Arbuckle, Kurzman, & Greenberg, 1996; Greenberg, 1995) and will not be discussed here.

Upon completing these exercises, the participants attempted the transfer condition. In the transfer exercise the participants were required to complete an exercise, similar to the Word evaluation, but shorter in length using a different word processing program (WordPerfect for Windows version 6.0a). The participants were then asked to complete the far transfer conditions, the results of which will not be discussed in this thesis as they will be examined in a subsequent paper.

The participants were then asked to complete the Attitudes Towards Computers Questionnaire for a second time in order to examine changes in attitudes over the study days, and a closing questionnaire which covered general feelings towards the study. Upon completing this session the participant was thanked for participating in the study and was given the $50.00 honorarium.

Measures of Word Processing Performance

Coding was based on an examination of the videotapes of the participants' interactions with the computer. In this study, only the practice phases of each day's session, the Word Processor Integration exercise, and the near transfer exercise were coded. With the exception of time required to complete each day's training, the training videotapes were not coded in any way.

Performance was measured in terms of time, accuracy, number of trials taken and frequency of help requests. Global measures include the time taken to complete each of the day's training and practice portions of the session, and the time taken to complete the final performance evaluations and the near-transfer condition. The global measures were used in order to determine whether there is some overall effect with regard to time of completion for the training or the practice conditions. Microscopic measures of time include the time taken to complete each block of trials or each individual item in the practice. Since there were 5 blocks of trials (2 trials per item per block) it was possible to determine whether overall, or for a specific condition, the participants speeded up as they practiced a particular type of command.

Determination of accuracy necessitated first the establishment of the units to be scored. Each day's exercise was comprised of a number of items that the participant was required to complete. Each task was in turn comprised of steps or molecules which had to be completed in order to successfully execute a command. A task analysis was conducted in order to identify the specific steps necessary to complete a command (Waern, 1991). For example, to change the font for a line of text (the task) the following series of steps had to be completed: Selection of the text to be modified, selection of the format menu, selection of the font submenu by clicking on the dialog box's scroll bar to select the new font, and clicking on the OK button to confirm the selection. Thus, this single task (change font) is in fact comprised of 5 steps, or molecules.

Correct performance was scored at two levels. First, each of the individual steps received a score of either 0 (fail) or 1 (success) based on the participant's *first trial attempt*. That is to say, the participant can attempt the item multiple times but at this level she was only scored on her first attempt. For example, while changing the font, the participant may have unsuccessfully selected the text. She then repeats her attempts to select it until she has successfully done so. Although she does select it in the end, she would receive a 0 for her first attempt at it.

At the second level of scoring, a three point system ranging between 0 and 2 points was applied to the overall accuracy for the task. A 0 represents a failure to complete the item, a 1 represents partial completion of an item, and a 2 represents successful completion of an item. A score of 1 is given if the participant executes the required command but otherwise alters the text in some other way. In addition, the participants may get a score of 1 if they perform the action on only part of the required text, or if they complete a command using an alternate or similar method to complete a command (e.g., the subject applies the wrong font to the text). Versions of this system have been used in previous research (Kelley, 1993; Kurzman & Arbuckle, 1994). Inter-rater reliability scores of 92% have been achieved using this system (Kelley, 1993). Note that accuracy for the Word Processor Integration task was only scored at this level.

That is, first trial performance was not scored, as the participant's ability to complete the task regardless of the number of trial required was the primary point of interest.

The types of errors made while working on the exercises were also scored. Twelve error categories, were predefined and are listed in Table 3. Similar error categories were used by Kelley (1993) and by Arbuckle and Kurzman (1994). Performance was also scored in terms of number of trials it took to complete each of the steps for a specific task. A new trial was defined as starting each time the participant began a particular step from the beginning. In addition, every time the participant abandoned the section in which she was working, a new trial has begun. Thus, if a participant was required to select a passage of text and she was selecting and deselecting the text, she was still on the same trial. However, if while attempting to select text she scrolls to a different part of the document, she had begun a new trial. In addition, if the participant made an error and had to start the step (or a series of steps) again, a new trial had begun. Finally, the number of times and types of help requested by the participant was scored for the practice phase only. Each time a participant asked for help with a problem, the nature of the problem was classified into one of five categories: (a) questions that pertain to the task instructions, (b) procedural ('how') questions, that pertain to the steps required to complete a command, (c) confirmatory questions that pertain to the correctness of a procedure used. For example, "Do I use this key?", "Is this how I do it?", (d) declarative ('why' / 'what') questions such as "Why did this happen?", "What did I do wrong?", and (e) advanced questions, or questions that are unrelated to the task itself, rather they deal with the system being

Table 3. Error Categories and Brief Descriptions

Category	Description
Mouse	Difficulty clicking, dragging, or positioning the mouse pointer.
Keyboard	Typing errors.
Special Key	Errors associated with the Backspace, Delete, Enter, or the Space Bar keys.
Insertion Point	Errors associated with positioning the insertion point.
Selection	Errors associated with the selection of text.
Scroll Bar	Errors associated with the scroll bars.
Menu	Use of incorrect menus.
Dialog Box	Errors made within a dialog box with the exception of those associated with the Cancel or OK Buttons
Dialog Box (Cancel or OK)	Errors made within a dialog box associated only with the Cancel or OK Buttons
Wrong Object	Participant works with the incorrect section of text, icon, etc.
Mode	Miscomprehension of the functional state of the interface.
Miscellaneous	Any error that does not fit into the categories listed above.
The following categories are not in themselves errors but are included here nonetheless.	
Experimenter	The experimenter either does or tells the participant how to do the task.
Attempt	The participant does not attempt the task.

Notes. Detailed descriptions of the error categories are presented in Appendix H.
Error categories are based on those developed by Kelley (1993) and Kurzman & Arbuckle (1994, 1995).

used. For example, "What is the difference between this and that?", "What does this key do?". These categories are based on a modified version of the categories devised by Briggs (1990).

Follow-up Phases

Mail Follow-up. Approximately two weeks after the completion of the study, a revised version of the multiple choice questionnaire given on Day 5, with the questions on each questionnaire in a different, random order, was mailed to the participants. They were asked to complete the quiz, the Attitudes Towards Computer Questionnaire (for the third time), the Feelings for Computer Questionnaire (for the second time), a follow-up questionnaire concerning the effect (if any) that the training had on their adoption of computers (Appendix I), and a Use of New Technologies Questionnaire (Appendix J). This questionnaire queried the participant's current use of new technologies. The questionnaire provided a listing of electronic devices (e.g., VCR, CD player) and services (e.g., Automatic Teller Machines, Call ID) and the participants were asked to indicate how many times they have used them, whether they have or plan to get the device or service, and how skilled they feel they are in using them. The participants were also mailed a certificate which acknowledged their participation in the study and their contribution to research. Self-addressed stamped envelopes were included with the questionnaire. The participants were told that upon receiving the completed questionnaires, their names would be placed in a draw for a $25.00 prize.

Telephone follow-up. Approximately one year after the completion of the study, the participants were telephoned at their homes and given a short 5-10 minute interview. The interview, presented in Appendix K, included questions on whether the participant had used a computer over the last year or had received any additional computer training, and whether participation in the study had any effect on her adoption of new technologies. In addition, the participants were given feedback with respect to the study's findings and were thanked again for their assistance.

Results

The results from the data analysis are divided into 6 sections. The first section presents statistical information related to the sample and data set. The second section examines missing data and explains how it was handled during data analysis. Analyses involving the reliability of measurement are examined in the third part. The fourth part presents the results regarding the acquisition of word processor skills while the fifth part examines the exercises administered on the final study day and the follow-up questionnaires. The final section examines the cognitive and motor correlates of word processing acquisition through a series of path analyses. All statistical procedures were computed using the following statistical packages: (a) Statistical Packages for the Social Sciences (SPSS, 1993), (b) BMDP (Dixon, 1988), (c) LISREL VII (Jöreskog & Sörbom, 1989), and (d) EQS (Bentler, 1995).

Part 1: Sample Characteristics

Subject Attrition

Fifty-nine participants were initially recruited to take part in this study. The first eight individuals recruited were used as pilot subjects. Observation of the performance of these participants helped in the identification and elimination of any remaining errors within the materials, in the establishment of the appropriate amount of material to be trained and practiced, and in the training of the experimenters. Once testing began, three of the participants that were recruited to participate in the actual study dropped out; one because of time commitments, one because of impaired vision which made it difficult for her to see the computer screen, and one because she found the study to be too difficult. The pilot subjects and dropouts had a mean age of 69.18 years (SD = 4.75 years) and mean education level of 16.09 years (SD = 3.21 years). Although these subjects were slightly older and more highly educated than those in the study sample, they did not differ statistically from these individuals.

The final sample consisted of 48 participants between the ages of 51 and 78 years (M = 65.75 years; SD = 6.00 years). Half the subjects were randomly assigned to either the Text or Multimedia training conditions. In addition, as described in the Methods section, the participants were further assigned to either the Variable practice (n = 24), or to one of the two Consistent practice conditions (n = 12 per condition).

Demographic and other background data

Demographic data were collected through an interview with the participants. Analyses on the demographic variables revealed no differences between the two Consistent practice groups suggesting that the participants made a homogenous sample. The two Consistent practice groups were therefore combined and from this point on are compared directly to the Variable practice group. Analyses on the demographic variables further indicated no significant differences between the Text and Multimedia conditions, or the Consistent and Variable practice groups, indicating that the participants in the training conditions and practice conditions form a homogenous sample (See Appendix L).

All of the participants were English speaking, with 79.2% being schooled in English, and generally well-educated, with 77.1% having some post-secondary education. Most of the participants (70.8%; 34) were not employed at the time they were participants in the study, with 85.3% (29) of these adults indicating that they had retired. The correlation between age and employment status is $r(48) = .20$, $p > .05$ suggesting that in this sample, one's age was not an indicator of employment status. Slightly over half (52.1%) of the sample was married and 22.9% of the women reported that they were widowed. Overall, the participants described themselves as healthy both when compared to others their own age and to a perfect state of health. The also reported a desire to engage in elaborative thought ($M = 8.08$). In general, the participants provided significantly lower ratings for eyesight and memory than for dexterity in their hands and hearing. All of the participants wore glasses; 56.2% (27) wore bifocals, 27.1% (13) wore glasses for close distance viewing, and 16.7% (8) wore glasses for distance.

Based on the Morningness-Eveningness Questionnaire, which classifies individuals into groups based on their circadian rhythms, 16 (33.3%) of the participants classified themselves as "morning persons". In contrast, only 1 (2.1%) person fell into the "evening person" category. The remaining 31 (64.6%) participants were classified in an intermediate category, indicating that they felt they could perform equally well throughout the day. Half of the participants completed the study during 5 consecutive mornings, while the other half chose to complete the study during afternoon sessions. Most of the "morning persons" (75%; 12) and 39% (12) of those who fell in the intermediate category participated in the morning sessions. The remaining 25% (4) of "morning persons", 19 (61.3%) of the intermediate persons, and the "evening person" completed the study in an afternoon session.

About half the participants (52.1%) reported little typing skill, with the remaining participants dividing equally into those reporting moderate (20.8%) or considerable (22.9%) typing abilities. In addition, almost two thirds of the participants (62.5%) reported that they were either currently working, or had previously worked at jobs where typing was required and that they had been doing so for an average of 13.7 years ($\underline{SD}$ = 14.8 years). On a formal test of typing skill, the participants typed an average of 40.8 words ($\underline{SD}$ = 25.6; range = 8 to 145 words) in two minutes. The participants also made an average of 8.3 errors ($\underline{SD}$ = 11.0 errors). The correlation between the number of words typed and number of errors made was $\underline{r}(48) = -.06$, $\underline{p} > .05$. These means are similar to those observed for other older novice computer users (e.g., Kelley, 1993). The correlation between actual typing skill and self-reported typing skill was $\underline{r}(46) = .51$, $\underline{p} < .001$ indicating that the participants were able to estimate their own typing performance with some degree of reliability.

When asked if they have ever used a computer, about two-thirds (31) of the participants indicated that they had some previous exposure to a computer with 6 (19%) individuals indicating that they had used a computer for over 10 hours. These participants were not excluded from the study as they received this experience at least 1 year prior to their participation in this study, they never used a word processor, and they had no experience with Windows. Just over a third (35.4%; 17) of the participants reported having a computer in their homes. Of these, 11 (22.9%) individuals indicated that they had an IBM personal computer, 4 (8.3%) had a Macintosh computer, and 2 (4.2%) either did not know or reported having another system (e.g., Amiga). Based on a 7-

point Likert scale, although the participants were very curious (*M* = 1.67) and eager (*M* = 2.04) to use a computer, they reported a moderate amount of anxiety (*M* = 3.81) about the prospect of using it. In terms of the four learning style classifications, 18 participants (37.5%) were Assimilators, 13 (27.1%) were Divergers, 10 (20.8%) were Accomodators, and 7 (14.6%) were Convergers.

Overall, the participants in the study did quite well on two tests of verbal abilities. On a vocabulary test they achieved an average score of 34.0 out of 44 (range = 23 to 41), and they achieved an average score of 36.4 out of 45 (range = 22 to 44) on the NAART. The correlation between performance on the vocabulary test and the NAART measures was $r(48) = .75$, $p < .001$.

Part 2: Missing Data

The following section deals with missing data during the performance evaluations, the cognitive tests and background questionnaires, as well as the 2-week follow-up, and the 1-yr telephone follow-up.

Performance Evaluations

When conducting applied research that includes few experimental manipulations, it is difficult to control for missing data. Although attempts were made to minimize the amount of missing data, data were missing for a number of reasons. In this study, data were missing due to experimenter error, and to the participants being unable or unwilling to complete a given test or lesson. In addition, because participants had control over the learning process, their use of the manuals, and their responses to the practice sessions, they were able to attempt or skip items at their own choosing, despite instruction to complete items in the prescribed order in training and to attempt all items in practice.

With respect to the performance evaluations, missing data are described in three ways; (a) at the global or block level, data are missing for a specific block of trials, (b) at the item level, the participant skipped a specific item, and (c) at the molecular level, the participant failed to attempt a specific molecule, or step, that comprises an item. Recall that the performance evaluation is broken down into 5 blocks of trials, with each block representing 2 trials per command learned. At the global level, data may be missing for a specific block because the participant was unable or unwilling to continue the session, or the participant had run out of time. As previously mentioned, although accuracy was stressed over time to completion, the subjects were told that they had a maximum of 4 hours to complete the session. Overall, missing data due to that time restriction were minimal. At the item level, data were missing for a specific item. If a participant did not attempt an item she received a score of 0 for the item, and was given an ATT (Attempt) error. In addition, the time required to complete the item was scored as 0. Determining the number of instances in which a participant failed to attempt an item is important because it will directly affect the participant's time. For example, two participants may have taken the same amount of time to complete an exercise yet one participant may have failed to attempt a third of the items. This difference must be taken into consideration when examining the time to complete the task.

All 48 participants completed all of the training sessions. At the global level, there were no missing data for the Introductory performance evaluation.

All 48 participants completed all of the items. For Lesson 1, one (2.08%) participant's videotape was lost, and one participant (2.08%) did not complete the final block of trials because she was too tired to continue. Five participants (10.42%) were missing data for at least 1 block of trials in Lesson 2. Two participants (4.17%) completed only the first 2 blocks of trials, one participant (2.08) completed only 3 blocks, and the two remaining participants (4.17%) were missing the final block of trials. Two of the participants (4.17%) indicated that they were too tired to continue, and three (6.25%) indicated that they had to leave by a specific time. For Lesson 3, 6 participants (12.50%) did not finish the exercises; 2 (4.17%) completed three blocks and the remaining 4 (8.33%) completed four blocks of trials. One of the participants (2.08%) indicated that she was too tired to continue, one (2.08%) had to leave by a specific time, one (2.08%) ran out of time, two participants (4.17%) could not complete the last block because the file that they were to edit was missing from the hard drive, and one participant (2.08%) did not complete the exercise for an unknown reason. For the Word Processor Integration task, data were missing for two participants (4.17%). One participant's (2.08%) videotape was defective, thus all data for the session were lost. The second participant (2.08%) was missing data for the first 6 items as the experimenter failed to turn on the VCR immediately. Data were missing for nine participants (18.75%) on the near transfer task. Five of the participants (10.42%) ran out of time, 3 participants (6.25%) refused to attempt the exercise, 1 participant's tape was defective (2.08%) and 1 was lost (2.08%). If a participant was missing a block of trials, her data for that session was not used. Overall, the amount of missing data was equal across training conditions. Table 4 summarizes the amount of missing data by session.

Table 4. Final Sample Sizes and Missing Data by Session

Session	Final Sample Size	% Missing from Original Sample (n = 48)
Introduction	48	0
Lesson 1	46	4.16%
Lesson 2	43	10.42%
Lesson 3	42	12.50%
Word Processor Integration Task	46	4.17%
Near Transfer	39	18.75%

There were relatively few missing data points due to unattempted items. For the Introductory session, there was an average of 0.2 unattempted items (SD = .4). There were 1.3 unattempted items (SD = 1.7) for Lesson 1; 0.6 unattempted items (SD = 1.0) for lesson 2; .5 unattempted items (SD = .8) for Lesson 3; 2.2 unattempted items (SD = 4.0) for the Word Processor Integration task, and 2.2 unattempted items (SD = 2.2) for the Near Transfer task.

Although there were only a few items that the participants failed to attempt at all, because each item consisted of multiple molecules, it was possible for a participant to fail to complete all the molecules for an item, which in turn could have had a negative, depressing effect on the dependent variables. Table 5 shows for each session, the maximum number of molecules per block and the mean number that were missed per block.

Table 5. Sample Sizes and Number of Missed Molecules by Session

Session	Molecules per Block	M_{missed}	(*SD*)
Introduction (n = 48)	19	0.52	(1.22)
Lesson 1 (n = 46)	49	13.39	(8.13)
Lesson 2 (n = 43)	69	11.14	(10.48)
Lesson 3 (n = 42)	78	12.71	(10.18)

Note. Microscopic measures of accuracy, for which the number of molecules are relevant, were collected only for the practice sessions and were not collected during the Word Processor Integration or Transfer tasks.

The Introductory session is qualitatively different from the three lessons, in that it did not deal with word processing training and all of the participants completed the practice phase of the session using only a single method. Because of these differences, it was examined separately from the other sessions. A 2 (Training Group) x 5 (Trial Block) repeated measures ANOVA was conducted in order to determine whether the number of unattempted molecules varied by trial block. Overall, this analysis yielded non-significant findings for the Training Condition and across Trial Block, indicating that for the Introductory session, the participants missed about the same number of molecules per block.

In order to allow comparisons between lessons, the data from Lessons 1, 2, and 3 were placed on an equivalent metric by dividing the number of unattempted molecules by the total number of molecules within a block of trials. A 2 (Training Group) x 2 (Practice Type) x 5 (Trial Block) x 3 (Lesson) repeated measures ANOVA was conducted to determine whether the number of unattempted molecules varied by Trial Block and Lesson. Overall, the number of missed molecules yielded non-significant findings for Training Condition and

Practice Type. Furthermore, Trial Block was not significant, indicating that overall, the participants omitted about same number of molecules during practice. In contrast, a significant Lesson effect was observed, $F(2,86) = 16.60$, $p < .001$, $\eta^2 = .27$, such that individuals omitted significantly more molecules for Lesson 1 ($M = .28$, $SD = .17$ molecules per item) than for Lessons 2 ($M = .16$, $SD = .14$ molecules per item) and 3 ($M = .14$, $SD = .11$ molecules per item) for which there were equivalent numbers of missed molecules.

Demographic and Cognitive Variables

There were relatively few instances of missing data for the demographic and cognitive variables due to the fact that the experimenter had control over the administration of the tests and questionnaires. With respect to the questionnaires, the participants were asked to complete all of the items. However, in some cases, a participant may have failed to complete a few questions. Provided the participant completed at least 85% of the items on a questionnaire, an estimated score for the questionnaire was derived by prorating the score over the number of questions that were answered. Otherwise, the subject's data were discarded. With respect to the cognitive tests, there were missing data for the following measures: (a) one participant (2.1%) refused to complete the Biber Figure Learning Test because she found it to be too difficult, (b) 2 participants (4.2%) did not complete the second administration of the Attitudes Towards Computers Questionnaire which was given on the final study day, due to time constraints, and (c) because the experimenter failed to save the data correctly, there were missing data for the mouse test (14.6%, 16.7%; first and second administration, respectively). The data for both administrations of the mouse test were missing for 3 participants (6.2% per administration). Furthermore, 4 participants (8.3%) were missing data for the first administration, and for 5 participants (10.4%) for the second administration. The participants with and without missing data were compared in order to determine whether these participants differed with respect to age and education. Furthermore, those participants who were missing data on either Mouse Test administration were compared to those participants with complete data on both administrations. No significant differences were observed between the groups for any of the variables thereby lending support to the notion that the pattern of missing data was random. Because the amount of missing data is relatively small, the cases in which there are missing data were dropped on an analysis-to-analysis basis.

Follow-up and 1-yr Follow-up

There were few missing data for the follow-up and 1-yr telephone follow-up. Only 2 participants failed to return the follow-up questionnaire, and 1 additional participant failed to complete one of the questionnaires (i.e., New Technology Questionnaire). Furthermore, only 1 participant was unable to complete the 1-year follow-up, which was conducted by telephone, because she had moved and left no forwarding telephone number.

Part 3: Reliability of Measurement

Experimenter and Computer Effects

Three experimenters were involved in the training and testing of the participants across the five study days. In order to determine whether there was an experimenter effect, Multivariate Analysis of Variance analyses (MANOVA) were conducted. The first analysis examined whether there was an experimenter effect for the time the participants required to complete the training sessions. A 4 (Session) x 3 (Experimenter) MANOVA yielded non-significant results (Pillai's $F(8,86) = 1.34$, $p > .05$, $\eta^2 = .11$). Pillai's criterion was used because it is more robust when there are unequal sample sizes per cell (Tabachnick & Fidell, 1996). A second analysis examined whether there was an experimenter effect on the amount of missing data across the practice phase of each day's session. As expected, an analysis of the number of skipped items, Pillai's $F(8,84) = 1.39$, $p > .05$, $\eta^2 = .12$, and missed molecules, Pillai's $F(8,84) = 1.93$, $p > .05$, $\eta^2 = .15$, across the practice sessions yielded non-significant experimenter effects. A final analysis examined whether there was an experimenter effect for some of the major dependent variables (Accuracy, Time, Errors, and Requests for Help) across the 4 practice sessions. The MANOVA yielded non-significant findings (Pillai's $F(32,42) = 1.64$, $p > .05$, $\eta^2 = .56$). Because one experimenter trained significantly more of the participants than the other two experimenters, the analyses were repeated in order to compare this experimenter with the other two. The results of these analyses were similar to those described above. Overall, the analyses presented here indicate that the experimenter did not have an effect on the major dependent variables in this study, nor on the amount of missing data.

In addition, two computers were used in the current study. A 4 (Accuracy, Time, Errors, and Requests for Help) x 2 (Computer) MANOVA across the 4 practice sessions was conducted and revealed non-significant findings (Pillai's $F(16,21) = 2.04$, $p > .05$, $\eta^2 = .61$). These results indicate that for the major dependent variables from the practice session, there were no differences in performance based on the computer that the participants used.

Reliability of Scoring

All of the videotapes which contained the participant's interactions with the computer were scored by a single rater. It is therefore important to assess the inter-rater reliability in order to determine whether a second coder would be able to score these interactions in the same way as the first coder. The inter-rater reliability was examined for a randomly selected practice evaluation exercise (Lesson 1), and for the Word Processor Integration Task. It was felt that the results from these two sessions would be a good indicator of the overall ability to train a second person to use the scoring system, and then to have that person use it independently. In addition, two sessions were chosen in order to keep the time required to train an individual to use the scoring system, and then to actually score the tapes, manageable.

A second coder was trained to criterion on the scoring system used in this study. The rater then randomly selected 8 videotapes (2 per condition) of participants who completed the session being assessed. The degree of agreement between the two coders for each of 5 major variables (Accuracy, First Trial Correct, Working Time, Help Requests, and Errors) was assessed through Pearson Correlations and Intraclass Correlation coefficients. Because Pearson correlations are measures of association, they are insensitive to any systematic differences between raters (Bartko & Carpenter, 1976). For example, if one rater were to be more rigid and systematically score events as errors while the second rater did not, their association may be quite high, but their agreement (i.e., assigning an error to the participant) would be quite low. The Intraclass Correlation Coefficient (ICC), however, is sensitive to both agreement and association (Fleenor, Fleenor, & Grossnickle, 1996; Streiner, 1995). An ICC is computed through an Analysis of Variance (ANOVA) in which the *MS* terms are used as indicators of variability within- and between- raters. For example, if two raters agree closely for a participant's data, their within variance is small and hence their reliability will be good. Similarly, the more judges vary among themselves, the lower will be the reliability (Bartko & Carpenter, 1976; Streiner, 1995).

As demonstrated in Table 6, with the exception of the number of errors made (r_{ICC} = .70) during Lesson 1, inter-rater reliabilities are quite high, (ICC_{range} = .78 to .97, Pearson r_{range} = .67 to .95) across the major dependent variables. An ICC of .75 or greater indicates good reliability. These results indicate that, in general, the two coders scored the videotapes similarly.

Table 6. Inter-Rater Reliabilities for the Major Dependent Variables

	Lesson 1		Word Processor Integration	
Variable	**Intraclass cor**	**Pearson cor**	**Intraclass cor**	**Pearson cor**
Accuracy	.90**	.91**	.96**	.91**
First Trial Correct	.92**	.86**		
Working Time	.92**	.85**	.97**	.95**
Errors	.70[a]	.70[a]	.95**	.91**
Help Requests	.85**	.78**	.97**	.94**

Note. N = 8 participants. * $p < .05$ ** $p < .01$ [a] $< .07$
Significance for ICC is based on an F statistic.
Shading refers to variables that were not scored during the particular session.

Given that errors are summed over 12 errors categories, it is feasible that both coders correctly identified an error, but coded it differently. The reliability statistics were therefore computed separately for each error category and are displayed in Table 7. The pattern of inter-rater reliability coefficients was variable. For example, in Lesson 1, 5 of the 11 error categories yielded coefficients that were high ($r_{ICC} > .75$), 2 categories yielded moderate coefficients ($r_{ICC} > .60$), and the reliability coefficients for 4 of the categories (Keyboard, Insertion point, Mode, and Miscellaneous errors) was unacceptable ($r_{ICC} < .60$). Interestingly, although the overall reliability for errors was quite high ($r_{ICC} = .95$) for the Word Processor Integration task, unacceptable ($r_{ICC} <$ .60) inter-rater reliabilities were observed for 2 different error categories (Special Keys and Scroll Bar errors).

Table 7. Inter-Rater Reliabilities for each error category

	Lesson 1		Word Processor Integration	
Variable	**Intraclass cor**	**Pearson cor**	**Intraclass cor**	**Pearson cor**
Mouse	.97**	.94**	.80*	.68*
Keyboard	.41	.38	.82*	.71*
Special Keys	.81*	.78*	.46	.31
Insertion Pt.	.11	.08	.92**	.90**
Selection			.84*	.73*
Scroll Bar	.68	.87**	.46	.31
Menu	.66	.59	.62	.45
Dialog	.87**	.79*	.92**	.86**
Dialog OK	.76*	.70*	.95**	.91*
Object	.83*	.71*	.70	.54
Mode	.48	.38	.95**	.93**
Miscellaneous	.31	.32	.89**	.82**

Note. $N = 8$ participants. * $p < .05$ ** $p < .01$
Shading refers to variables that were not scored during the particular session.

These results indicate that although the two raters were able to identify the production of an error, there was some variability in the way the raters coded some types of them. These results, however, are similar to those observed by Kelley et al. (1996) in which they observed low reliability coefficients for Scroll Bar Errors, Special Key Errors, Insertion Point Errors, Miscellaneous errors, and Mouse Errors.

Part 4: Analyses of Word Processing Results

This section presents the results regarding the acquisition of word processing skills. The first section presents the analyses of time required to complete the Training Sessions. In the second section, the methods used in analyzing the dependent measures from the practice periods are described, and the analytic strategies for handling missing data are presented. The specific analyses of the major outcome variables are then presented. For each outcome measure, the effects of training group and practice type were compared in the context of each of the day's practice sessions. The effect of practice was also examined by looking at the participant's performance across blocks of trials within each session. A fine-grained analysis of the effects of variable versus consistent practice, based only on the items relevant to this manipulation, is also provided. Finally, supplementary analyses on the error categories, as well as on the types of help requests made by the participants are also reported.

Training Time

Although the participant's interactions with the computer during training were videotaped, these tapes were not scored. One measure, however, that is relevant to this study is the amount of time the participants required in order to complete each of the training sessions. Time to complete the training sessions was examined through a 2 (Training Condition) x 4 (Training Session) repeated measures ANOVA.[3] There was a main effect for Training Condition ($F(1,46)$ =

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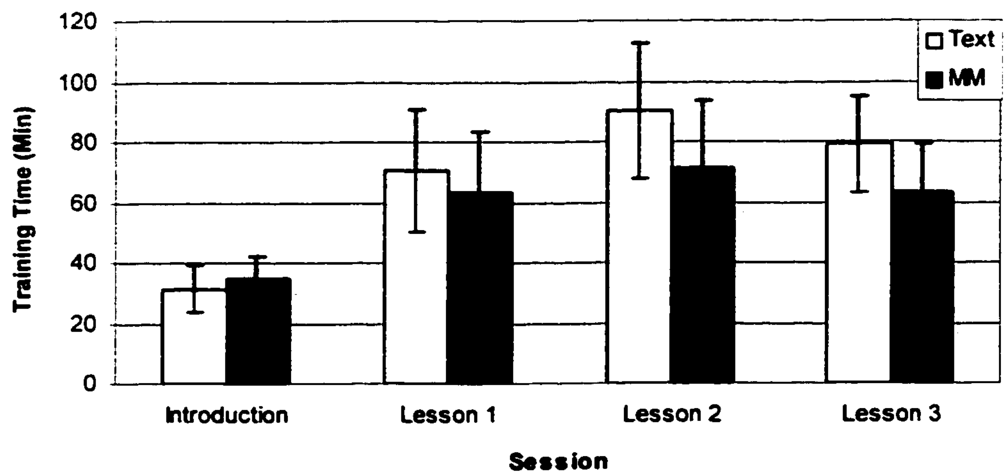
[3] Practice type was not included in this analysis as training did not vary according to the type of practice the subjects received *after* the completion of the training session. Nonetheless, as one can argue that each preceding day's practice can have an effect on subsequent performance during training, a preliminary analysis was conducted in which practice type was included as an independent variable. As expected, it was not significant.

7.20, $p < .01$, $\eta^2 = .14$), such that participants in the Text Condition (M = 135.66 min) took longer to complete each training session than did participants in the Multimedia Condition (M = 115.89 min). In addition, there was a Training Session effect ($F(3,44) = 215.06$, $p < .001$, $\eta^2 = .94$), such that the participants took significantly less time to complete the Introductory training session (M = 32.93 min) than any of the remaining three training sessions. In addition, they took more time to complete Lesson 2 (M = 80.66 min) than Lesson 1 (M = 66.88 min) or Lesson 3 (M = 71.08 min) which did not differ significantly from each other. The post-hoc comparisons are based upon an alpha level of $p < .01$, representing the Bonferroni rules for post-hoc comparisons. These differences in training times are not surprising given that Lesson 2 contained the most information and the Introductory session contained the least.

A Training Condition x Training Session interaction was also observed ($F(3,138) = 14.39$, $p < .001$, $\eta^2 = .49$). As Figure 1 shows, participants in the Text condition took significantly longer to complete Lessons 2 and 3 than did the participants in the Multimedia condition. There were no group differences for the Introductory session or for Lesson 1.

Figure 1. Training Group x Session Interaction for Training Time



<u>Analytic Procedures</u>

An extensive amount of data was collected during the participant's performance in the practice phase of each day's lesson. Each of the measures was collected by block, resulting in a total of 5 measurements per dependent variable. These 5 scores were then summed together in order to derive a total score. The results described below are based on doubly repeated measures ANOVAs that include 2 between subjects variables (Training Group, Text vs. Multimedia; and Practice Type, Consistent vs. Variable) and 2 within-subjects variables (Lessons 1 through 3; and 5 Trial Blocks per lesson). Follow-up analyses and significant interactions were examined, where appropriate, through simple main effects or through pairwise t-tests (using a Bonferroni correction). Because each lesson required the participant to complete a different number of items, the variables had to be converted to a common metric in order to conduct these analyses, and to allow comparisons between sessions. Accuracy scores were therefore converted into proportions of correct responses while the remaining dependent variables (time, errors, help, and interventions), which were simply a tabulation of instances or measured in minutes, were divided by the number of practice items within a block of trials. As previously discussed, the Introductory session is both qualitatively different, and much shorter, than the three word processor training lessons. For those reasons, it was analyzed separately through a 2 (Training Group) x 5 (Trial Block) repeated measures ANOVA. These analyses are presented at the end of this section, after the analyses of the dependent variables for Lessons 1 through 3.

Although the study was designed to consist of a balanced design (i.e., equal number of subjects across cells), if for a given cell, data were completely missing for a subject, the result was an unbalanced design. To take account of this problem, the analyses used an unweighted-means approach where each cell is given equal weight regardless of its sample size (Tabachnick & Fidell, 1996).

During training, the participants learned multiple methods to correctly complete specific commands. The practice condition was established in order to examine whether individuals who performed the commands consistently using a single method (Consistent practice) differed from those who used competing methods (Variable practice). However, most of the items practiced by the participants required the use of a single method while only a few of the items varied by condition. Table 8 lists the number of items practiced per session, the number of items that were executed the same way by all participants, and those for which the procedure differed according to the practice type condition.

Table 8. Breakdown of new commands practiced by session

Lesson[a]	Total Commands		Completed the Same		Completed Differently (Practice Condition)	
	Commands	Items	Commands	Items	Commands	Items
1	5	55	4	45	1	10
2	6	50	4[b]	30	2	20
3	5	40	3[b]	20	2	20

Notes. [a] All participants completed the Introductory session using a single method.
[b] Includes one trial for each Open and Close a file which was trained during Lesson 1.

The results obtained from an analysis based on all of the items may therefore be somewhat misleading given that the participants completed a majority of the commands using similar methods. It is possible that the performance variables, which were computed by summing across all practice items within a block, may have masked any effects that would be observed if the analysis had been restricted to only those items that were affected by the fixed-variable practice. In order to examine this possibility, the analyses were repeated separately for those practice items that differed according to the practice condition in order to focus exclusively on this subset of items. These analyses are discussed for each dependent variable after the presentation of the results based on all items.

Outcome Measures from the Practice Phase[4]

Time Measures

Three measures of time taken during the practice period were collected. The first, Block Time, is simply the time a participant started a trial block subtracted from the time she completed it. This measure of time is somewhat crude in that it includes time during which the participant did not actually work on the computer (e.g., thinking time, and short breaks[5]). In order to get a more

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[4] This section focuses on the outcome measures for Lessons 1 through 3. The analyses for the Introductory Session are presented in a subsequent section.

[5] When a participant required a break, it was not included in any of the time measures. However, it is quite reasonable to assume that between items, a participant could take a short break (e.g., 30 secs) before embarking on to a subsequent item. These types of breaks are uncontrollable from a measurement point of view.

refined measure of time, the actual times during which the participant worked on each of the items were summed together, and from hereafter is referred to as Working Time. For any item, timing began once the participant started an item, and ended when the participant completed the item or when it became clear that the participant had given up on it. By subtracting Working Time from Total Block Time, it was possible to obtain Reflection Time, which is thought to reflect the amount of time the participant spent thinking about the task, or replenishing her resources in order to deal with the subsequent items.

Separate analyses were conducted for Working Time and Reflection Time. Because Total Time is simply the linear combination of these two variables, it was not analyzed. As expected, across each of the practice sessions, the participants spent significantly more time working on the items than reflecting on how to do them. Table 9 presents the amount of time the participants spent working on the practice items and reflecting on them, as well as the t-values.

Table 9. Percent of Time per Item Spent Working Versus Reflecting by Session

	Working Time		**Reflection Time**		
Session	**Time per Item (min)**	**% of Overall Time**	**Time per Item (min)**	**% of Overall Time**	**t-value (df)**
Lesson 1	1.06 (.33)	82.4 %	0.23 (.11)	17.6 %	19.00 (45)
Lesson 2	1.47 (.47)	82.7 %	0.31 (.08)	17.3 %	17.29 (42)
Lesson 3	2.15 (.58)	89.3 %	0.26 (.07)	10.7 %	21.88 (41)

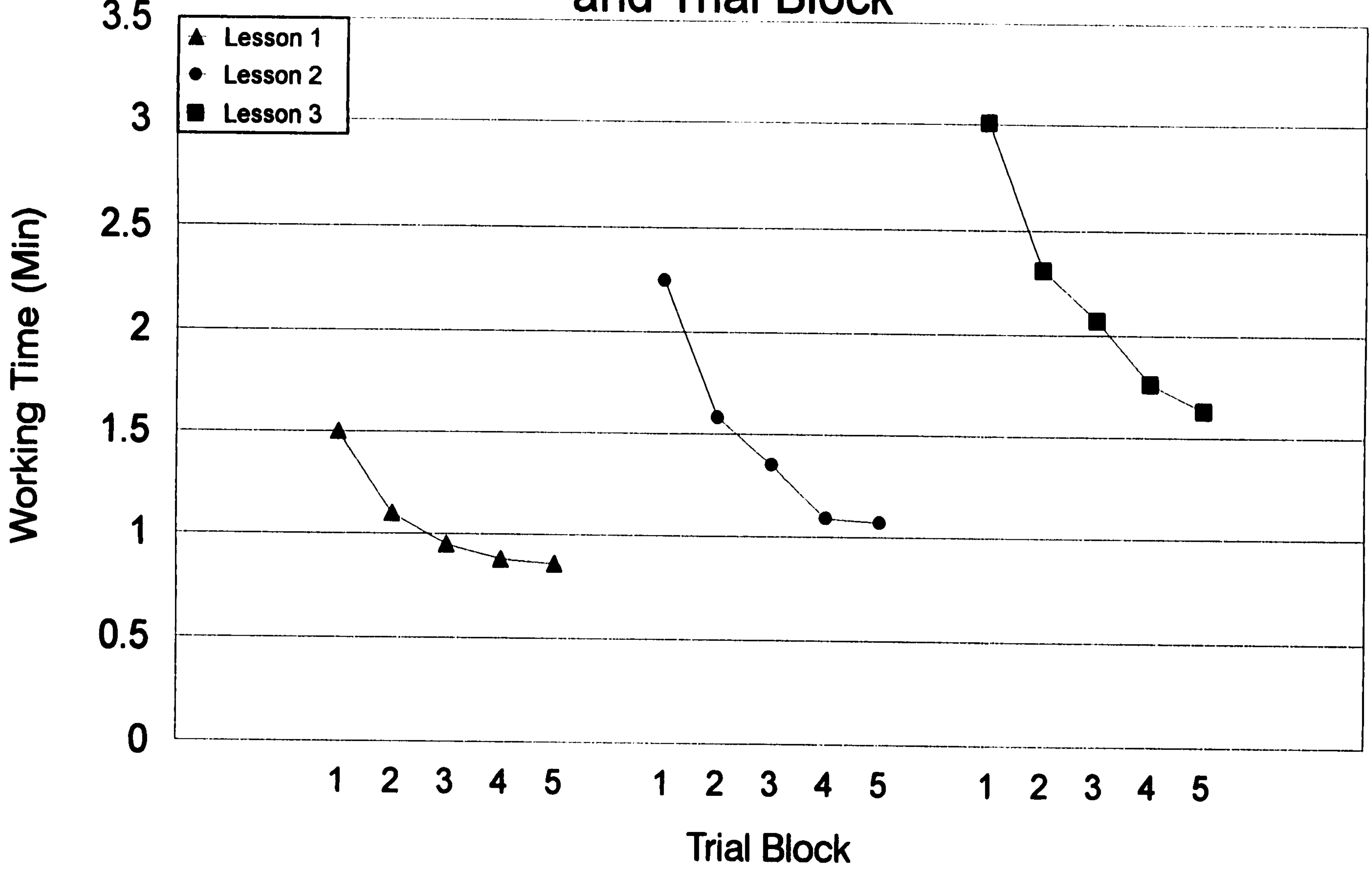
Note. Brackets refers to standard deviation (in minutes).
All t-values, which test for the difference between Working and Reflection times during practice, were significant at $p < .001$

Results from the 2 (Training Group) x 2 (Practice Type) x 5 (Trial Block) x 3 (Lesson) repeated measures ANOVA on Working Time yielded no main effects for Training Group or Practice Type. The Working Time data, including significant ($p < .001$) linear and quadratic trends are depicted graphically in Figure 2, and shows that the amount of block-to-block decline decreases as practice progresses.

The analysis yielded significant effects for Lesson, $F(2,68) = 196.67$, $p < .001$, $\eta^2 = .85$, with participants requiring significantly more Working Time for each succeeding lesson, and Trial Block, $F(4,136) = 176.19$, $p < .001$, $\eta^2 = .84$, with participants requiring less Working Time for each successive block of trials. In addition, a Lesson x Trial Block interaction, $F(8,272) = 14.76$, $p < .001$, $\eta^2 = .30$, was observed, with the participants requiring more time to complete a block of trials for each succeeding lesson, but to a different degree for each of them. For example, whereas the average change in Working Time between the first and final trial blocks was only .64 minutes per item for Lesson 1, the average change per item was significantly higher for Lessons 2 (1.18 min) and 3 (1.38 min).

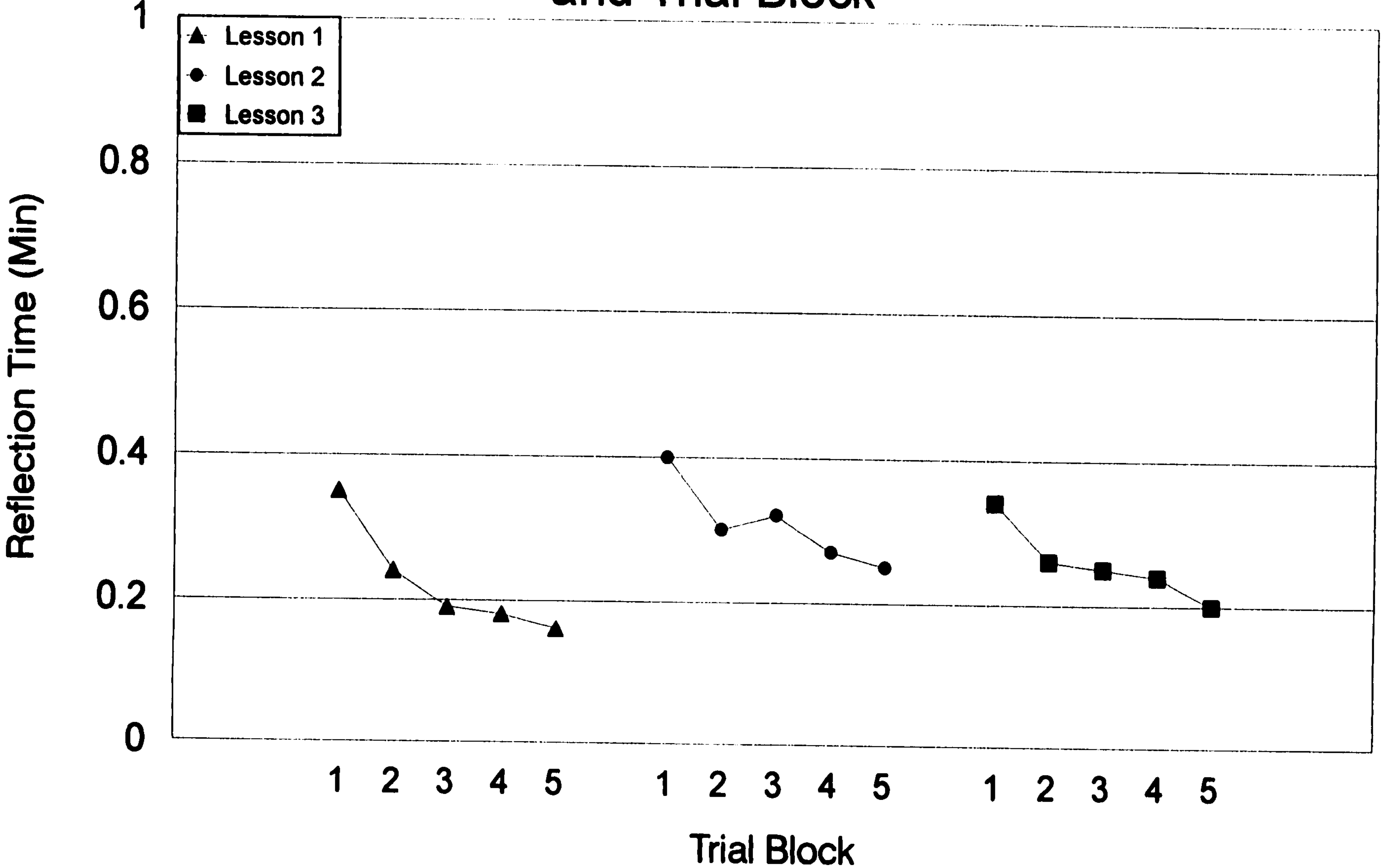
In the analysis of Reflection Time, a significant Lesson effect was observed, $F(2,68) = 29.61$, $p < .001$, $\eta^2 = .47$, with participants requiring significantly more of each measure of time for each succeeding lesson. This is presented graphically in Figure 3. A significant effect for Trial Block was also observed, $F(4,136) = 28.11$, $p < .001$, $\eta^2 = .45$ with participants requiring less Reflection Time with practice. In addition, a significant Practice Type x Trial Block x Lesson interaction was observed, $F(8,272) = 2.57$, $p < .01$, $\eta^2 = .07$.

Figure 2. Working Time as a function of Training Lesson and Trial Block



Note. Significant quadratic trends were observed for each of the sessions.
Working times per block were divided by the number of practice items within the block in order to allow comparisons between sessions and to make trends more explicit.

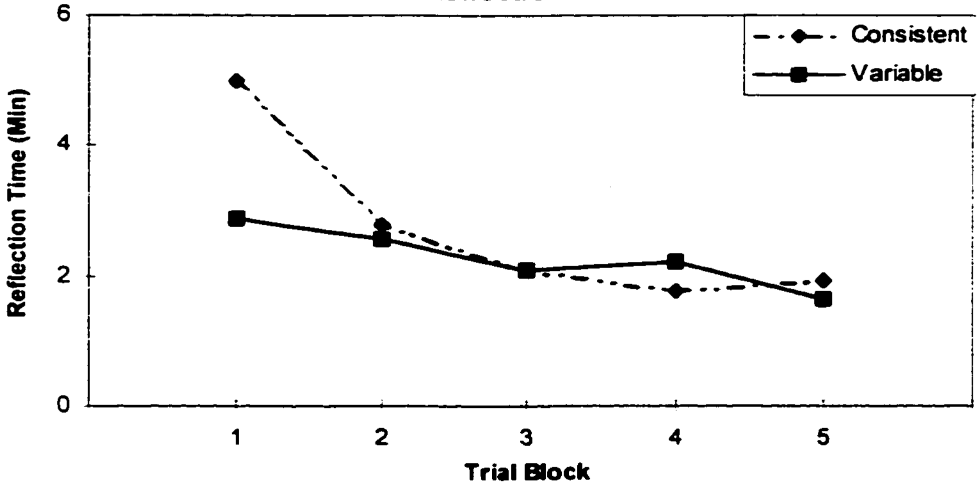
Figure 3. Reflection Time as a function of Training Lesson and Trial Block



Note. A significant linear trend was observed for Lesson 3.
A significant quadratic trend was observed for Lessons 1 and 2.
Reflection times per block were divided by the number of practice items within the block in order to allow comparisons between sessions and to make trends more explicit.

The source of this interaction, which is displayed in Figure 4, arises from Lesson 1 in which individuals in the Consistent practice group required a significantly greater amount of Reflection Time on the first block of trials. To examine further differences in performance based on practice type, additional analyses of Working Time[6] were conducted only on the subset of items that were performed differently according to the practice condition. Overall, the results parallel those discussed above, indicating that individuals who practice executing commands using a single method or shifting between different methods take about the same amount of time to complete them.

Figure 4. Lesson 1: Practice Type x Trial Block Interaction for Reflection Time



6 Reflection time was not examined because for each block of trials it was computed by subtracting Working Time from the overall block time. Therefore, there is no method by which one could obtain Reflection Time only for selected items within a block of trials.

Accuracy Measures

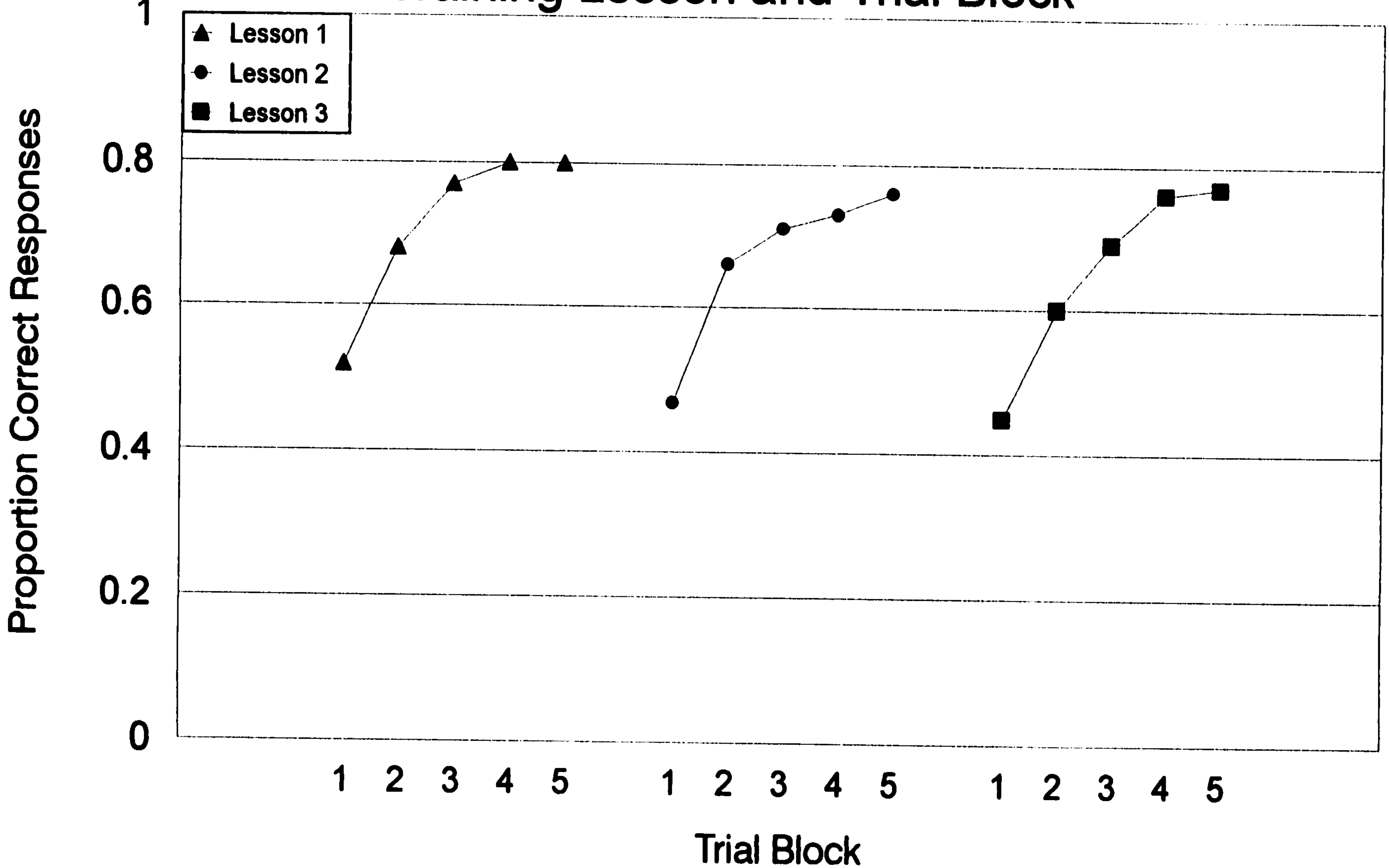
As described in the Method section, two measures of performance accuracy were collected. The first, overall accuracy, was based on a score ranging from 0 to 2 for each of the exercise items. The second, first trial accuracy, was based on the proportion of molecules that the participant performed correctly on her first trial. First trial accuracy was thought to be a more sensitive method to measure changes in performance over time. Repeated measures ANOVAs were conducted separately for these two measures of performance. Because the total number of items and molecules differed across sessions, overall accuracy was expressed as the proportion of items correct.

1. Overall Accuracy

Results from the 2 (Training Group) x 2 (Practice Type) x 5 (Trial Block) x 3 (Lesson) repeated measures ANOVA showed that overall accuracy significantly decreased across lessons although the difference was not significant between Lessons 2 and 3, $F(2,68) = 18.52$, $p < .001$, $\eta^2 = .35$. The participants achieved an averaged score of 78.74 out of a possible 110 points (70.75% correct responses) on Lesson 1, 66.65 out of a possible 100 points (62.17%) on Lesson 2, and 52.31 out of a possible 80 points (60.81%) on Lesson 3. This decrease is most likely due to the fact that the lessons were designed so that easier concepts were trained first.

Across the three lessons, no main effects or interactions for either the training or practice conditions were observed. A significant Trial Block effect was observed, $F(4,136) = 109.56$, $p < .001$, $\eta^2 = .76$, such that performance increased with practice. Figure 5 depicts graphically the significant linear and quadratic trends which shows the amount of block-to-block gain that increased as practice progressed. Additional analyses, which were conducted to further

Figure 5. Proportion Overall Accuracy as a function of Training Lesson and Trial Block



<u>Note</u>. Significant quadratic trends were observed for Lessons 1 through 3.

examine differences in performance based on practice type, were parallel to those discussed above, indicating that individuals who practice executing commands using a single method or shifting between different methods perform similarly.

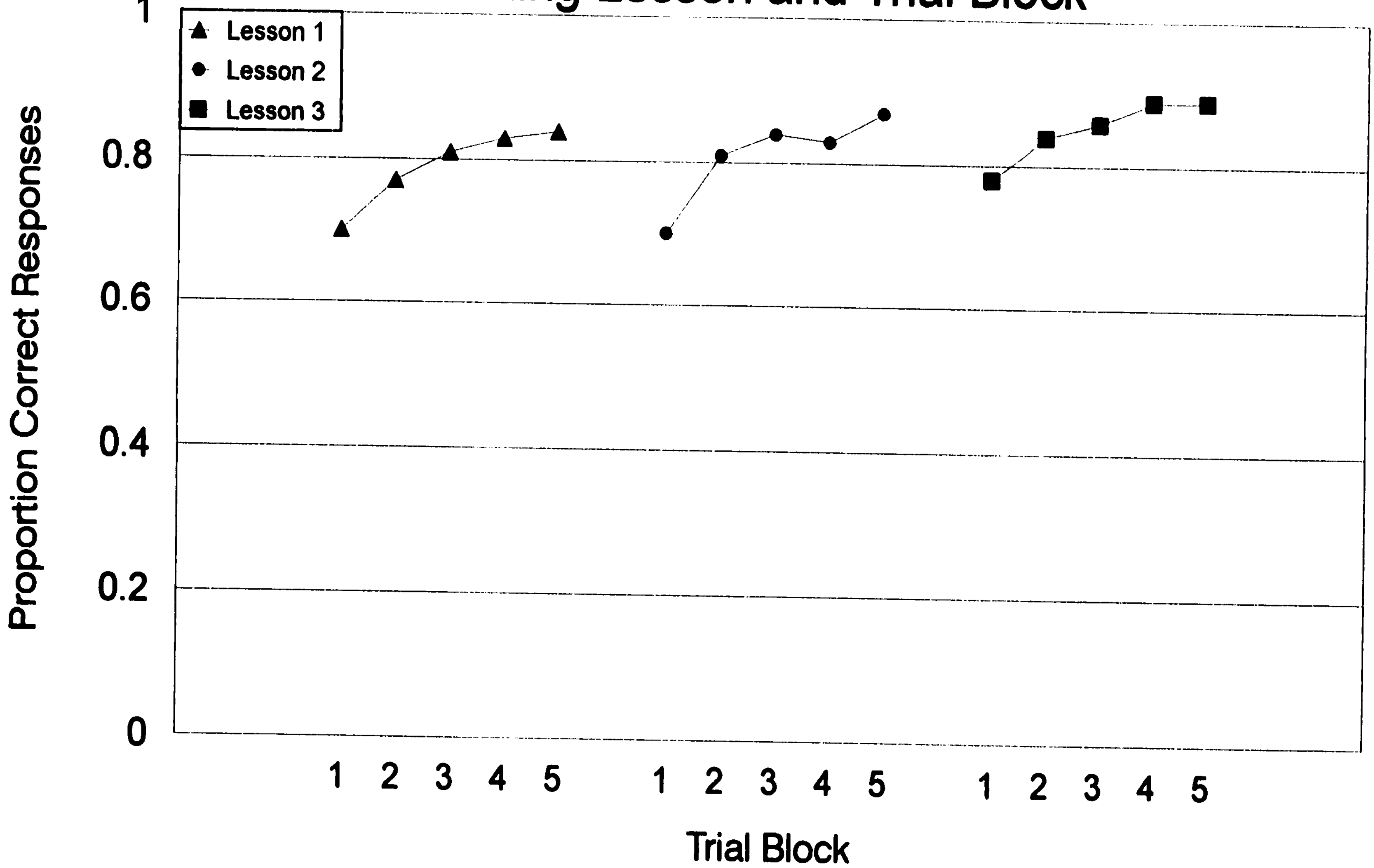
2. First Trial Accuracy

As previously described, the practice items can be broken into their component parts, referred to as molecules. Percentage of molecules correctly completed on the participant's first attempt were 80% (SD = 10%), 81% (SD = 9%) and 85% (SD = 7%) for Lessons 1 through 3 respectively. The analyses yielded similar findings to those obtained by the overall accuracy data and the data are depicted graphically in Figure 6. In addition, the analyses that were conducted to further examine differences in performance based on practice type, were also similar to those discussed above. Furthermore, the correlations between these two variables ranged between .88 and .94, indicating that they measure virtually the same thing. First trial accuracy will therefore not be discussed further.

Total Errors

The total number of errors was obtained by summing across the 12 error categories that were scored. Errors within each category are analysed in a subsequent section. Overall, results from the 2 (Training Group) x 2 (Practice Type) x 5 (Trial Block) x 3 (Lesson) repeated measures MANOVA revealed that total errors per item significantly increased across Lessons, $F(2,68) = 46.37$, $p < .001$, $\eta^2 = .58$. Parallelling the accuracy data, the participants produced many errors in Lesson 1 (M = .99 errors per item; SD = .32) and even more errors on Lessons 2 (M = 1.64; SD = .90) and 3 (M = 1.86; SD = .83).

Figure 6. Proportion First Trial Accuracy as a function of Training Lesson and Trial Block



Note. Significant quadratic trends were observed for Lesson 1 through 3.

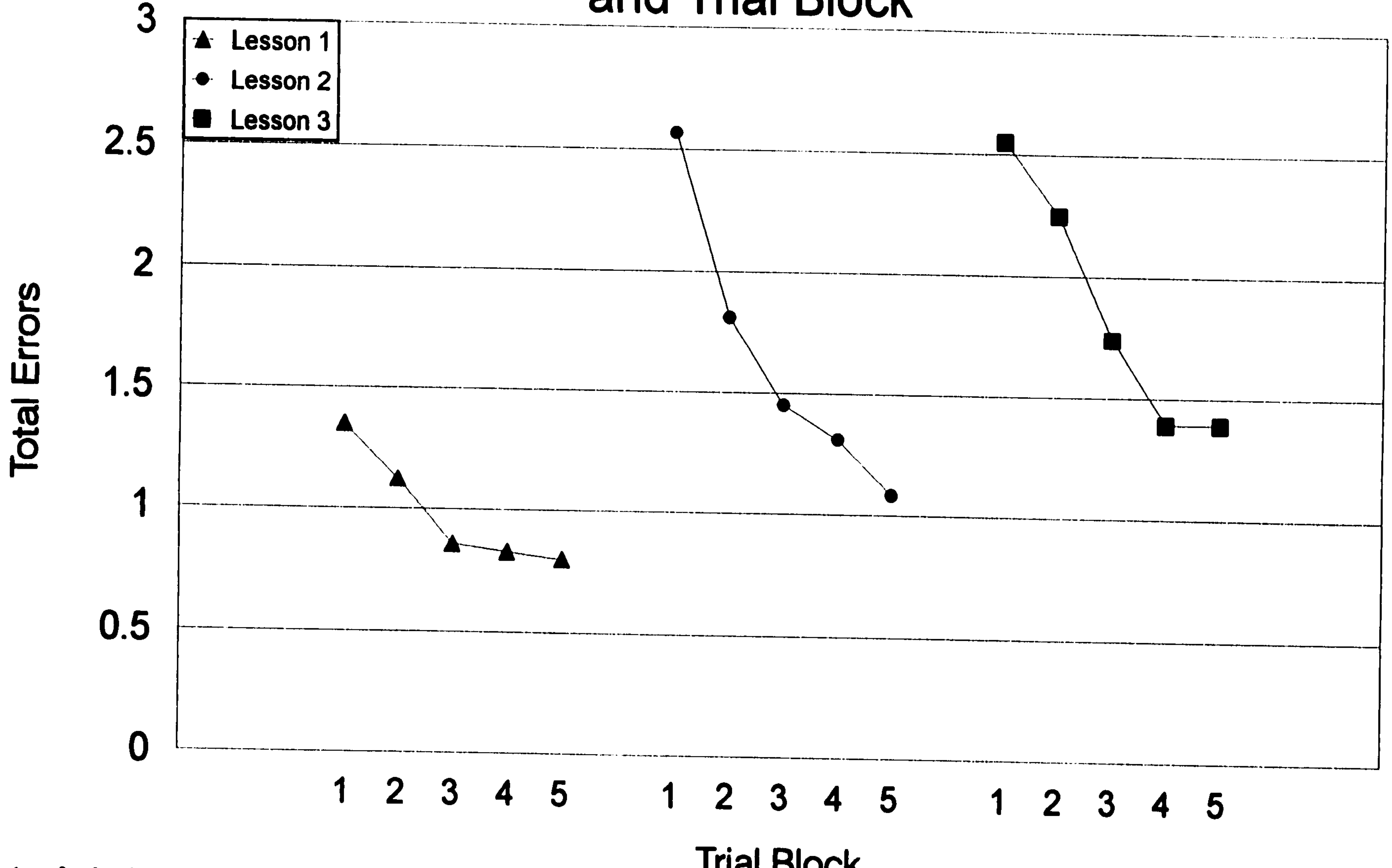
Across the three lessons, no main effects for either the Training Group or Practice Type conditions were observed. A significant Trial Block effect, $F(4,136) = 67.72$, $p < .001$, $\eta^2 = .67$, was observed, indicating that the participant's production of incorrect responses decreased with practice. Significant linear and quadratic trends were also observed, with the amount of block-to-block gain increasing as practice progressed (see Figure 7). A Lesson x Trial Block interaction, $F(8,272) = 6.16$, $p < .001$, $\eta^2 = .15$, was also observed with the participants producing fewer errors for each succeeding lesson, but to a different degree for each of the trial blocks within them. For example, whereas the average change in the number of errors between the first and last trial blocks was only .55 errors per item for Lesson 1, the average change per item was significantly higher for Lessons 2 (1.49 errors) and 3 (1.16 errors). The analyses that were conducted to examine differences in performance based on practice type, yielded no additional findings to the ones described above.

Overall, the findings discussed here are very similar to those obtained for the accuracy data, suggesting that the number of errors produced and accuracy of performance provide redundant information. In fact, the correlations between errors produced and overall accuracy for each of the lessons ranged between -.72 and -.84, indicating that participants who produced more errors were less accurate in their performance.

Error Categories

As previously described, participants made few errors in total during the Introductory session. In fact, the only categories of errors possible during this

Figure 7. Total Errors as a function of Training Lesson and Trial Block



<u>Note</u>. A significant linear trend was observed for Lesson 2.
A significant quadratic trend was observed for Lessons 1 and 3.
Total Errors per block were divided by the number of practice items within the block in order to allow comparisons between sessions and to make trends more explicit.

session included Mouse errors, Object Errors, Mode errors, and Miscellaneous errors. Whereas participants made approximately the same number of mouse errors (range = 1.73 to 2.23 errors) across blocks of trials, they made fewer object errors ($F(1,184) = 8.98$, $p < .001$, $\eta^2 = .16$), and mode errors ($F(1,184) = 2.91$, $p < .05$, $\eta^2 = .06$) with practice. The number of miscellaneous errors made was small ($M = .04$ errors) but consistent across trials.

Table 10 presents the number of errors for the first and final blocks of trials for all 12 error categories for Lessons 1 through 3. A 2 (Training) x 2 (Practice) x 5 (Block) repeated measures MANOVA on error types was conducted separately for each of the three lessons. Overall, these analyses showed that within each lesson, the number of errors produced, decreased with practice for most of the categories. With practice, errors decreased in 8 of the 11 categories for Lessons 1 and 2, and for 7 of the 12 error categories in Lesson 3. Although there were three instances in which the number of errors were *larger* for the final block of trials, in no case was this increase significant statistically.

With respect to group differences, the pattern of results is inconsistent. For example, during Lesson 1, individuals in the Variable Practice condition ($M = 11.17$) made significantly more insertion point errors than individuals in the Consistent Practice condition ($M = 6.38$), most probably due to the fact that individuals in the Variable Practice condition had to keep track of whether they were to place the insertion point before or after text to be edited (i.e, to correctly use the backspace or delete key) while individuals in the Consistent Practice condition always placed the insertion point either before, or after, the text. Furthermore, individuals trained in the Text condition made significantly more scroll bar (M = .75) and mode errors (M = 6.83) than individuals in the Multimedia condition (M = .22, 4.43, respectively).

Table 10. Number and Types of errors made across practice sessions for the first and final blocks of trials

	Lesson 1			Lesson 2			Lesson 3		
Type	B1	B5	Δ	B1	B5	Δ	B1	B5	Δ
MSE	2.83	1.65	* 1.18	1.69	1.40	.29	1.98	2.05	-.07
KEY	1.34	1.02	* .32				.46	.55	-.09
SCR	.17	0	* .17	1.52	1.09	* .43	.73	.43	.30
SEL				6.06	1.42	* 4.64	2.90	1.98	* .92
SPK	1.36	.93	.43	.13	.02	.11	.71	.19	* .52
INP	2.00	1.28	* .72	1.56	1.28	* .28	1.88	.67	* 1.21
MEN	1.49	.98	* .51	6.10	2.19	* 3.91	3.48	1.31	* 2.17
DLG	1.51	.50	* 1.01	1.52	.40	* 1.12	4.87	2.07	* 2.80
DLK	1.45	.39	* 1.06	.85	.30	* .55	2.33	.67	* 1.66
MOD	1.68	1.02	* .66	2.92	.98	* 1.94	2.21	.60	* 1.61
OBJ	.34	.57	-.23	3.10	1.53	* 1.57	.69	.36	.33
MIS	.74	.46	.28	.83	.21	* .62	.25	.25	0
Total	14.91	8.80	* 6.17	27.06	10.81	*16.25	22.48	11.12	*11.36

Note. * $p < .05$ Based on the within-subjects component of the 2 (Training) x 2 (Practice) x 5 (Block) repeated measures MANOVA.

Shading refers to types of error that could not be made during the session.

B1 = First block of trials; B5 = Final block of trials; Δ refers to relative change from Block 1 to 5; See Appendix H for a detailed description of the error categories, or Table 3 for a brief definition of the error categories.

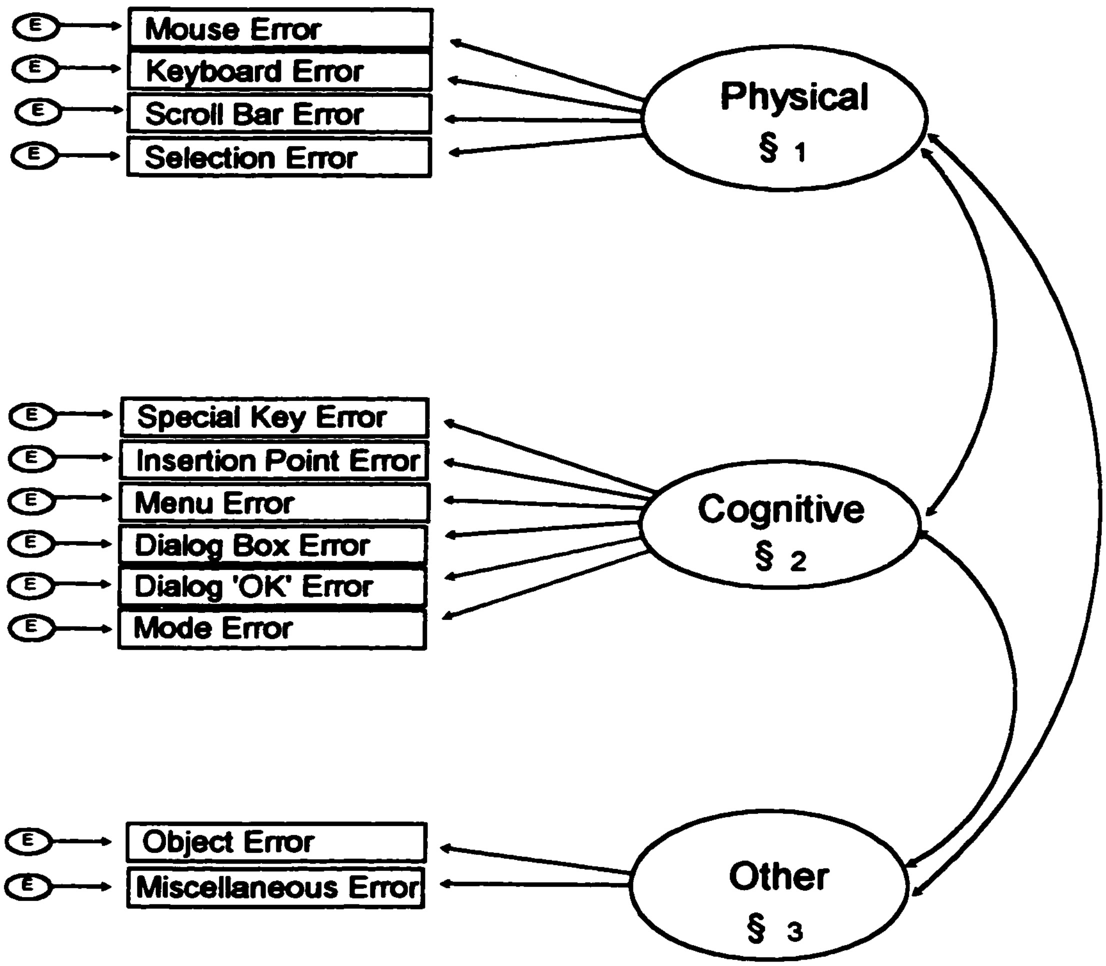
During Lesson 2, individuals trained with multimedia demonstrations made significantly more mouse errors (M = 8.08), selection errors (M = 20.63), and miscellaneous errors (M = 3.33) but fewer errors with the special keys (M = .13) than individuals in the Text condition (M = 5.79, 13.67, 1.79, .46, respectively). During Lesson 3, individuals in the Variable practice condition made significantly more mouse errors (M = 10.63) than individuals in the Consistent practice condition (M = 6.46). In addition, Training x Block interactions were observed for dialog errors and mode errors, while a Practice Type x Block interaction was observed for mode errors.

Modelling the error categories

The 12 error categories were thought to be divisible into three broad classes: (a) errors that are based on the physical aspects of using a computer which include errors using the mouse or keyboard, and errors made when selecting text or scrolling through the document, (b) errors based on one's understanding of, or memory for, the use of specific special keys (e.g., backspace and delete), menus, and dialog boxes, as well as one's ability to remember to place the insertion point, click on the OK button to exit a dialog box, and one's general understanding of the interface, and (c) miscellaneous errors or errors due to inattention (e.g., doing commands on the wrong section of text).

In order to test this model, the error categories across sessions were summed together in order to get the total number of errors made per category. A confirmatory factor analysis was then performed through LISREL VII (Jöreskog & Sörbom, 1989). In the present model, each measured variable was specified as having a loading on only one latent construct. The latent factors were allowed to correlate with each other and the unique (i.e., random error) factors were specified as being uncorrelated among any other factors or measured variables. Furthermore, all of the coefficients in the variance-covariance matrix of the latent factors (Phi) were free to be estimated by LISREL. The diagonal elements consisted of the factor variances and the off-diagonals are covariances. The error/uniqueness components of each measured variable (i.e., the diagonal values of the theta delta matrix) were also free to be estimated by LISREL. The off-diagonal elements were set to zero since it was assumed that there were no correlations between the errors of the measured variables. In contrast to the common exploratory factor analytic models, LISREL allows for covariances among error/uniqueness (Marsh & Hocevar, 1985, 1987). A three factor model of classes of errors was hypothesized with each measured variable having a loading on only one latent construct (i.e., one class of errors). The conceptual model used for the present analysis is represented in Figure 8. Specifically, the three latent constructs are depicted in ovals and include: (a) errors associated with the physical aspects of using a computer, (b) errors associated with the cognitive aspects of using a computer, and (c) other types of errors. The measured variables include 12 error categories which are depicted in rectangles. Finally, measurement error or uniqueness (depicted as ϵ within circles) is associated with each of the measured variables. Uniqueness refers to a composite of random measurement error and specific measurement error associated with a particular measuring instrument. In a cross-sectional study, the two can not be separated (Gerbing & Anderson, 1984). The statistical model included 12 factor loadings, 6 coefficients in the phi variance-covariance matrix, and 12 error/uniqueness components to be estimated.

Figure 8. Three factor CFA model for Error Categories.



Within each factor, one loading was arbitrarily fixed to unity (i.e., 3 factors were set to 1), in order to identify the model by setting reference indicators, and to set a scale or metric for the factors (Marsh & Hocevar, 1985). The total number of parameters to be estimated was 27 and the analysis was conducted on the data from 47 participants. Although the subject to parameter ratio is considered to be extremely small, such analyses have been discussed in the literature (Tabachnick & Fidell, 1996) when they are used for exploratory purposes.

The confirmatory factor analysis was conducted on the observed correlation matrices, rather than the covariance matrix, since either kind of matrix will yield the same statistical indices of fit (Cudeck, 1989). As expected, the independence model that tests the hypothesis that all variables are uncorrelated was easily rejectable, χ^2 (66, N = 47) = 303.44, $p < .01$. In contrast, the test of the 3 factor model that assumes the 12 error categories represent 3 latent constructs yielded a chi-square of 65.62 ($p > .05$) with 51 degrees of freedom and a comparative fit index (CFI) of .94. A CFI value greater than .90 is indicative of a good fitting model and the CFI does an excellent job at estimating model fit even in very small samples (Bentler, 1995). Alternative approaches for the evaluation of the closeness of fit have been described (Bentler & Bonet, 1980; Bollen, 1990; Byrne, 1989; Marsh, Balla, & McDonald, 1988). Two of these methods for estimating goodness of fit also indicated satisfactory fit of the model to the data. Specifically, the Goodness of Fit Index (GFI), which is considered to be the relative amount of variance and covariance jointly accounted for by the model, was .81 and exceeded the .80 criterion for good fit when using that method (Byrne, 1989). In addition, the ratio of the chi square to degrees of freedom was 1.29 which likewise indicated good fit (Byrne, 1989). A third method, the Adjusted Goodness-of-fit Index (AGF; Brown, 1986), which adjusts the GFI for degrees of freedom, yielded a value of .71, which was lower than the criterion (Byrne, 1989).

Taken together, three of the four indices indicate that the correlation matrix and the hypothesized model are similar and a three factor model adequately represents the data. However, given the extremely small sample size, these analyses would need to be replicated with a larger sample before one can confidently say that the 12 types of errors can be divided reliably into 3 broad categories.

<u>Help</u>

Two variables were included in order to control for the amount of help given to the participant. The first, Requests for Help, is the number of instances in which the participant requested help from the experimenter. The second, Interventions, is the number of instances in which the experimenter actually provided help to the participant, whether it was requested or initiated by the experimenter. Because Requests for Help could have, but did not always result in an Intervention, there is a fairly large degree of overlap between these two variables with the correlations ranging from .33 to .69 for the different sessions.

<u>1. Requests for Help</u>

Overall, total requests for help per exercise item significantly increased across lessons from .27 (<u>SD</u> = .15) on Lesson 1 to .43 (<u>SD</u> = .31) on Lesson

2 and .47 ($\underline{SD}$ = .27) on Lesson 3, $\underline{F}(2,68) = 19.90$, $\underline{p} < .001$, $\eta^2 = .37$. Across the three lessons, no main effects for either the training or practice conditions were observed. There was a significant effect of Trial Block, $\underline{F}(4,136) = 90.01$, $\underline{p} < .001$, $\eta^2 = .73$, and a Lesson x Trial Block interaction, $\underline{F}(8,272) = 7.64$, $\underline{p} < .001$, $\eta^2 = .18$. This interaction revealed that a decrease in number of requests for help was observed across blocks of trials, but to a different degree for each of the lessons. Whereas the average change in requests for help between the first and final blocks of Lesson 1 was only .49, it was much higher for Lessons 2 (.83 requests per item) and 3 (.85 requests per item). Nonetheless, these results indicate that as the participants learned how to use the word processor, they required less help. A significant Training Group x Trial Block interaction was also observed, $F(4,136) = 3.31$, $\underline{p} < .01$, $\eta^2 = .09$, which arose from Lesson 3. Individuals in the Multimedia condition made significantly more requests for help during the first block of trials but no longer differed from the Text condition with additional trials (see Fig. 9). Significant quadratic trends were observed for each of the three lessons (see Figure 10).

Figure 9. Lesson 3: Training Group x Trial Block Interaction for Requests for Help

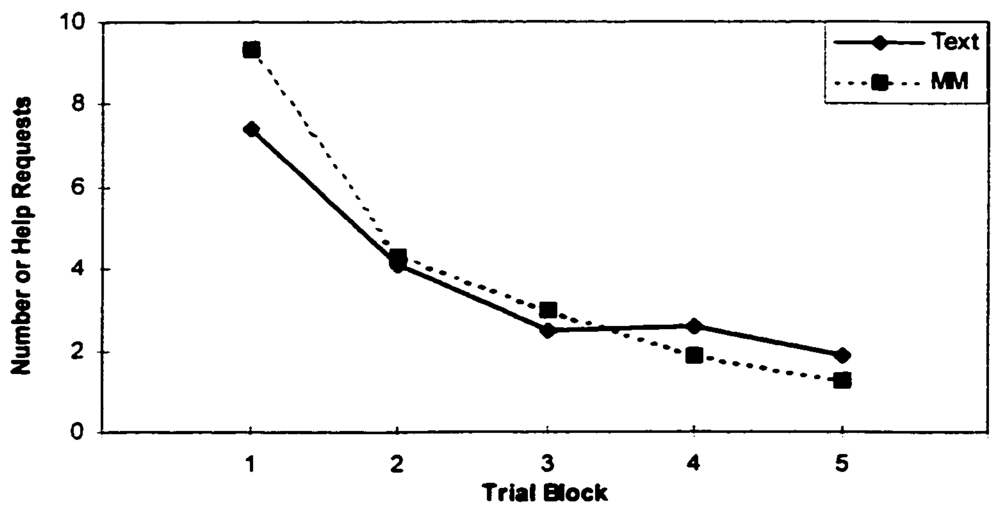
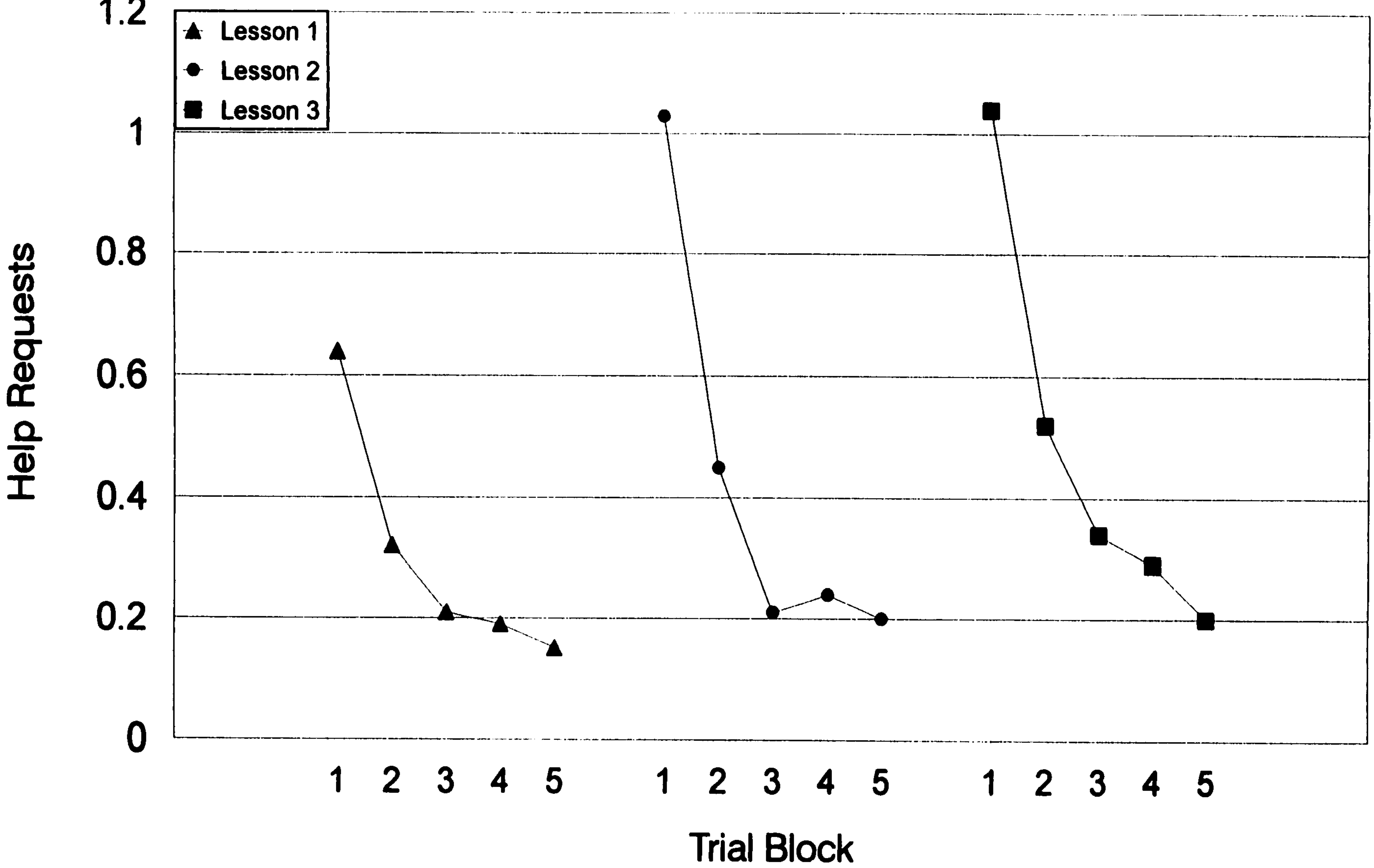


Figure 10. Requests for Help as a function of Training Lesson and Trial Block



Note. **Significant quadratic trends were observed for each of the sessions.**
Based on number of help requests per item.
Hel requests per block were divided by the number of practice items within the block in order to allow comparisons between sessions and to make trends more explicit.

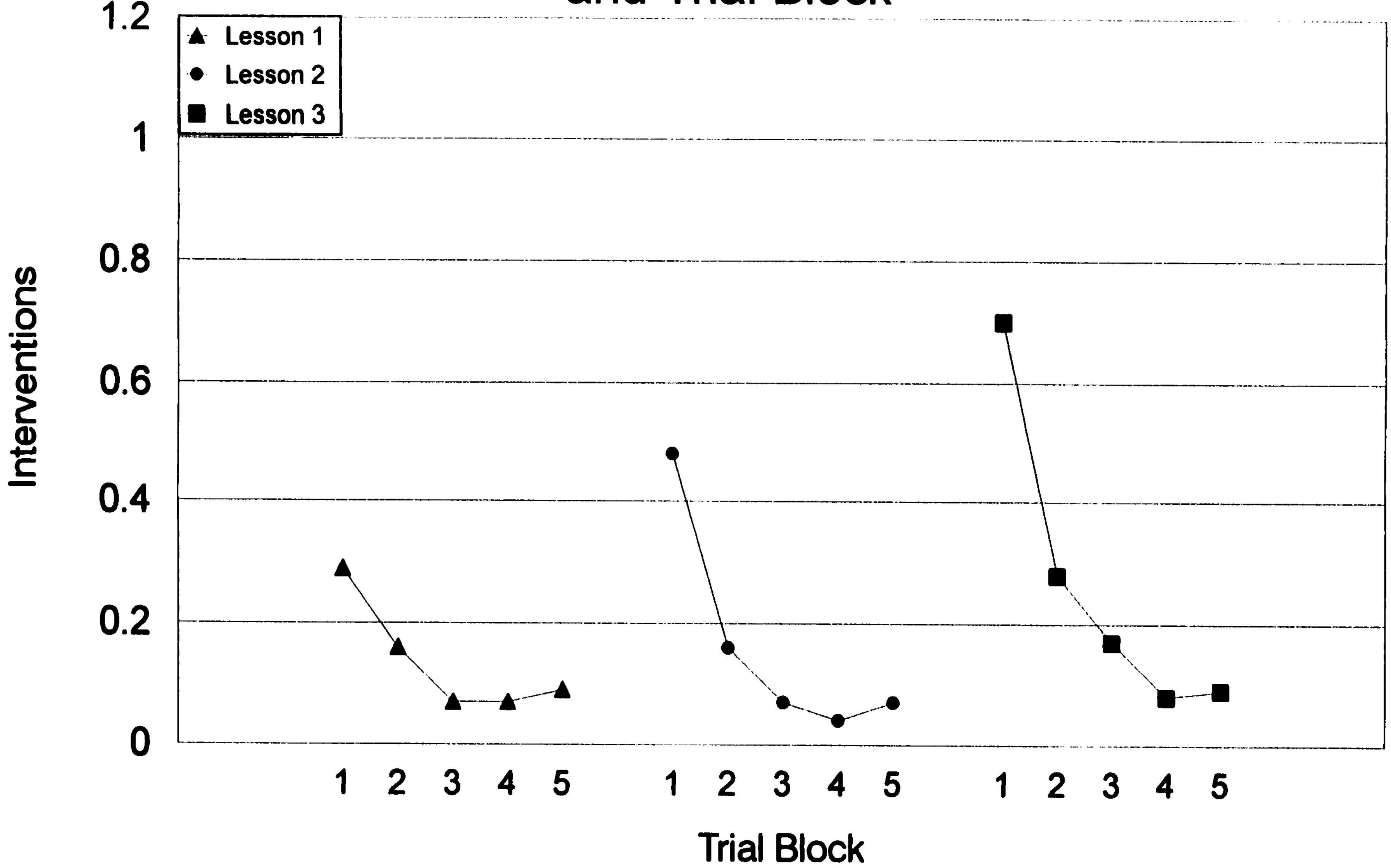
The analyses conducted on the subset of items relevant to the manipulation of practice type, yielded no additional finding over those described above.

2. Interventions

As with help requests, the number of interventions increased significantly across lessons, $F(2,68) = 20.11$, $p < .001$, $\eta^2 = .37$. The participants required 0.14 interventions per item ($SD = .15$) during Lesson 1, 0.16 intervention per item ($SD = .17$) during Lesson 2, and .26 interventions per item ($SD = 14.34$) during Lesson 3. Again, these results most probably reflect the fact that more difficult concepts were trained as the days progressed. Results from the 2 (Training Group) x 2 (Practice Type) x 5 (Trial Block) x 3 (Lesson) repeated measures MANOVA yielded nonsignificant findings for the main effects of Training Group and Practice Type. Parallelling help requests, a main effect for Trial Block, $F(4,136) = 54.58$, $p < .001$, $\eta^2 = .62$, and a Lesson x Trial Block interaction was observed, $F(8,272) = 7.40$, $p < .001$, $\eta^2 = .18$, indicating that the number of interventions consistently decreased across blocks of trials for each of the three lessons, but at a different rate for each of the lessons. Whereas the average change in interventions between the first and final blocks of Lesson 1 was only .20, it was much higher for Lessons 2 (.41 interventions) and 3 (.50 interventions). Significant quadratic trends were also observed for each of the three lessons (see Figure 11).

A significant Training Group x Block interaction was also observed, $F(4,136) = 3.84$, $p < .01$, $\eta^2 = .09$, which arose from Lesson 1. Although none of the individual pairwise comparisons were significant, there was a crossover effects such that individuals in the Multimedia condition initially

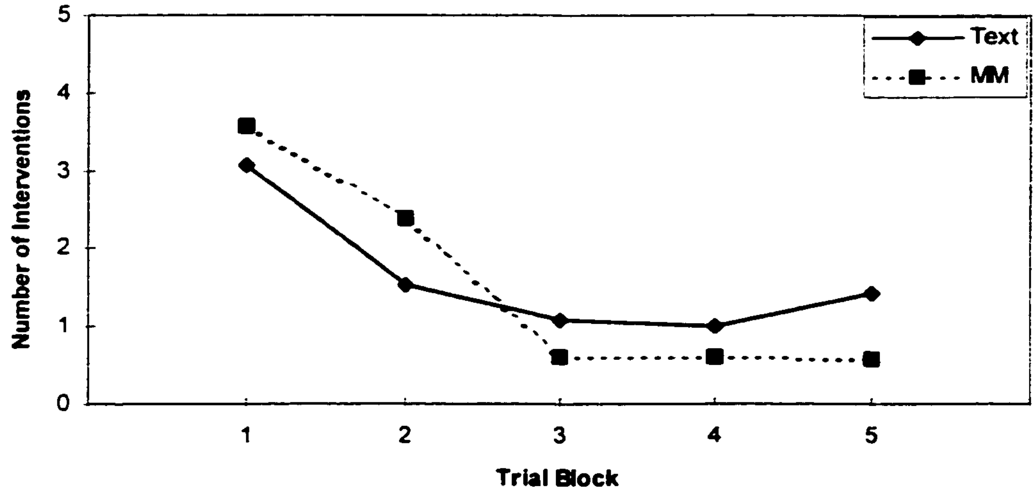
Figure 11. Interventions as a function of Training Lesson and Trial Block



<u>Note</u>. A significant linear trend was observed for the Introductory Session. Significant quadratic trends were observed for Lessons 1 through 3. Interventions per block were divided by the number of practice items within the block in order to allow comparisons between sessions and to make trends more explicit.

required more interventions than those in the Text condition but by the third block of trials the pattern was reversed (see Fig. 12). This interaction was no longer observed when the analyses were repeated only on those items that varied according to the practice condition.

Figure 12. Lesson 1: Training Group x Trial Block Interaction for Number of Interventions



Types of Requests for Help

As discussed in the Methods section, requests for help were divided into five categories; (a) questions pertaining to the task instruction, (b) procedural questions, (c) confirmatory questions, (d) declarative questions, and (e) advanced questions. The mean number of help requests across session for each of the 5 help request categories is presented in Table 11.

Table 11. Total Number and Types of Help Requests by Session

Session	Task Instructions	Procedural Questions	Confirmatory Questions	Declarative Questions	Advanced Questions	Overall
Lesson 1	0.87 (0.84)	5.53 (3.44)	3.11 (3.45)	4.26 (2.72)	0.87 (1.23)	14.63 (8.38)
Lesson 2	0.68 (1.02)	5.34 (3.48)	8.21 (8.53)	6.45 (5.14)	0.63 (1.08)	21.32 (15.35)
Lesson 3	1.00 (0.93)	5.32 (3.51)	6.50 (4.84)	5.13 (3.11)	0.92 (1.50)	18.87 (10.72)
Overall	2.55 (1.81)	16.19 (9.12)	17.82 (14.48)	15.84 15.84)	2.42 (2.71)	54.82 (31.49)

Notes. Brackets refers to standard deviation.
N = 38 participants (only those who completed all 3 lessons).

Types of help requests were analyzed through a series of 2 (Training Group) x 2 (Practice Type) x 5 (Help Request category) x 3 (Lesson) repeated measures MANOVA. Overall, no group differences with respect to Training condition or Practice type were observed. The observed main effect for Lesson, $F(2,68) = 9.33$, $p < .001$, $\eta^2 = .21$, is consistent to the one previously described. A main effect for Type of Help Request, $F(4,136) = 49.98$, $p < .001$, $\eta^2 = .60$, was also observed. When summed across sessions, individuals asked about the same number of questions pertaining to the task instructions ($M = 2.88$) and advanced type questions ($M = 2.57$), and these were significantly fewer than that of procedural ($M = 17.48$), confirmatory ($M = 19.03$), or declarative ($M = 16.99$) questions, for which equal amounts were requested. Furthermore, within sessions, the types of questions asked did not vary as a function of blocks of trials.

Introductory Session

As previously stated, the Introductory session is both qualitatively different, and much shorter, than the three word processor training lessons. In addition, because all participants completed the Introductory session using the same method, it serves no purpose to include Practice type in these analyses. Thus, the analyses described here were conducted through a series of 2 (Training Group) x 5 (Trial Block) repeated measures ANOVAs[7].

Overall, the participants performed quite well on the 30-item Introductory session. They achieved a score of 52.35 out of a possible 60 points (87.34%) and made an average of only 11.33 errors (SD = 9.65 errors) overall. In addition, on their first attempt the participants correctly completed 90% (SD = 7%) of the total number of molecules. The correlation between first trial performance and overall accuracy was .81. The participants completed the session quickly, requiring only 3.96 minutes (SD = 1.88 minutes) of Working Time and significantly less (M = 2.02, SD = .75 minutes) Reflection Time, $t(47) = 8.33$, $p < .001$. The participants also required very little help (M = 1.79, SD = 1.88 help requests) and even fewer interventions (M = .44, SD = 0.85 interventions) overall.

No main effects for Training Group was observed for the Introductory session, most probably due to the ease of the items trained during this session. However, a significant Trial Block effect was observed for Working Time,

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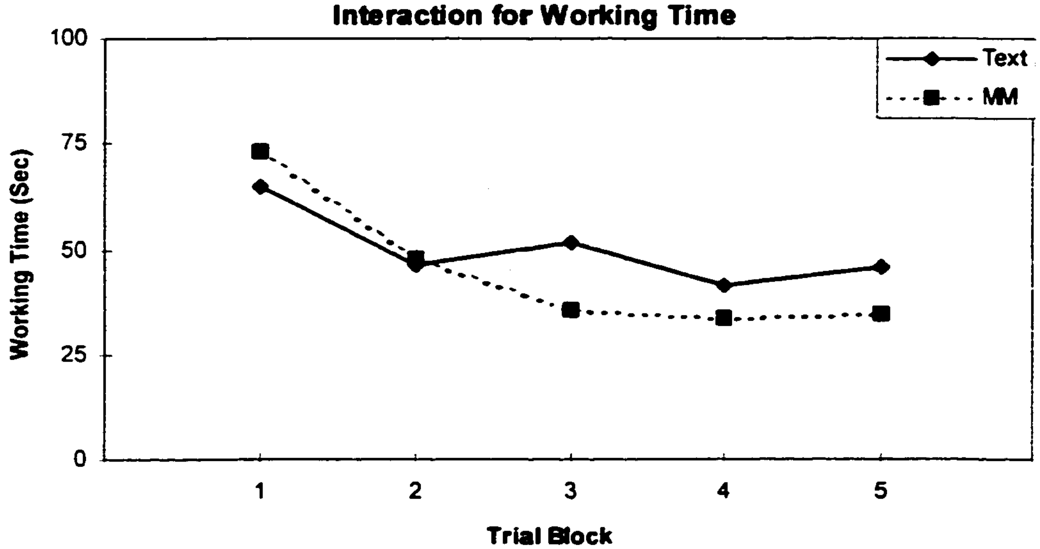
[7] Supplemental analyses were conducted to examine performance on the Introductory session relative to the word processor training lessons. In all cases, performance on the Introductory session was superior to that of the other lessons, most likely due to the relative ease of the tasks presented in this session.

$F(4,184) = 20.91$, $p < .001$, $\eta^2 = .31$, and Reflection Time, $F(4,184) = 15.90$, $p < .001$, $\eta^2 = .26$, with both measures of time decreasing with successive blocks of trials. In addition, a significant Training Group x Trial Block interaction was observed for Working time, $F(4,184) = 3.14$, $p < .05$, $\eta^2 = .31$, in which there was a crossover effect such that individuals in the Multimedia condition initially required more time than those in the Text condition, but with additional blocks the Text group required more time than the Multimedia group (see Figure 13).

Figure 13. Introductory Session: Training Group x Trial Block Interaction for Working Time



Part 5: Final Day and Follow-up

Multiple Choice Quizzes

Immediately after completing the training phase of each day's session, the participants were asked to complete a 10-item multiple choice quiz. On Day

5 and at post-test (i.e., the mail follow-up), all participants were asked to complete a final quiz which contained all the items from each of the four days of training. Internal consistency reliabilities were .71 across the four daily quizzes, .73 for the Day 5 quiz, and .85 for the post-test quiz. Average item-to-total correlations was .46 on the training day quizzes, .47 on the Day 5 quiz, and .48 on the post-training quiz. These results indicate that the test could reliably differentiate between those who had learned the material and those who did not. The means and standard deviations for the multiple choice quizzes are presented in Table 12.

Table 12. Means and Standard Deviations for the multiple choice quizzes

	Study Day		**Final Day**		**Follow-up**	
Introductory Session	6.46	(2.08)	6.81	(1.95)	6.89	(2.39)
Lesson 1	4.48	(1.73)	4.79	(1.91)	5.09	(1.66)
Lesson 2	4.46	(1.61)	4.42	(1.33)	5.13	(1.60)
Lesson 3	5.29	(1.64)	5.31	(1.64)	4.80	(1.89)
Overall Score	20.69	(5.04)	21.33	(5.05)	21.81	(5.26)

Note. The inter-correlations for Overall Quiz Score across administrations ranged between $r = .61$ and .71, $p < .001$. The 40-item final day and follow-up quizzes were divided into the four lessons from which they derived. Performance on each individual quiz is based on a score of 10. Maximum overall score is 40. Brackets refer to Standard Deviations.

Performance on each training day's quiz was summed together and compared to the quizzes administered during the final study day and at follow-up through a 2 (Training condition) x 3 (Administration Time) repeated measures

ANOVA[8]. Across the four session's quizzes, neither a training condition, $F(1,44) = .20$, $p > .05$, nor an administration time effect, $F(2,88) = 1.96$, $p > .05$, were observed[9]. These results suggest that, regardless of the type of training provided, what the participants learned during training, remained stable over time

Given that the multiple choice quiz was administered immediately following the training phase of each day's session, it is of interest to determine the relationship between training and quiz performance. Time to complete the training, which was the only measure collected during training, was used as a measure of training performance. With the exception of the correlation between time to complete the Introductory session and the multiple choice quiz for that session ($r = -.48$, $p < .001$), the correlations did not differ significantly from 0, suggesting that training time was not a good predictor of multiple choice quiz performance ($r_{range} = -.25$ to $.12$).

The relation between performance on the quiz and actual performance on the word processor during practice is another element of interest. In order to

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8 Practice Type was not included in this analysis as this condition was only introduced in the practice phase of each day's session. Nonetheless, as one can argue that each preceding day's practice can have an effect on subsequent quiz performance, a preliminary analysis was conducted in which practice type was included as an independent variable. As expected, it was not significant.

9 The average number of days between Day 5 and receipt of the follow-up quiz was 43.75 ($SD = 33.88$ days). Because of positive skew, this variable was log transformed. Delay days, as a potential covariate, was examined in order to determine whether it was a significant predictor of the follow-up quiz. Overall, the number of days did not predict performance on the follow-up quiz (Beta = .11, $p > .05$, $r = -.23$, $p > .05$). Delay days was therefore not included as a covariate in any of these analyses.

examine this relationship, Pearson correlations were performed between each day's quiz and three of the major dependent variables from the first block of each day's session (Accuracy score, Working Time, and Number of Errors). Because performance increased as a function of practice, it was felt that the relationship between performance on the first block of trials and the quiz would be more meaningful than overall performance during practice. Given the participant's excellent performance during the Introductory session, it was not included in the current analyses. Furthermore, given that all of the participants completed the first block of trials, the data for all of the participants were included here.

Table 13 displays the pattern of correlations which are in the expected direction. For example, the higher ones quiz score, the better one's accuracy on each of the three lessons. Furthermore, higher quiz scores were associated with less Working Time for Lesson 3, and fewer errors during Lessons 2 and 3.

Table 13. Pearson Correlation Coefficients between Quiz and First Block Performance Variables

	Lesson 1	Lesson 2	Lesson 3
Accuracy	.34*	.37**	.44**
Working Time	-.26	-.24	-.50**
Errors	-.18	-.34*	-.43**

Note. * $p < .05$; ** $p < .01$

Integration and Transfer

During the final study day, the participants' ability to integrate and retain what they word processing task. In this task, the participants were required to use all of the commands that they had learned and practiced during the preceding days in order to edit a document. A 2 (Training Group) x 2 (Practice Type) multivariate analysis of variance (MANOVA) was performed on the following major dependent variables: overall accuracy score, Working Time, Reflection Time, number of errors, Requests for Help, Interventions, and number of items unattempted[10]. The analysis yielded non-significant findings for Training Group (Wilks' λ $F(7,36) = 1.16$, $p > .05$, $\eta^2 = .18$), Practice Type (Wilks' λ $F(7,36) = .51$, $p > .05$, $\eta^2 = .09$) and their interaction (Wilks' λ $F(7,36) = .51$, $p > .05$, $\eta^2 = .09$). Given these non-significant findings, univariate ANOVAs were not conducted.

An important part of any training system is to determine whether the trainee can apply what was taught to other similar functions (i.e., near-transfer). Transfer was assessed by having the participants attempt a similar exercise to the one described above, using a different word processor to which they had never before been exposed. A similar analysis to the one described for the word processor integration task was performed on the near transfer data and also yielded non-significant findings for Training Group (Wilks' λ $F(7,29) = .82$, $p > .05$, $\eta^2 = .16$), Practice Type (Wilks' λ $F(7,29) = .40$, $p > .05$, $\eta^2 = .09$) and their interaction (Wilks' λ $F(7,29) = .67$, $p > .05$, $\eta^2 = .14$). Given these non-significant findings, univariate ANOVAs were not conducted.

Table 14 presents the means and standard deviations for the word processor integration and near transfer tasks as a ratio of total task items. Given that a significant difference between unattempted items was observed

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10 The scoring of these exercises focused on item scores rather than the scoring of individual molecules. Thus, the proportion of first trial correct responses was unavailable.

across the two tasks ($t(38) = -3.99$, $p < .001$), the variables described above were adjusted to control for unattempted items. Although the means changed slightly, the adjustment had no significant effect on the results. The results described in the table are therefore based upon the uncorrected means.

The participants performed similar procedures in both the Word Processor Integration and Near Transfer tasks. As can be seen in the table, although the participants' Accuracy score was about equal, the participants required significantly more Working Time, Help, and Interventions per item during the Word Processor Integration task than during the Near Transfer task. Interestingly, participants required about the same amount of Reflection Time in both tasks.

In order to compare the dependent variables during the practice sessions and the Word Processor Integration and Near Transfer tasks, dependent variables per item were computed and then averaged over the sessions[11]. Overall, the participant's performance on the Word Processor Integration task was significantly lower than during the practice sessions. Accuracy scores were between 19 and 56% lower on the Word Processor Integration task. In the Near Transfer task, whereas participants required 96% more Reflection time, Working Time was 48% less than that required during the practice sessions. With the exception of the number of errors made, performance on the remaining variables was between 8 and 16% lower on the Near Transfer task.

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[11] The scores on the major dependent variables were summed across Lessons 1 and 3 and then divided by 3 (the number of lessons). Performance on the Introductory session was not included because; (a) there was very little variability in performance during this session, and (b) the skills required to complete the Introductory session were integrated within all other Lessons.

Overall, these data suggest that although the participants improved over the course of practice, when they were required to integrate everything that they had learned, or transfer it to a novel task, their performance decreased to about the level obtained during the first or second blocks of practice trials.

Table 14. Means and standard deviations for major dependent variables as a function of the number of items in the task

Dependent Variables	Per Item Avg across sessions[a]	Word Processor Integration	Near Transfer	t-test
Accuracy (proportion)	.70 (.13)	.58 (.17)	.61 (.17)	-1.64
Working Time/items	1.48 (.40)	1.77 (.47)	.98 (.25)	10.56 *
Reflection Time/item	.25 (.06)	.59 (.19)	.51 (.19)	2.25
Errors/item	1.41 (.64)	2.11 (.96)	1.36 (.65)	4.96 *
Help Requests/item	.38 (.22)	.76 (.40)	.39 (.23)	7.63 *
Interventions/item	.16 (.13)	.24 (.18)	.15 (.14)	3.14 *
Unattempted items/items	.01 (.02)	.04 (.04)	.09 (.09)	-3.89 *

Note. Ratios were computed by dividing the dependent variable by the number of items in each of the tasks.
t-tests compare the Word Processor Integration and Near Transfer tasks and are based on the dependent variable divided by the number of items in the task.
N = 32 for all comparisons which reflect the size of the sample for those participants who completed all three practice sessions, and both the Word Processor Integration and near transfer tasks.
Number of items = 28, 23 (Word Processor Integration, Near Transfer task)
* $p < .001$, df = 31
[a] Dependent variables per item were computed and averaged over Lessons 1 through 3.

During these tasks, participants were able to complete the items using any method they had learned. The technique by which they completed the commands was not examined. The following analyses were conducted on the subset of items which varied by condition during the practice sessions. Specifically, 13 of the 28 Word Processor Integration task items and 11 of the 23 Near Transfer task items were those which were varied according to practice condition. In order to examine whether the participants who practiced a single method differed from those who used dual methods, a 2 (Training Group) x 2 (Practice Type) MANOVA was conducted on the 6 major dependent variables: overall Accuracy score, Working Time, errors, requests for help, interventions, and number of unattempted items.

For the Word Processor Integration task, the analysis yielded non-significant findings for Training Group (Wilks' λ $F(5,38) = 1.27$, $p > .05$, $\eta^2 = .14$), Practice Type (Wilks' λ $F(5,38) = .52$, $p > .05$, $\eta^2 = .06$) and their subsequent interaction (Wilks' λ $F(5,38) = .54$, $p > .05$, $\eta^2 = .07$). A similar analysis performed on the Near Transfer data also yielded nonsignificant findings for Training Group (Wilks' λ $F(5,31) = 1.15$, $p > .05$, $\eta^2 = .16$), Practice Type (Wilks' λ $F(5,31) = .85$, $p > .05$, $\eta^2 = .09$) and the subsequent interaction (Wilks' λ $F(5,31) = .71$, $p > .05$, $\eta^2 = .10$). Given these non-significant findings, univariate ANOVAs were not conducted.

Mouse Test

The Mouse Test was administered on Day 1 prior to any computer training, and readministered on Day 5 after completion of all computer-related exercises in order to examine the degree to which one's ability to use the mouse increased with practice.

As described in the Method section, the Mouse Test was designed to assess the skills of button clicking, mouse manipulation, and their combination and was based on modified versions of the Finger Tapping and Trail Making Tests. Mouse clicking was assessed for both the left and right hand. Given that 87.2% of the participants were right handed, the expected right-sided dominance was obtained during both Mouse Test administrations, $t(35) = 8.04$, 5.94 (Day 1 & Day 5, respectively), $p < .001$. Furthermore, the correlation between hands was $r(36) = .71$, .79 (Day 1 & Day 5, respectively), $p < .001$ indicating that high right-handed performance was related to high left-handed performance for both administrations. Because laterality was irrelevant to this study, the average performance for the two hands was considered to be more important than individual hand performance.

A repeated measures MANOVA conducted on the three Mouse Test tasks yielded a significant multivariate effect of time administration, Wilks' λ $F(3,33) = 11.17$, $p < .001$, $\eta^2 = .50$. Follow-up analyses showed no change across administrations in tapping the mouse (M = 42.25, 43.92, $F(1,35) = 2.05$, $p > .05$), but a significant decrease in time to complete the mouse manipulation task from Day 1 (M = 66.65 secs) to Day 5 (M = 45.60 secs), $F(1,35) = 34.50$, $p < .001$, $\eta^2 = .50$), and also in the time to complete the combined clicking and manipulation task from Day 1 (M = 87.30 secs) to Day 5 (M = 57.19 secs), $F(1,35) = 17.20$, $p < .001$, $\eta^2 = .33$.

In order to examine the validity of the Mouse Test, Pearson correlation coefficients were computed between the mouse test components and the Finger Tapping Test and Trail Making Test (Form A), on which the Mouse Test was based. Average mouse clicking significantly correlated with average finger tapping for both administrations, $r(36) = .70, .58, p < .001$, respectively. Whereas mouse manipulation on Day 1 was only moderately correlated with Trails A, $r(36) = .35, p < .05$, on Day 5 it was highly correlated, $r(36) = .58$, $p < .001$. Similarly, the combined clicking and manipulation task was less correlated for Day 1, $r(36) = .35, p < .05$, than it was for Day 5, $r(36) = .47$, $p < .01$. Given that the mouse was a completely novel task for the participants, it is not surprising that the correlations are higher for the second mouse test administration.

With respect to performance during practice, Mouse Test performance was not related to any of the major dependent variables (accuracy, working time, errors) or to any of the specific error categories.

Attitudes Towards Computers

The Attitudes Towards Computers Questionnaire (ATCQ; Jay & Willis, 1992) which had been administered in the Introductory session, was readministered on Day 5, and then again as part of the mail-out questionnaire package at follow-up. A 2 (Training Group) x 2 (Practice Type) x 3 (Administration Time) repeated measures multivariate analysis of variance (MANOVA) was performed on the 7 dimensions of the ATCQ[12]. A significant

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12 Due to missing data during administration times 2 and 3, the sample size across all three administrations equals 44 participants in order to allow direct comparisons over time. Those participants with missing data on either of the two latter administrations (there was no missing data for the first administration) were compared on initial ATCQ scores to those with complete ATCQ data. These analyses yielded no differences in attitudes, suggesting that missing data were unrelated to attitude, and were in fact random.

time of administration effect was observed, $F(2,40) = 5.44$, $p < .01$, $\eta^2 = .21$, with attitudes becoming more positive over time. The group main effects, and their subsequent interactions with administration time were nonsignificant. Follow-up analyses which were conducted separately for each of the seven attitude dimensions, are summarized in Table 15.

Table 15. Means and Standard Deviations for the ATCQ over time

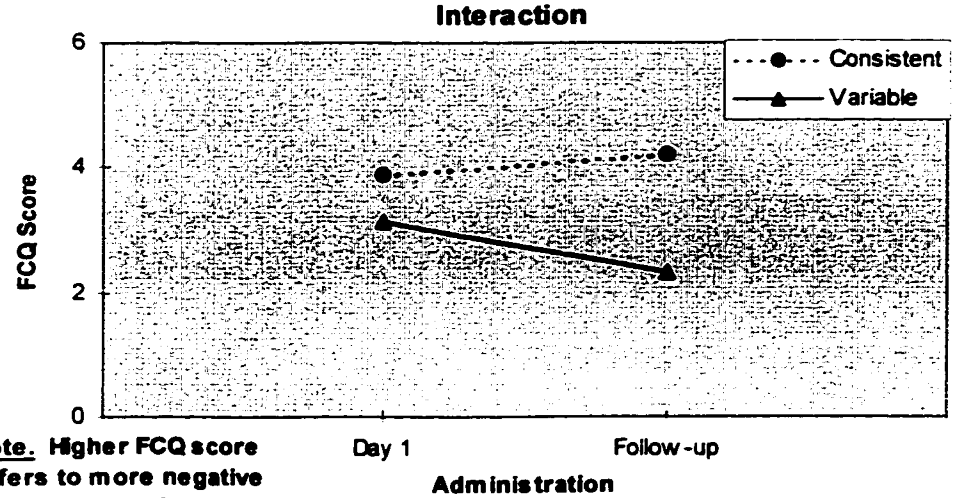
ATCQ Dimension	Day 1	Day 5	Follow-up	Administration F(2,82)
Comfort	14.85 (3.36)	12.45 (2.99)^	12.64 (3.13)^	18.75, η^2 = .31 ***
Efficacy	11.55 (2.02)	10.68 (2.05)^	10.36 (1.79)^	6.07, η^2 = .13 **
Gender Equality	9.43 (3.08)	8.45 (2.61)^	8.66 (2.77)	3.08, η^2 = .07 *
Control	13.89 (1.92)	13.36 (2.40)	12.90 (1.75)^	5.60, η^2 = .12 **
Dehumanization	21.35 (4.10)	21.77 (3.87)	22.16 (3.41)	1.35, η^2 = .03 NS
Interest	9.30 (2.31)	9.14 (2.10)	8.95 (2.07)	0.15, η^2 = .02 NS
Utility	14.68 (2.42)	14.78 (2.33)	14.68 (2.32)	0.03, η^2 = .00 NS
Total ATCQ	95.04 (8.97)	90.65 (7.50)^	90.35 (7.07)^	13.07, η^2 = .24 ***

Notes. ^ = significantly different from Day 1 ($p < .017$ using the Bonferroni Correction for multiple comparisons). No significant differences were observed between Day 5 attitudes and those at follow-up. Lower numbers reflect more positive attitudes.
*** $p < .001$; ** $p < .01$; * $p < .05$; NS = Non-Significant.

Significant administration effects were observed for the dimensions of computer comfort, efficacy, control, and for gender equality. When compared to attitudes at Day 1, better attitudes for the comfort and efficacy dimensions were observed both at Day 5 and at follow-up. Gender equality was significantly better only at Day 5, and Control, only at follow-up. No significant differences were observed between the follow-up administration and that on Day 5. The intercorrelations between the ATCQ administrations were quite high; Day 1 and Day 5, $r(44) = .62$, $p < .001$; Day 5 and follow-up, $r(44) = .67$, $p < .001$; and Day 1 and follow-up, $r(44) = .70$, $p < .001$.

The Feelings Towards Computers Questionnaire (FCQ) was also administered on Day 1 but was re-administered only at follow-up. A 2 (Training Group) x 2 (Practice Type) x 2 (Administration Time) repeated measures multivariate analysis of variance (MANOVA) was performed and yielded a significant administration effect, $F(1,43) = 28.23$, $p < .001$, $\eta^2 = .40$, with more positive feelings reported at follow-up (M = 4.04 vs. 2.73, Day 1 and follow-up, respectively; Lower scores indicate more favourable attitude). Although the group main effects were nonsignificant, an unexpected significant Practice Type x Administration interaction was observed, $F(1,43) = 5.47$, $p < .05$, $\eta^2 = .11$. As Figure 14 shows, attitudes became more positive over time in the Variable Practice group.

Figure 14. FCQ: Practice Type x Administration Time Interaction



Note. **Higher FCQ score refers to more negative feelings towards computers.**

In order to examine the relationship between performance during the practice sessions and pre- and post-training attitudes towards computers, the participant's accuracy scores, number of errors produced, and working times were averaged across the three lessons. Overall, accuracy ($r(38) = .43$, $p < .01$) and the number of errors produced ($r(38) = -.54$, $p < .001$) across sessions was related to pre-training attitudes towards computers, with individuals with *more* negative attitudes achieving better overall accuracy and producing fewer errors[13]. It is possible that individuals with more negative attitudes performed better because they paid more attention to the task. None of the performance measures were related to post-training attitudes. Furthermore with regard to the Word Processor Integration and Near Transfer tasks, there was no relationship between computer attitudes measured at any of the three occasions and accuracy, working time, or errors.

Closing Questionnaire

On the final day of the study, the participants were asked to rate various factors surrounding their training experience on Likert Scales ranging from 1 (Excellent) to 5 (Terrible). In general, the participants gave very high ratings to their experience in the study. Overall, their ratings of the training sessions ($M = 1.44$, range = 1 to 3) and Word Processor ($M = 1.54$, range = 1 to 3) were uniformly high. Although 81.3% (39) of the participants reported that they would possibly or definitely use a word processor in the future, all 48 participants reported that if given the opportunity they would definitely like to

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[13] Recall that lower scores indicate more positive attitudes towards computers.

use a word processor. The participants universally rated the computer (M = 1.60) and its ease of use (M = 1.67) quite highly. With respect to various aspects of the computer, the ratings for the monitor (M = 1.52), mouse (M = 2.00), and keyboard (M = 1.81) were also quite high. Only 3 participants reported some difficulty reading text from the screen of the monitor. Furthermore, they gave equally high ratings for the quality of the training manuals (M = 1.73), and the help received from the experimenters (M = 1.25).

The participants in the Multimedia condition were provided with additional questions in order to obtain their ratings of the multimedia demonstrations. Overall, the participants gave high ratings for the quality of the demonstrations (M = 1.71) and generally agreed that the demonstrations helped them learn how to use the word processor (M = 1.67). Whereas all of the participants indicated that they had no difficulty understanding the verbal component of the demonstrations, 87.5% of the participants felt that the speed of the demonstrations was adequate.

The participants felt that the passages they edited while working on the word processor were neither interesting nor boring (M = 2.93). When asked to identify, from a list of 20-topics, the passages which they had edited during the practice, the participants were able to correctly identify only 6.87 (SD = 4.64 topics) of 11 topics. In addition, they incorrectly identified and average of 1.84 (SD = .93) topics from a list of 9 distractors. The relatively low rate of correct identification suggests that while working on the documents, the participants did not spend a great deal of time analyzing them.

On the final day of the study, the participants reported that they were just as eager (M = 1.87 vs. 2.04 prior to training) and curious (M = 1.75 vs.

1.65) about using a computer as they were prior to training. In addition, they now reported significantly less anxiety (M = 3.81) about using a computer than they had prior to participating in the study (M = 4.62, $t(47) = -2.88$, $p < .001$).

When asked to rate the two most difficult procedures learned during training from a list of 28 word processor commands, the most common responses included moving (n = 14) and copying (n = 11) text, followed by selecting text (n = 9), searching for text (n = 7), and using the scroll bars (n = 6). The participants indicated that opening (n = 23) and closing (n = 14) a file, followed by starting the word processor (n = 10), and using the backspace and delete keys (n = 8) were among the easiest commands to learn.

Follow-up Questionnaire

A questionnaire was sent to the participants about two weeks after they completed the study. The participants were asked to complete and return via mail, a variety of measures which included a general rating of their training experience. The questionnaires were returned an average of 43.74 days (SD = 33.88 days) after they were sent out. On a Likert scale ranging from 1 (Not at all Skilled) to 5 (Very Skilled), the participants reported feeling somewhat unskilled with word processing in general (M = 2.62), but significantly more skilled (M = 3.11) with Word, the word processor on which they were trained, $t(44) = 4.02$, $p < .001$. The participants generally felt that the instructor was effective (M = 1.50), and that overall, the training effectively taught them how to use a word processor (M = 1.74). In fact, from a list of 28 word processing commands, the participants felt that they could independently execute 22.18

commands (SD = 4.23 commands, range = 10 to 28).

The relationship between performance during the practice sessions and responses on the follow-up questionnaire was examined by averaging the participant's accuracy scores, number of errors produced, and working times across the three lessons. Overall, there was no relationship between performance during the practice lessons and the participant's ratings of their own perceived level of word processing skill or the number of word processing commands they could independently execute. Interestingly, accuracy on the Word Processor Integration task ($r(45) = .40$, $p < .01$) was positively correlated with, and Working Time ($r(45) = -.36$, $p < .01$) was negatively correlated to, the number of commands they felt they could independently execute. Furthermore, this relationship was not observed for the Near Transfer task.

The participants were also asked to complete a Use of New Technologies Questionnaire so that it would be possible to examine the technologies that they use in their daily lives. The participants were asked to indicate the number of times they have used the device and their perceived level of skill with it. A summary of these data is presented in Table 16. Overall, the participants reported using an average of 9.00 (SD = 3.53) different devices on more than 10 occasions, 1.49 (SD = 1.52) on less than 10 occasions, and they never used 6.31 (SD = 4.53) devices. The most commonly used items included photocopiers (41 participants), microwaves (38 participants), answering machines (36 participants), and videocassette recorders (35 participants). Items never used included electronic personal organizers (29 participants), video games (24 participants), wireless headphones (23 participants), and FAX machines (22 participants).

Table 16. New Technology Questionnaire: Self-reported use of Technologies and Skill Level

New Technology	Technology Use			Skill Level	
	Never	< 10 Times	> 10 Times	Unskilled	Skilled
Answering Machine	6.7 (3)	4.4 (2)	80.0 (36)	6.7 (3)	73.3 (33)
ATM	15.6 (7)	8.9 (4)	66.7 (30)	4.4 (2)	64.4 (29)
CD Player	31.1 (14)	13.3 (6)	46.7 (21)	13.3 (6)	42.2 (19)
Cellular Phone	46.7 (21)	2.2 (1)	28.9 (13)	15.6 (7)	26.7 (12)
Digital Audio Tape	46.7 (21)	4.4 (2)	20.0 (9)	11.1 (5)	26.7 (12)
Direct Payment	31.1 (14)	8.9 (4)	44.4 (20)	13.3 (6)	40.0 (18)
Extended Phone	24.4 (11)	2.2 (1)	60.0 (27)	8.9 (4)	51.1 (23)
FAX Machine	48.9 (22)	2.2 (1)	37.8 (17)	17.8 (8)	33.3 (15)
Library Catalogue	31.1 (14)	11.1 (5)	42.2 (19)	24.4 (11)	22.2 (10)
Microwave	6.7 (3)	8.9 (4)	84.4 (38)	8.9 (4)	73.3 (33)
Multi-Line Phone	28.9 (13)	8.9 (4)	40.0 (18)	4.4 (2)	37.8 (17)
Personal Organizer	64.4 (29)	4.4 (2)	4.4 (2)	17.8 (8)	4.4 (2)
Photocopier	2.2 (1)	2.2 (1)	91.1 (41)	4.4 (2)	73.3 (33)
Video Cassette Recorder	11.1 (5)	4.4 (2)	77.8 (35)	11.1 (5)	68.9 (31)
Video Games	53.3 (24)	15.6 (7)	2.2 (1)	24.4 (11)	4.4 (2)
Video Camera	37.8 (17)	17.8 (8)	20.0 (9)	31.1 (14)	22.2 (10)
Voice Mail	42.2 (19)	4.4 (2)	26.7 (12)	8.9 (4)	17.8 (8)
Walkman	26.7 (12)	6.7 (3)	60.0 (27)	8.9 (4)	62.2 (28)
Wireless Headphones	51.1 (23)	4.4 (2)	13.3 (6)	6.7 (3)	17.8 (8)
Wireless Phone	24.4 (11)	6.7 (3)	60.0 (27)	6.7 (3)	55.6 (25)

Note. Based on a sample of 45. Sums may not add up to sample size due to missing data. Items listed in alphabetical order.

The participants indicated that they were skilled at 8.24 (SD = 3.81) and unskilled at 9.31 (SD = 5.05) devices. Whereas participants felt most skilled using answering machines, microwaves, and photocopiers (33 participants each), they felt most unskilled using a video camera (14 participants), video games and computerized library catalogues (11 participants each). The correlation between the number of devices used more than 10 times and the number of items that one reported being skilled at was quite high ($r(45) = .84$, $p < .001$). The correlation between number of items used less than 10 times and the number of items reported being unskilled at was $r(45) = .51$, $p < .001$. There was no relationship between performance on the practice lessons or transfer tasks and the number of technologies a participant uses or their perceived skill at using them, suggesting that facility or use of other new technologies does not transfer, or enable one to more easily learn to use a computer.

1-Year Follow-up Interview

Approximately 1 year after their participation in the study ($M = 400.38$ days, $SD = 91.66$ days, range = 241 - 534 days) a follow-up interview was conducted by telephone. The purpose of this interview was to determine whether participation in the training study had any effect on one's desire to learn more about computers, and whether the participants had used a computer or had received any additional computer training during the year.

On a Likert scale ranging from 1 (Very Effective) to 7 (Very Ineffective), whereas the participants reported that the study was very effective in teaching them about computers and how to use a computer ($M = 2.30$), and increased their desire to learn more about computers ($M = 2.04$), their experience was only somewhat useful for them during the year following their participation ($M = 3.57$). Almost two-thirds of the participants (61.7%; 29 participants) reported that they had used a computer, and 42.6% (20 participants) reported that following their participation in the study they either took a course (13 participants), read computer training books (5 participants), or had a private tutors (2 participants). These participants generally reported that their experience was more useful (M = 2.90) than those who did not use a computer (M = 4.67), $F(1,45) = 9.75$, $p < .01$, $\eta^2 = .42$. The correlation between the participants ratings on the final day of the study of their desire to use a word processor in the future and their actual use during the year following the study was r (47) = -.33, $p < .05$, indicating that those who gave a lower rating on the 5-point Likert scale (lower score indicated greater degree of desire) were more likely to use a computer during the subsequent year. Overall, there was no relationship between performance during the practice lessons and the participant's ratings the effectiveness of the study in teaching them how to use a computer. However, accuracy on the Word Processor Integration task ($r(44) = .49$, $p < .001$) was positively correlated to their rating of the effectiveness of the study, and accuracy on the Near Transfer task was correlated to one's use of a computer during the year following the completion of the study ($r(36) = .46$, $p < .01$). There was a significant correlation between the participant's 1-year rating of the study's effectiveness in teaching them how to use a computer and their ratings of Word ($r(44) = -.59$, $p < .001$) and word processing in general ($r(44) = -.39$, $p < .01$) on the 2-week follow-up questionnaire (note that lower scores on the 1-year rating scale indicated greater effectiveness ratings).

The participant's were given three hypothetical scenarios regarding computer training programs. Each scenario was rated on a 7-point Likert scale ranging from 1 (Very Interested) to 7 (Very Uninterested). Overall, the participants stated that they would be very interested ($\underline{M}$ = 1.72) in participating in a computer training course if it were offered only to adults over the age of 50. In addition, they reported that they would be willing to purchase software with fewer features if it included more detailed tutorials ($\underline{M}$ = 2.32) or multimedia demonstrations and detailed written instructions ($\underline{M}$ = 2.96). In addition, all but one of the participants stated that they had heard about the Internet. In fact, 32.6% (15) of the participants stated that they had used the Internet for e-mail (8 participants) or the World Wide Web (7 participants). On a 7-point Likert scale, the participants reported that they are very interested in learning more about the Internet ($\underline{M}$ = 1.91).

Part 6: Cognitive and Motor Correlates of Word Processing Acquisition

Variable Selection

The participants completed many tests and measures which were thought to be related to the acquisition of word processing skills. Each test yields multiple outcome variables. For example, when scoring the California Verbal Learning Test (CVLT), outcome variables include the number of items recalled per learning trial, short-delay and long-delay recall, distractor list recall, and recognition recall. Additional variables include, for example, type of errors made (intrusions vs. perseverations), and learning rate across trials. This section describes the rationale used to minimize the number of outcome variables for a specific test.

For the CVLT, the primary outcome variables chosen were the number of items recalled over the 5 learning trials (which measures verbal learning over time) and the number of items recalled at delay (delayed verbal memory).

Similar variables were chosen for the Biber Figure Learning Test (BFLT). As described in the Method section, the BFLT yields two sets of relevant scores; the number of items correctly drawn and accuracy of drawing based on a score of 3 points per drawing. Correlations between these two scoring methods was high both for total score after 5 trials ($r(47) = .89$, $p < .001$, and for delayed recall ($r(47) = .88$, $p < .001$, and hence only one measure, number of correct items, was retained for analysis. This measure was retained because it facilitated direct comparisons to performance on the CVLT.

The Finger Tapping Test yields performance scores for both the left and right hand. The average performance for the two hands was computed and used in this study because, as previously described, most of the participants were right handed, the expected right-handed dominance was observed and laterality was not a focus of this study.

Vigil, a test of sustained attention yields, for each of 4 blocks, the number of correct responses, the number and type of errors (omission, commission), and the average reaction time. Furthermore, the test includes a practice trial followed by two test trials. Because the practice trial was brief it was not considered to be reliable. Overall performance was computed by summing the performance for each of the four test blocks. As expected, the participants performance on the 'K' task ($M = 35.38$ correct responses) was superior to that of the more difficult 'AK' task ($M = 34.11$ correct responses), $t(47) = 4.82$, $p < .001$. Furthermore, the average latency time during the 'K' task ($M = .42$ sec) was significantly different from that obtained during the 'AK' task ($M = .39$ sec), $t(47) = 3.52$, $p < .001$. Whereas correlation between latencies was significant $r(47) = .45$, $p < .01$, the correlation between correct responses was not ($r(47) = .23$, $p > .05$. The data for the two tasks were therefore examined separately.

The Trail Making and the Word Fluency Tests yield error scores in addition to the primary performance scores. These error scores were not used because they were felt to be irrelevant to the purpose of this study. All other cognitive tests and measures yielded a single outcome score, hence no selection of measures was required.

Factor Analysis

As previously discussed, the participants completed many tests and measures that examined individual differences. Given that individuals in the training and practice conditions in general did not differ in performance on the word processing tasks, this section examines the relationship of these measures and performance of the entire sample on the word processor.

Overall, the sample size in this study is quite small while the number of measured variables is large. To reduce the number of variables measuring potential cognitive and motor correlates of word processing acquisition, a principal-axis factor analysis with a Varimax rotation was conducted[14] (Gorsuch, 1983). Factor scores were then computed, and saved, using the regression approach which yields the highest correlation between a factor and its factor scores. This method, when applied to the rotated factor solution ensures orthogonal (uncorrelated) standardized factor scores with a mean of 0 and SD of 1.00. Table 17 displays the means and standard deviations for these measures,

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[14] In order to examine the stability of the factor solution, the analysis was repeated using a principal components approach (Tabachnick & Fidell, 1996). In addition, additional analyses were conducted using both Quartimax and Equamax rotations. These analyses yielded virtually identical solutions to the one reported above.

as well as the factor loadings and communalities (i.e., the sum of squared loading, or variance, that is accounted for by a variable when summed across factors). The intercorrelations between all measures that were included in the factor analysis are presented in Appendix M. A Scree test and the criterion of eigenvalues over 1.0 suggested the presence of five reliable and meaningful factors after rotation. Overall, 68.6% of the variance was accounted for by the factor analysis. The first factor, Learning and Memory, consists of the learning measures and subsequent delayed recall trials, as well as a test of incidental memory, and accounts for 34% of the variance. The second factor, Language, includes all three measures that examine language functions and accounts for 10.9% of the variance. The third factor, Attention/Speed, accounts for 10.1% of the variance and includes all of the timed measures that involve attention and speed of information processing. The fourth factor, Manual Control, accounts for 7.7% of the variance and includes those measures which are directly based on motor control and speed of both hands. The final factor, Visuospatial Abilities, accounts for 6.0% of the variance and includes performance on the block design task, and accuracy (i.e., number of correct responses) on both sustained attention subtests. Given that both measures involve accuracy in abstracting information from a spatial array, it seems logical that they load together. As expected, the average latency of responses on the sustained attention task loaded together with the other measures of speed (Factor 3).

Table 17. Means, Standard Deviations, Factor Loadings[a], and Communalities (C) of Cognitive Measures

Measure	Mean	*SD*	Range	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	C
Factor 1: Learning & Memory (eigenvalue = 6.11)									
BFLT - Long Delay Free Recall (x/15)	11.57	2.85	3 - 15	.87					.84
BFLT - Trials 1 - 5 (x/75)	49.09	11.59	18 - 67	.83			.32		.84
CVLT - Trials 1 - 5 (x/ 80)	52.35	9.37	34 - 73	.82	.31				.81
CVLT - Long Delay Free Recall (x/16)	10.83	2.71	6 - 16	.61	.43				.79
Digit Symbol - Incidental Memory (x/9)	5.23	2.59	0 - 9	.56				.39	.55
Factor 2: Language (eigenvalue = 1.97)									
NAART (x/45)	36.44	6.22	22 - 44		.86				.78
Advanced Vocabulary Test (x/44)	34.02	4.42	23 - 41		.86				.75
Word Fluency	43.02	12.49	20 - 75		.60	.37			.59
Factor 3: Attention/Speed (eigenvalue = 1.81)									
Vigil 'AK' Task - Average Latency (secs)	.39	.07	.27 - .56			.73			.59
Vigil 'K' Task - Average Latency (secs)	.42	.05	.34 - .58			.72			.60
Trails A (secs)	36.07	11.41	18.0 - 62.3			.66			.62
Digit Symbol (x/93)	46.42	11.10	25 - 76		.35	.60	.35		.70
Trails B (secs)	92.22	37.23	47.2 - 210.0		.42	.57			.60

(Table Continues)

Measure	Mean	*SD*	Range	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	C
Factor 4: Manual Control (eigenvalue = 1.38)									
Finger Tapping (Avg Left, Right)	47.70	6.38	30.7 - 62.2				.79		.73
Typing Test (Words Correct)	40.83	25.56	8 - 145				.76		.65
Factor 5: Visuospatial Abilities (eigenvalue = 1.08)									
Vigil - 'K' Correct Responses (x/36)	35.38	1.01	32 - 36					.75	.64
Vigil - 'AK' Correct Responses (x/36)	34.13	1.76	29 - 36		.38			.64	.60
Block Design (x/51)	24.13	7.39	4 - 43	.35			.32	.50	.65

Note. Only factor loadings greater than |.30| are included.
C = Communality (i.e., the sum of squared loading, or variance, that is accounted for by a variable when summed across factors).
[a] Mean substitution was used for the few instances of missing data.

Path Analysis

The use of path analysis makes it possible to assess the direct and indirect effects on the acquisition and transferability of word processing skills through the use of multiple regression techniques. In the present case, age and education were used as exogenous variables. An exogenous variable is one that is not considered to be causally dependent on any of the other variables in the model (Pedhazur, 1982). Thus, in the present case no attempt is made to explain the variability of age and education or their relation with other exogenous variables, and they remain unanalyzed in the system. In contrast, endogenous variables are ones whose variation is explained by exogenous or other endogenous variables, and they can have one or more causal inputs in the path model, indicated by arrows coming to them, as well as one or more causal outputs, indicated by arrows that go from them to the output variables. Ordinary least squares multiple regression techniques (McClendon, 1994; Pedhazur, 1982), in which each endogenous variable in the model is regressed in turn on all of the causally prior variables, was used in order to examine the direct and indirect effects on word processing performance. The models examined here are recursive, that is, the causal flow is unidirectional, thus a variable cannot be both a cause and an effect of the same other variable. Rather, an endogenous variable can be treated as a dependent variable in one set of variables and an independent variable in relation to other variables. Thus, each path coefficient is the beta-weight for the precursor variable on the endogenous variable. In an attempt to control for practical significance, a two step-approach was used to calculate the path coefficients. First, when the standardized regression coefficient (beta weights) for a particular path was less than .10 (Casey, Nuttall, & Pezaris, 1997; Hackett, 1985), that path was dropped. The model was then recalculated to produce a trimmed model in which only those paths that were statistically significant ($p < .05$) were retained (Pedhazur, 1982). The process of path elimination is referred to as 'theory trimming' and its purpose is to identify the most streamlined model which adequately portrays the relationship among the variables.

A path analysis is conducted on correlations between two variables. The correlations can be decomposed into three components: direct, indirect, and spurious effects. The direct effects are the effects from the precursor variable in the dependent variable directly, without being mediated by other variables in the model. The indirect effects are the effects of the precursor variable as operating through, or mediated by, other variables on the dependent variable. The direct and indirect effects are summed to yield the total true causal effects, whereas the spurious effect is due to unexplained factors (i.e., variance unexplained by the path model) and is obtained by subtracting the total effect from the bivariate correlation coefficient.

Theoretical Models

Three separate path analyses were conducted in order to examine the acquisition of word processing skills across sessions. A fourth model examined quiz performance. Because the analyses of word processing skill acquisition had consistently shown no main effects of either training condition or practice condition, these variables were not included in any of the models. Thus, the principal focus of these models was on the contribution of cognitive and motor factors to word processing acquisition. As well, models considered computer attitudes and past and present access to computers.

Each model surveyed a single critical dependent variable that has been examined in word processing training studies. Specifically, Model 1 examined accuracy scores across sessions, Model 2 examined Working Time[15], and Model 3 examined the number of errors made across sessions. Proportion of first trial correct responses was not examined because these variables were not scored during the Word Processing Integration or Near Transfer tasks.

The means, standard deviations, and ranges for the variables used in the models are shown in Table 18. Within all three models, age and education were entered first as exogenous variables. The second stage of entry included 5 endogenous variables, specifically the five factors from the factor analysis described above. It was hypothesized that age and education would have a direct effect on at least some of these factors, which would in turn be related to one's abilities when learning to use a word processor. Furthermore, it was hypothesized that age and education may also have a direct effect on one's performance on at least the first practice session.[16]

The second stage also included three measures of computer attitudes and prior experience as exogenous variables. First, the number of hours the participant had used a computer in the past was included as a categorical

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15 A path analysis for Reflection Time across sessions yielded a model virtually identical to that of Working Time. It will therefore not be discussed further.

16 Performance during the Introductory session was not included in these analyses due to the participant's near perfect performance (M = 52.35 out of a maximum possible score of 60) on the exercise, and little variability in scores (SD = 6.29).

Table 18. Means and Standard Deviations for all Variables in the Path Analyses

Variable	Mean	Standard Deviation	Range
Age (years)	65.75	6.00	51 - 78
Education (years)	15.42	2.72	8 - 21
Attitudes Towards Computers	94.50	9.07	77 - 115
Training Time: Lesson 1 (min)	66.88	18.02	37.07 - 112.67
Training Time: Lesson 2 (min)	80.66	20.41	46.83 - 135.27
Training Time: Lesson 3 (min)	71.08	15.89	43.07 - 112.33
Lesson 1: Accuracy	78.74	15.40	36 - 106
Lesson 2: Accuracy	66.70	15.78	29 - 89
Lesson 3: Accuracy	52.31	11.85	30 - 70
Word Processor Integration: Accuracy	29.50	10.81	4 - 49
Transfer: Accuracy	26.72	8.15	12 - 43
Lesson 1: Working Time (min)	58.36	18.14	33.02 - 133.63
Lesson 2: Working Time (min)	73.46	23.49	38.78 - 119.98
Lesson 3: Working Time (min)	86.18	23.30	53.48 - 135.98
Word Processor Integration: Working Time (min)	52.65	17.91	13.02 - 106.95
Transfer: Working Time (min)	23.69	6.28	11.45 - 37.37
Lesson 1: Errors	54.57	26.84	21 - 148
Lesson 2: Errors	82.16	45.21	25 - 227
Lesson 3: Errors	74.55	33.15	18 - 151
Word Processor Integration: Errors	61.57	28.16	18 - 144
Transfer: Errors	33.15	15.16	10 - 68

Notes. Factor Scores, which are uncorrelated with one another, have a mean of 0 and Standard Deviation of 1.0.
Computer in the home was coded as 1, No home computer was coded as 0.
Hours of computer use ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).

variable ranging from 0 (never used a computer) through to 4 (more than 11 hours previous computer use). Recall that all participants reported having never used a word processor or any Windows-based software. Second, whether or not the individual had a computer in the home was included as a dichotomous variable as it was hypothesized that such individuals, although not having used it, may be more familiar with some of the terminology and would subsequently find it easier to use[17]. The third exogenous variable was total score on the Attitudes Towards Computer Questionnaire as it has been shown that one's attitude could directly effect learning (e.g., Danowski & Sacks, 1980; Morris, 1994). The critical dependent variable for each day's session were entered at subsequent stages, one at a time, followed by performance on the word processing integration task and then the near transfer task. Time to complete each day's training session was included as an exogenous variable for each specific day. Initially, performance on each day's multiple choice quiz was included as an exogenous variable for that particular day, however, it was consistently nonsignificant and was subsequently dropped. The intercorrelations between all of the variables for each of the full path models are presented in Appendices N through P. An assumption in path analysis is that exogenous variables are not highly correlated (Pedhazur, 1982). Of the 78 pairwise correlations that represent the intercorrelations between the exogenous variables and factor scores, 74 were below the Bonferroni-corrected critical

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[17] The correlation between hours of previous computer use and possession of a computer in the home was $r(48) = .08$, $p > .05$. In fact, only 9 of 17 participants who reported having a computer in the home reported *any* experience using it, with only 2 of the participants reporting that they had greater than 11 hours of computer experience.

value of ±.41, indicating that there was relatively little redundancy in the variable set. As would be expected, intercorrelations among each day's training time was highly correlated, as was the correlation between education and language abilities which is frequently reported in the literature. The factor scores, which are endogenous, have a mean of 0 and Standard Deviation of 1.0 and are uncorrelated with one another.

In order to handle missing data, all of the analyses were run twice, once deleting all cases of missing data and once using mean substitution. Because the two methods yielded similar models, only the analyses in which mean substitution for missing data was used, are presented here.

Education was a significant predictor for two of the five factors; language (β = .411) and speed (β = -.307), with more highly educated individuals performing better on measures of language skills and requiring less time on tests involving speed. Age was a significant predictor of memory (β = -.337), with older adults performing more poorly on tests involving learning and memory.

Model 1: Accuracy

The first model specifically examined the accuracy of performance across study days. The path diagram in Figure 15 provides a visual representation of the causal pathways that were obtained in the trimmed version of the path analysis. Each path coefficient is the beta-weight for the precursor variable on the endogenous variable. The direct effects are the path coefficients (beta-weights) for each of the variables that remain in the trimmed model (i.e., $p <$ .10). Indirect effects were computed for each pathway in the path analysis by multiplying the path coefficients (beta-weights) together along a pathway.

Within the figure, thick lines refer to path coefficients that were significant at $p < .01$, medium lines refer to those that were significant at $p < .05$, and dotted lines were used when the path coefficient was between $p < .05$ and $p < .10$.

Previous research has demonstrated that performance on tests of specific cognitive abilities (e.g., language, visuospatial abilities) are good predictors of word processing accuracy. In this study, overall accuracy during the first practice session was best predicted by one's age (older adults performed more poorly), time to complete the first day's training (those who completed the training session more quickly performed better), and initial attitude towards using a computer (those with more *negative* attitudes performed better, possibly because they had more negative attitudesthey paid more attention to the task)[18]. Although none of the cognitive factors was a significant direct predictor of performance during the first practice session, visuospatial abilities was the only factor to be a significant predictor of first day's training time ($\beta = -.285$), with those who performed more poorly on measures of visuospatial abilities requiring more time to complete the training. Visuospatial abilities therefore has an indirect effect on the first day accuracy.

As hypothesized, subsequent sessions, including that of the Word Processor Integration and near transfer tasks, were significantly predicted by accuracy on the preceding day. In addition, age ($\beta = -.324, -.348$) had a direct effect on accuracy during Lessons 1 and 2 (with older adults being less accurate), but not for Lesson 3 or the remaining tasks. Furthermore, accuracy on Lesson 3 was directly affected by performance on Lesson 1 ($\beta = .425$;

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18 Recall that lower scores indicate more positive attitudes towards computers.

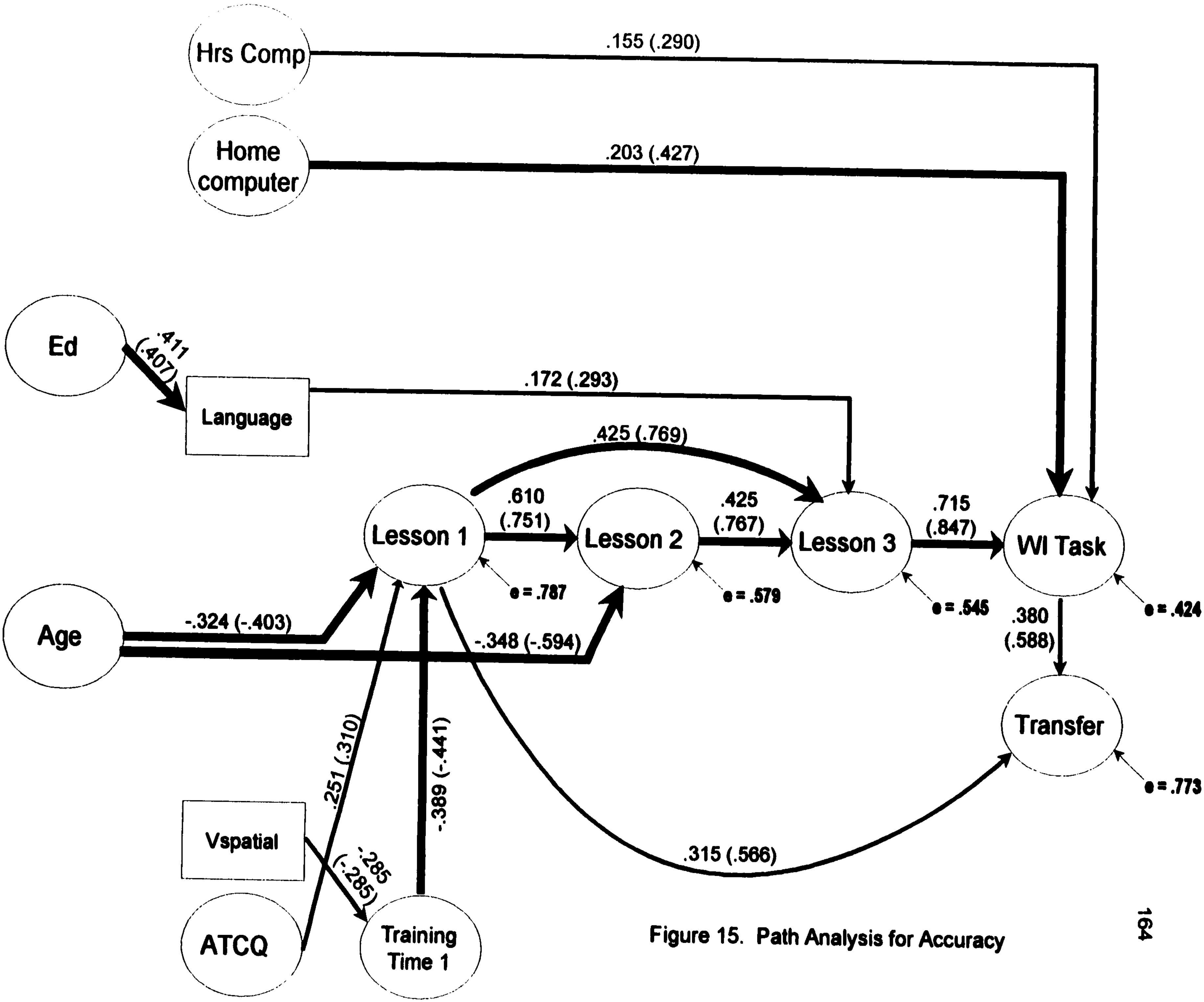

Figure 15. Path Analysis for Accuracy

higher accuracy on Lesson 1 was associated with higher accuracy on Lesson 3), suggesting that by Lesson 3, which involved the most difficult procedures, age is less important than one having a good understanding of basic word processing skills. Accuracy on Lesson 3 was also directly predicted by Language abilities (β =.172; those with better language abilities achieved higher accuracy scores). This relationship may be due to the fact that procedures required to execute the commands trained during Lesson 3 were rather lengthy and required better comprehension in order to complete them correctly. As expected, accuracy on the Word Processor Integration task was predicted by accuracy on Lesson 3 (β =.715), but also by the presence of a computer in the home (β =.203), and by the number of hours of previous computer experience (β =.155). One possibility is that individuals who either had some previous computer experience or a computer in the home, were more familiar with some of the concepts associated with using a computer, which helped them when they were required to integrate everything that they had learned[19]. This hypothesis is consistent with the conclusions of Kelley et al. (1994) in which they suggested that positive transfer may be a function of general knowledge about computers rather than specific knowledge about a word processor. Direct effects on near transfer accuracy were obtained for the Word Processor Integration task (β =.380) and accuracy on Lesson 1 (β =.315). It is possible that one's first experience with a word processor is critical to later performance,

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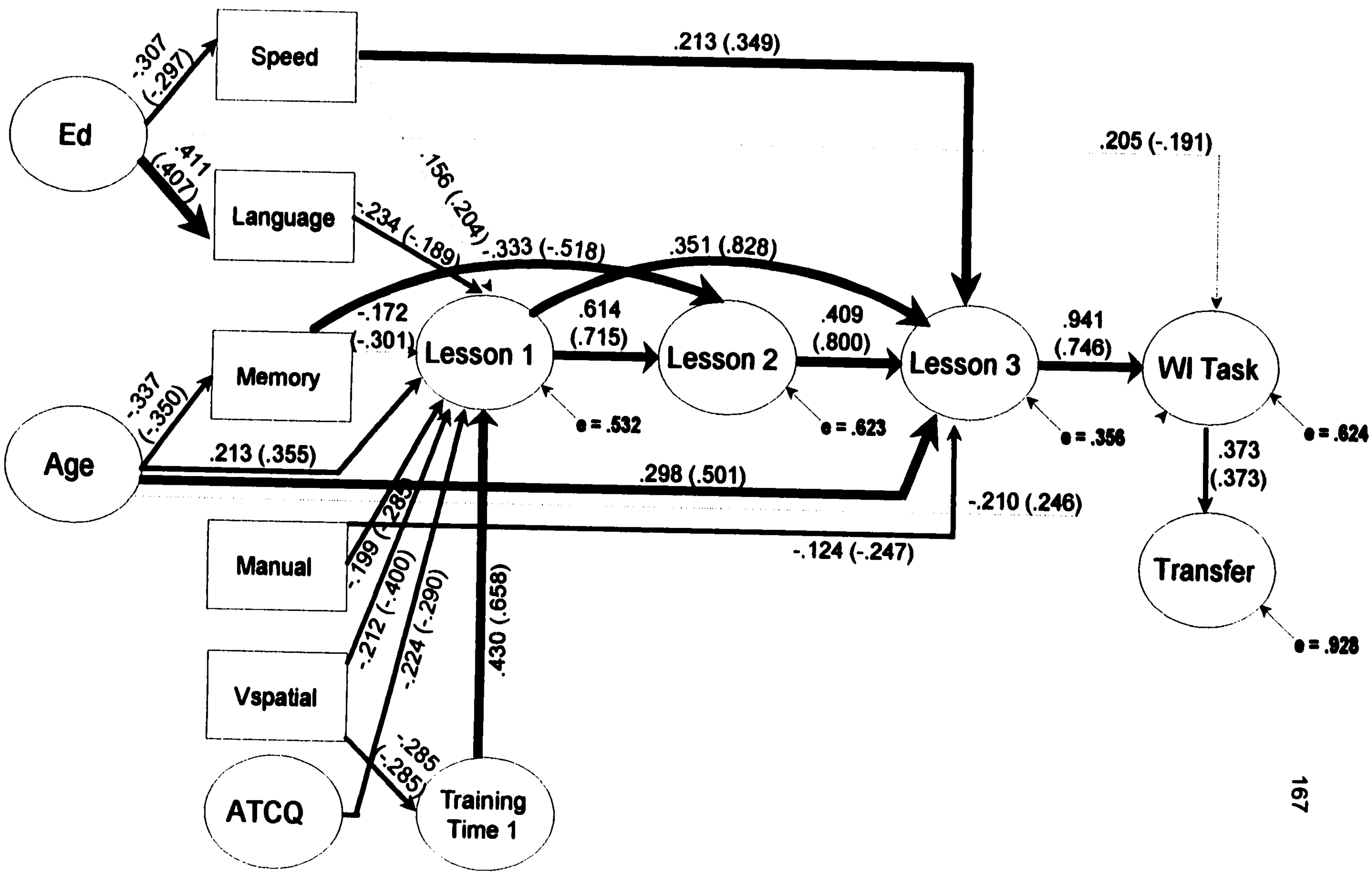
19 A second possibility is that the participants used the computer at home during the course of the training or discussed word processing procedures with family members. However, all of the participants were asked, on a daily basis, not to use a computer or discuss the training with other people.

suggesting that if a person is able to be trained to perform well initially, they may have less difficulty learning more complex procedures later. The direct and indirect path coefficients, Pearson correlations, and R^2 values for this model are displayed in Appendix Q.

Model 2: Working Time

The second model examined Working Time across study days. The path diagram for the trimmed model is presented in Figure 16. Appendix R displays the direct and indirect path coefficients, Pearson correlations, and R^2 values for this model. Whereas specific abilities were generally unrelated to accuracy in Model 1, in this model, all of the factors yielded direct effects to the time required to complete Lesson 1 (lower scores on tests of language, memory, visuospatial, and manual abilities were associated with longer times, and better performance on the speed factor was associated with shorter times). A direct effect was also observed between the time required to complete the first day's training session and the time to complete Lesson 1 (β = .430). In addition, a direct effect was observed between one's attitudes and time during Lesson 1 (β = .-224) with more positive attitudes being associated with lower times. As discussed in Model 1, direct effects were obtained between each day and the immediately preceding one or ones. Memory also had a direct effect on the time required to complete Lesson 2 (β = -.333), with lower memory scores being associated with greater times. It is possible that those participants with lower memory scores required more time to refamiliarize themselves with the basic commands required to complete the lesson. Lesson 3 had direct effects from age (β = .298), Manual Abilities (β = -.124) and Speed (β = .213) as

Figure 16. Path Analysis for Working Time

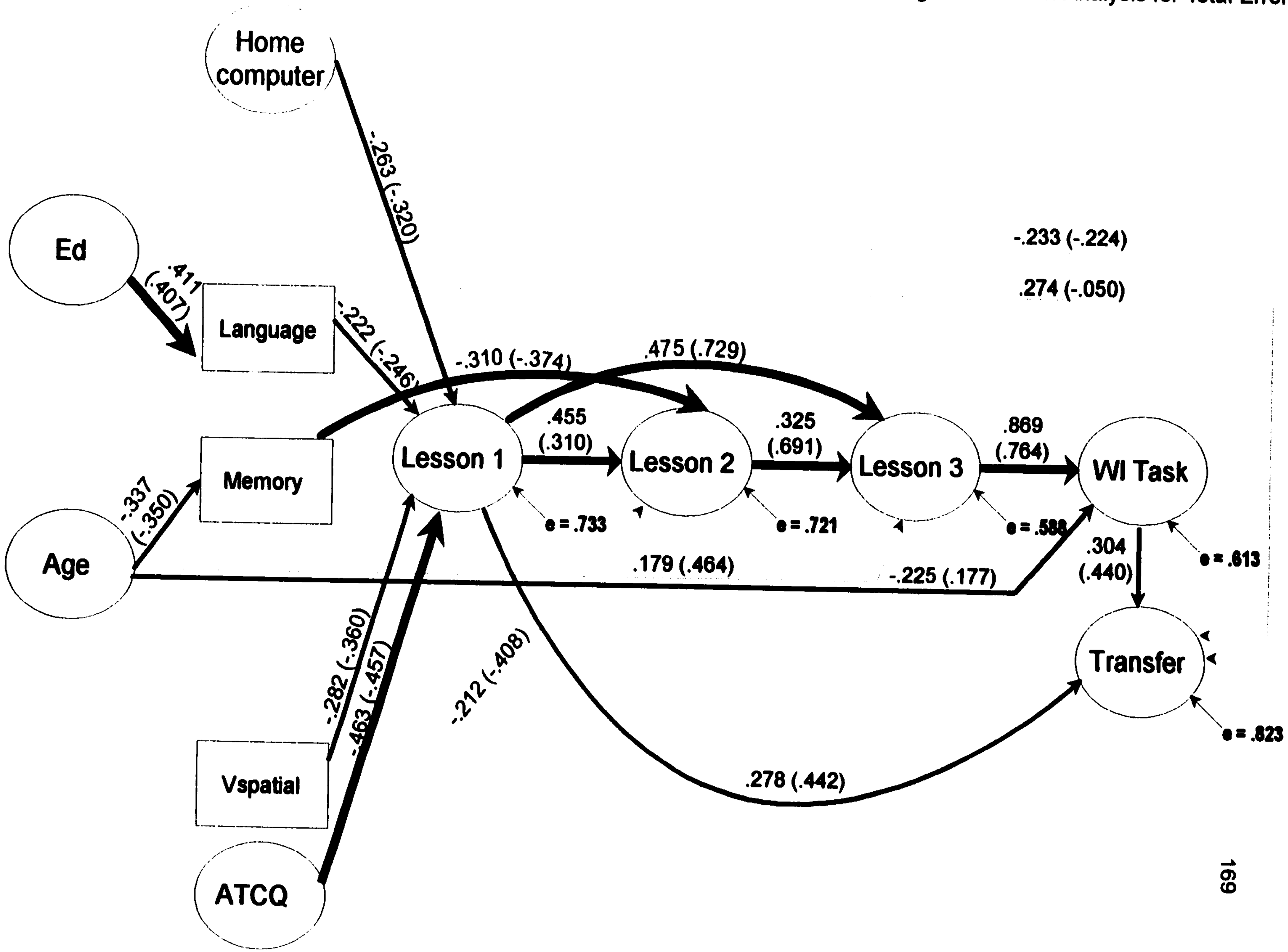


well as from Lesson 1 (β = .351). Working Time during the Word Processor Integration task had direct effects from age (β = -.210) and education (β = .205). Time to complete the Near Transfer task had a direct effect only from the time required to complete the Word Processor Integration task (β = .373).

Model 3: Total Errors

The third model examined total errors across study days. The path diagram for the trimmed model is presented in Figure 17 and Appendix S presents the direct and indirect path coefficients, Pearson correlations, and R^2 values for this model. Direct effects were observed for the Language (β = -.222) and Visuospatial (β = -.282) factors and Lesson 1, indicating that lower abilities on these factors were associated with more errors. Furthermore, direct effects between attitudes and errors (β = -.463; individuals with *more* positive attitudes made more errors) and individuals with a computer in the home (β = -.263) were observed. As expected, direct effects were obtained between each day and the preceding day or days. Attitudes (β = -.212) and the memory factor (β = -.310) yielded direct effects with errors made during Lesson 2. Lesson 3 had direct effects from Lesson 1 (β =.475) and age (β =.179). Age also had a direct effect on the Word Processor Integration task (β = -.225) but it was in the unexpected direction in that younger women made more errors. One possibility is that the older-old adults were more cautious about making incorrect responses than were the younger-old participants (for a discussion of cautiousness and its effects on performance see Salthouse, 1991). Direct effects were observed between Lesson 1 (β =.278), language abilities (β =.274), and education (β = -.233) and errors made during the near transfer task.

Figure 17. Path Analysis for Total Errors



The Relationship of Individual Differences and Performance: Additional Analyses

The path analyses described above suggest that specific abilities are more directly related to earlier sessions than to later ones. The best predictor of the word processing measure of interest (accuracy, time, errors), however, was the previous day's score. To better ascertain the relationship between the individual difference variables and performance, additional regression analyses were conducted in which the previous day's performance was not included. These analyses simply looked at the direct effects of the individual differences factors as well as age and education on performance. The results of the regressions for the acquisition of word processing skills across sessions is presented in Appendix T.

These data demonstrate that different variables predicted accuracy, working time and the number of errors made across practice sessions (see Appendix T). Age was an important predictor of accuracy for all three Lessons. Even with the limited age range used in this study, these results are consistent with the previous research which states that older adults have more difficulties using a word processor than younger adults. Years of education was a significant predictor (β = .25) of accuracy only for Lesson 3. The Visuospatial (β = .24) and Memory (β = .36) factors were significant predictors of Lesson 2. Attitudes towards computers was an important predictor for lessons 2 and 3 but not for Lesson 1. The Memory factor (β = .30) was also a significant predictor of accuracy on Lesson 3. None of the individual difference factors directly predicted accuracy on the first lesson. With regard to Working Time, age was a significant predictor only for Lessons 1 (β = .38) and 3 (β = .37), and education only predicted Working Time (β = -.27) for Lesson 3. In addition, Lesson 1 was predicted by the Speed (β =.25), Language (β = -.33), and Manual abilities (β = -.30), Lesson 2 by the Memory (β = -.54) ability, and Lesson 3 by the Memory (β = -.27), Speed (β = -.34), and Manual Control (β = -.24) abilities. Attitudes towards computers was not a significant predictor of Working Time for any of the lessons. Errors was predicted by age for Lessons 1 (β =.29) and 3 (β =.43), and education predicted errors only on Lesson 3 (β = -.30). Whereas Language (β = -.34) abilities was the only individual ability factor to predict errors during Lesson 1, Memory (β = -.39) predicted errors on Lesson 2. The remaining ability factors did not predict the number of errors made for any of the lessons. Computer attitudes was a significant predictor of errors produced for the first two lessons.

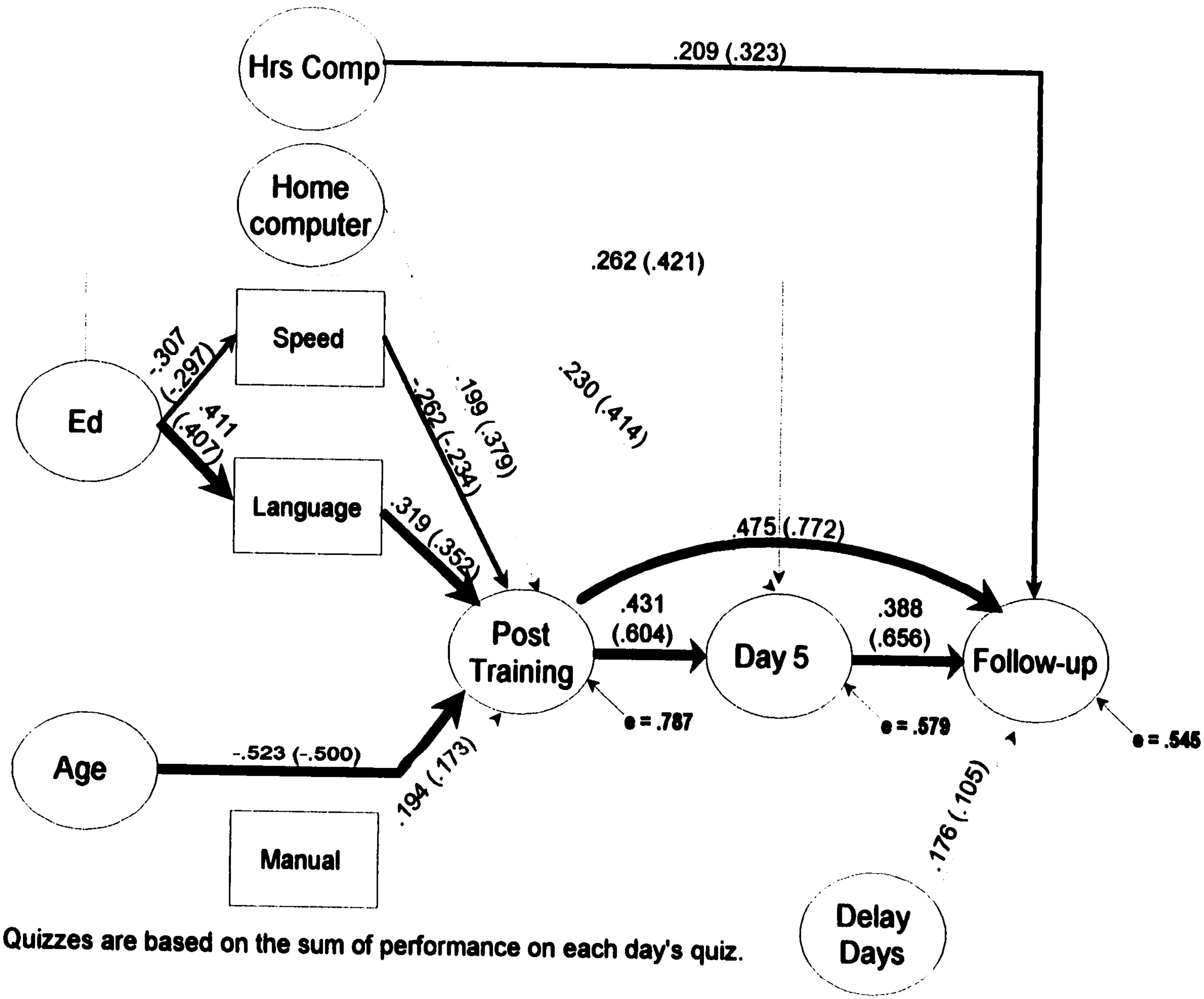
On the Word Processor Integration task, 3 of the 5 factors significantly predicted accuracy (Visuospatial, Memory, and Language abilities). Attitudes towards computers was also an important predictor, however the direction of the relationship was counter to that which was expected; individuals with worse pre-training attitudes performed better. The reason for this relationship is unknown, however it is possible that those individuals who had more negative attitudes paid more attention to their performance during the exercise in order to compensate for their attitudes. Further research would be required in order to examine this hypothesis. As expected, age also predicted accuracy (β = -.31), with older adults achieving lower accuracy scores. Working Time was best predicted by visuospatial abilities (β = -.29) and the number of errors made was best predicted by attitudes towards computers (β =.33), which was in the expected direction. Performance on the near transfer task was predicted only by education (β =.34), with more highly educated individuals achieving better scores, and the number of errors made was predicted by age, with older individuals making more errors. None of the variables predicted the time required to complete the task.

Model 4: Multiple Choice Quizzes

A path analysis was conducted in order to determine the relationship of the individual difference factors and performance on the multiple choice quizzes. This model included the same exogenous and endogenous variables that were entered into the models discussed above. The path diagram for the trimmed model is presented in Figure 18. Overall, the Speed (β = -.262), Language (β = .319), and Manual ability (β = .194) factors had direct effects, which were in the expected direction, on the sum of the post-training quizzes. In addition, having a computer in the home had a positive effect on both the sum of the post-training quizzes (β = .199) and on the final day's quiz performance (β = .262). As expected, the sum of the post-training quizzes (β = .431) had a direct effect on the final day's quiz, as did education (β = .262). The number of delay days was entered as an exogenous predictor for the follow-up quiz (β = .176). The follow-up quiz had direct effects from both previous quiz administrations, as well as from the number of hours of previous computer use (β = .209). Surprisingly, the memory factor was not a significant predictor of performance at any time.

Additional analyses were conducted separately for each quiz administration in order to further examine the relationship between individual differences and quiz performance. Only the ability factors, age, and education were included in these analyses. Different variables also predicted performance

Figure 18. Path Analysis - Quizzes



Note. Quizzes are based on the sum of performance on each day's quiz.

on the multiple choice quizzes. Whereas performance on the sum of the post-training quizzes and performance on the final day's quiz were predicted by age (β = -.54, -.42,), Speed (β = -.30, -.26), and Language (β = .37, .32), education (β = .42) was the only significant predictor of performance on the follow-up quiz.

Discussion

The goal of present study was to extend the research on training older adults to learn to use a word processor. Specifically, this study investigated whether multimedia demonstrations enhance learning over a text-based manual, and whether practicing commands using a single or dual methods affected learning. Unlike previous research in which training methods were compared after brief training and limited practice, this study examined the effects of practice on learning to use a wordprocessor. Transfer of training on one word processor to a second word processor was also examined, as was the relationship among attitudes towards computers, individual difference variables and performance. This chapter discusses the results of the study, with attention to their implications for training older adults learning to use a word processor. The limitations of the present study are addressed, and suggestions regarding directions for future research are presented.

Are multimedia demonstrations beneficial to older adults learning to use a word processor?

It was hypothesized that the addition of multimedia demonstrations to text-based training may help individuals learn to use a word processor because they would enable better elaborative encoding. In turn, the elaborative encoding would increase one's recall of the information, hence performance would improve to a greater degree than would be possible in the absence of these demonstrations (Najjar, 1996a, b). If this hypothesis were valid, then one would expect to see differences during either or both of the quizzes administered immediately after training and the practice phase of each day's session, especially during the first block of trials.

Overall, individuals in the multimedia condition required about 15% less time to complete the actual training than did individuals in the text condition. Although this trend is consistent with the research of Palmiter et al. (1991) and Palmiter and Eklerton (1993), it is significantly less than the 50% difference that they observed in the former study and the 33% difference they observed in the latter.

No training group differences were observed for any of the post-training quizzes, suggesting that individuals in both the text and multimedia condition retained about the same amount of information after training. During the practice sessions, no group differences were observed for any of the major dependent variables, performance, working time, reflection time, errors, number of trials, requests for help, and interventions. Training Group x Trial Block interactions were occasionally observed, with individuals in the text condition displaying an initial time advantage, but this advantage was largely lost by the second block of trials. These interactions, however, may in fact be artifacts of the data as they were observed only sporadically. No training group differences were observed for the Word Processor Integration task and the transfer task, indicating that both training methods resulted in similar levels of word processing skill.

These results suggest that although the addition of multimedia demonstrations decreases the amount of time required during training, they do not provide any additional benefits once the training has been completed (i.e., during practice or transfer). It is possible that during training the demonstrations helped individuals with the proceduralization of the steps required to execute a command because the learner was able to observe, in real time, the steps necessary for its successful execution. Palmiter and Eklerton (1993) suggested that individuals who receive demonstrations may in fact attempt to mimic the behaviour they observed, rather than try to reason out the method necessary to execute the required command. If this mimicry were operative we would expect to see differences in the number of errors committed by individuals in both groups, which was not the case here.

The current study differs from the Palmiter studies and those reviewed by Najjar (1995, 1996a, 1997) in many important ways. First, the training manuals used in this study embodied the suggestions by Carroll (1993) and Carrol and Carithers (1984) pertaining to the authoring of Minimal Manuals and included many of the important features that characterize the Discovery Method of learning. For example, training was self-paced, complex tasks were divided into meaningful pieces, focus was placed on allowing the person to comprehend conceptual information rather than on simple rote-memorization, and instruction attempted to instill an ability to recognize, and recover from, errors. Second, unlike the manuals used in the Palmiter studies which consisted solely of textual information, the manuals used in this study also included illustrations to help orient the trainee to the task. The manuals also went through a rigorous review procedure in order to confirm that there were no errors in information and to ensure that the training was at the novice level. Third, unlike many studies, help was available to the participants as necessary. Individuals in both conditions asked approximately the same number of questions during practice. It would be interesting to examine the number and types of questions asked during the actual training phase of the study in order to determine whether group differences would emerge. Last, the information presented in the Palmiter studies and in many of those reviewed by Najjar (1995, 1996a, 1997) consisted primarily of procedural information. In the current study, although using a word processor is inherently based on a series of procedures, training focused both on the procedures necessary to execute a command (i.e., "knowing how"), as well as on declarative information in order to render a better understanding of the purpose of the command and how it consolidates with one's use of the system (i.e., "knowing what"). In fact, Greenberg (see also Arbuckle et al., 1996), using data from the current study examined a set of 14 multiple choice questions (7 each that were procedural or declaratively based) that were administered on the final day of the study and at follow-up. Although no group differences were observed, they found significant differences between types of questions asked, with individuals correctly responding to more procedural questions initially, but no differences being observed at follow-up. These results suggest that procedural and declarative information is processed differently.

As previously mentioned, the addition of multimedia demonstrations is becoming more prevalent within newly published software, the premise being that their inclusion will aid users in learning how to use the application. It is assumed that by including these demonstrations within the on-line help, users have everything they need at their disposal to learn and use the software. Past reports, however, suggest that people prefer written manuals to those presented on the computer (Carroll, Mack, Lewis, Grischkowsy, & Robertson, 1985). Although the present results suggest that multimedia demonstrations are not as advantageous as current software publishers appear to believe, the participants in this study generally reported that they liked them and found them to be helpful. These demonstrations can play an important role by allowing individuals to view the outcome of executing a command and more importantly, they can act to reinforce or remind a person how to execute a command. However, given past findings of people's reluctance to use on-line help and the fact that, as the present study found, multimedia alone does not yield better performance than a manual, multimedia demonstrations will not replace a well-written manual that includes features from the Discovery Method of learning.

It may be possible to improve the effectiveness of multimedia presentations by making them fully interactive. Allowing the user to both view and interact with the demonstration may improve learning and increase the likelihood that the person would in fact use it. For example, if a person would like to learn a new procedure, s/he could view the demonstration and then the computer could ask the person to attempt the procedure through a sample. The computer could provide feedback, encouragement, and solutions to errors. These types of interactive computer-based training techniques are beginning to appear within popular software packages, however, they need to be examined through research.

Does performance differ when commands are consistently executed using a single method or varied between two methods?

It has been suggested that training individuals to use different interfaces and/or a variety of methods to execute commands requires the use of multiple memory systems and the establishment of different schemas (Kelley, 1993).

Given that many experienced users of word processors spontaneously use combinations of methods (e.g., menus, hot keys, and icons) in order to increase their speed and efficiency, this study was interested in determining whether novices who practiced executing commands using two methods would perform differently than those who consistently used a single method. For example, whereas individuals in the Consistent Practice condition always used the Delete key to modify text, those who were in the Variable condition switched between use of the Backspace and Delete keys to do the same thing.

It was hypothesized that due to working memory limitations and interference based on recalling the different commands, the performance of individuals who were required to use multiple methods would initially be inferior to that of individuals who used only a single method. No such findings were observed either when the analyses were based on all items completed during a specific session, or when the analyses were conducted on just the subset of items which the participants performed either consistently or which were varied.

In this study, the procedures that varied by condition were relatively low level. That is, they most probably did not tax working memory. Using the delete key or backspace key, or selecting text versus placing the insertion point somewhere in the target paragraph does not require a great deal of attentional resources. In fact, the samples provided above (i.e., selecting text, using special keys) are integral to successfully using a word processor. In addition, except for the addition of the multimedia demonstrations, all of the participants received identical training. Thus, all of the participants were initially trained to use the multiple methods that only some of the participants later practiced. It is therefore possible that individuals who practiced only a single method may have encountered a certain degree of confusion because they had in fact been taught that multiple methods exist to execute the command. In fact, although the participants were required to execute a command in a specific manner, on occasion individuals in both conditions spontaneously used a different method to execute it, suggesting that they would use the method that they felt most comfortable with. Given that there are generally more than two ways to execute a command, future research should examine whether training individuals to use multiple methods (i.e., more than 2 methods) has an effect on learning.

In this study, all of the commands were conducted through the use of menus. Additional methods to execute a command include the use of hot-keys (e.g., ALT-B for bold) or icons. It is therefore likely that the different methods to execute the commands required the use of only a single memory system. Although Kelley (1993) demonstrated that the consistent use of menus results in superior performance for novice adults of any age, studies have not examined training combinations of methods. It is quite possible that if individuals were trained to use these different interfaces in unison they may be slower initially, but they would be more efficient in the end than those who used only a single method. This is an issue that needs to be investigated further.

How does performance change with practice?

Many studies have demonstrated the lack of a main effect for training type. O'Toole and Wagner (1985), for example in their study of rehabilitation counsellors learning to use a word processor, found no differences between training methods and concluded that actual contact with the computer is more important than any of the three training methods that they had used. Researchers in human-computer interactions have long been searching for the 'best method' to train individuals to use a computer. What they often fail to recall is that "practice makes perfect" and that the development of a skill requires both time and practice. The human-computer interaction research has also failed to examine how performance changes with practice. In this study, it was hypothesized that even if group differences were observed initially, with practice these differences would be lost. According to Charness (1995), novice users' accuracy increases by about 33% by the end of the training, regardless of the interface used. We would therefore expect an even greater increase with additional practice. That is exactly what was observed in this study. Over the course of each day's session, performance increased across all of the major dependent variables. For example, accuracy increased by over 50% as a function of the initial score, errors and working time decreased by over 40%, and requests for help or interventions decreased by over 70%. Table 19 presents the results for the first and final block of trials for each lesson, as well as the percent change between them.

Although this study included 10 trials per command trained, this does not compare with the thousands of trials generally given within the skill acquisition literature. It would be interesting to monitor performance of novices learning to use a computer in order to observe, in a natural setting (e.g., at home or in the office), how one's performance changes with time and whether the development of a skill in word processing follows the three broad phases of skill acquisition (Ackerman, 1986, 1988, 1990, 1992; Anderson, 1981, 1982). The cognitive stage is the first stage of skill acquisition. It is characterized by a high cognitive load on the trainee in the context of understanding task instructions, general familiarization with task goals, and the formulation of strategies to accomplish the tasks. Once the trainee has acquired the basic procedures s/he proceeds to the associative phase of skill acquisition. The associative phase involves the proceduralization of task strategies in a manner that makes performance quicker and less prone to errors. The final stage of skill acquisition is the autonomous stage and involves the automatization of task skills, such that performance proceeds with little or no attentional effort. Performance at this phase of skill acquisition is typically highly speeded and quite accurate.

Table 19. Means for the first and final blocks of the major dependent variables and percent change over time[a].

	Lesson 1			Lesson 2			Lesson 3		
Variable	**B1**	**B5**	**%Δ**	**B1**	**B5**	**%Δ**	**B1**	**B5**	**%Δ**
Accuracy	.52	.80	53.85	.45	.76	68.89	.43	.77	79.07
Working Time	16.81	9.50	43.49	23.49	10.74	54.28	25.69	12.49	51.38
Reflection Time	3.88	1.81	53.35	4.02	2.52	37.31	2.72	1.58	41.92
Errors	15.02	8.80	41.41	27.06	10.81	60.05	22.48	10.66	52.58
Help	6.94	1.63	76.51	10.94	1.98	81.90	8.54	1.57	81.62
Interventions	3.32	1.02	69.28	5.54	.67	87.91	6.98	.69	90.11

Note. [a] Percent change was computed using the equation |(B1 - B5)| / B1 * 100, where B1 = Mean score for Block 1, B5 = Mean score for Block 5.

To examine empirically whether individuals learning to use a computer proceed through similar stages, a study can be conducted in which novice users' word processing performance is monitored over time. For example, an interface could be developed and added to a person's computer which would: (a) track the commands and method of executing them (i.e., menus, hot keys, or icons), and (b) provide skill-based exercises at specific intervals (e.g., after every 25 hours of use). Thus, after the individual uses the word processor for a given interval, an exercise (e.g., make a table that is 5 columns by 3 rows and which is centered across the line) appears on the screen, at which time s/he must complete it as quickly as possible using any method they choose. In addition the following can also be included; (a) multiple choice questions can appear on the screen in order to examine declarative versus procedural types of knowledge over time, (b) tests of specific abilities (e.g., mouse usability, typing, spatial abilities, etc.) can be administered via the computer in order to further examine their relationship to the development of computer skills, (c) transfer can be assessed through additional exercises administered via the computer, and (d) help requests could be enumerated by surveying the frequency by which the user accesses the online-help facility. Such a system, one which is tightly integrated within the word processor and is fully automated, would adequately examine how novice users develop word processing skills over time.

Can individuals transfer what they had learned?

Transfer is a central purpose of many training programs (Adams, 1987). In essence, the training programs are based upon the assumption that knowledge and skills, which are learned to perform a particular task, will positively influence performance on other more-or-less related tasks (Jelsma, Merriënboer, & Bijlstra, 1990). Researchers studying human-computer interactions, have often failed to examine this issue. Furthermore, the few studies that have examined transfer differ on how they define transfer. For example, whereas one study may examine whether individuals can complete commands that they have never before executed (e.g., Kamouri et al., 1986), other studies have defined transfer as the ability to integrate what they had learned during training to complete an exercise that includes all aspects of the training (e.g., Polson et al., 1987). Furthermore, transfer has also been examined in the context of one's ability to work with novel applications (e.g., Karat, Boyes, Weisberger, & Schafer, 1986). In the present study, transfer was examined through the Word Processor Integration task, which assessed the participants ability to integrate everything they have learned in a single exercise, as well as through the Near Transfer task which examined their ability to work with a word processor which they had not previously had the opportunity to work with.

As hypothesized, no group differences were observed either on the Word Processor Integration or Near Transfer tasks. Although a decline in performance was expected for the transfer tasks, it is disconcerting that the participants were able to only complete correctly about 50% of the test items, representing a decline of about 23% when performance across sessions were averaged together. Performance on the Near Transfer task was somewhat better than that of the Word Processing Integration task. Because of the similarity of the tasks, it is possible that the Word Processor Integration task, which was done first, acted as a practice exercise, allowing the participants to review the procedures necessary to complete the items. Overall, these results suggest that the participants were able to transfer what they had learned both to an exercise that integrated everything that they had learned and to a similar, albeit a different, word processor which they had not previously been exposed to; however there was a reduction in performance scores such that the proportion of correct responses was about equal to that obtained during the first practice block of each session, and time and errors were about equal to the performance during the second block of practice trials. It is postulated that, if participants were given additional practice at integrating everything that they learned, performance would increase rapidly.

Two caveats to these findings should be noted. First, some of the participants commented that they found the instructions to the transfer tasks to be somewhat confusing. In these tasks, the participants were asked to edit a file according to the written instructions. Words to be modified were written in bold, and they were told to place the paragraphs in a prescribed order. Some of the participants failed to change the words while others failed to place the paragraphs in their required order. It is therefore possible that these results are an underestimate of the participant's true abilities due to the fact that some of the participants failed to comprehend the instructions or to recall specific components of them. Second, the nature of these transfer tasks differ significantly from the tasks which the participants completed during practice. During the practice, the participants were given structured exercises which enabled them to attempt multiple trials of specific commands. During the transfer tasks, the participants integrated everything that they had learned into a single exercise. The distinction between these tasks is similar to that of 'part-whole' learning. It has been previously shown (e.g., Adams, 1987) that the performance of individuals who learn a novel task that has been divided into component skills (part-learning), differs from that of individuals for whom the task remains undivided (whole-learning). Specifically, whereas individuals complete the training more quickly and make fewer errors when the tasks are divided into more basic components, their performance on transfer tasks is inferior to those individuals who are trained via a whole learning approach. It is therefore possible that the decrease in performance on the transfer tasks that was observed here is due to the fact that the participants were trained via component skills. Future research would be required to examine this hypothesis and the effects of part versus whole learning when older adults learn to use a computer.

How do attitudes change with training and practice?

As expected, when a multidimensional attitudes towards computers questionnaire was administered, the participants reported having more positive feelings of comfort and self-efficacy using computers, and felt more strongly that computers are important to both men and women at the end of training. Furthermore, the attitude change was maintained for two of these three dimensions (comfort and self-efficacy) and tended to remain more positive for the third (Gender equality) for at least 6 weeks following training. In addition, the feeling that individuals have control over computers, although not initially changed, became more positive at follow-up. As expected, the type of training method did not affect attitudes towards computers.

Although these results are generally in keeping with those observed by others (e.g., Jay & Willis, 1992; Kurzman & Arbuckle, 1994; Morrell et al., 1996), no changes were observed for the dimensions of interest and dehumanization. This finding is not too surprising because the participants had fairly positive attitudes at the beginning of the study. Their willingness to participate in the study is itself an indicator of their desire to learn more about computers. It would be interesting to determine the degree of change, and whether it would remain stable, in adults who were less interested in computers.

According to Czaja (1996), a person's initial exposure to technology affects their future attitudes towards, and willingness to use, the technology. For example, in her 1989 study (Czaja et al., 1989) participants who performed poorly and rated the training session and/or word processor more negatively had more negative attitudes towards computers following training than did those who had a more positive learning experience. This relationship was not observed in the current study as the correlation between post-training attitudes and the participants ratings of the training was only .06.

<u>What is the relationship between individual difference variables and performance?</u>

Based on the path analyses which were conducted on accuracy, working time, and errors, the best predictor of word processing performance was the previous day's score. Furthermore, as hypothesized, general abilities were more directly related to earlier sessions than to later ones. To further examine the relationship between individual difference variables and performance, additional regression analyses were conducted in which the previous day's performance was not included. These analyses also demonstrated that general abilities were related to performance but different individual difference variables predicted accuracy, working time and the number of errors made.

As hypothesized, age was an important predictor of performance even within the limited age-range in this study. Whereas all 5 ability factors significantly predicted the amount of working time required to complete the first lesson, the number of errors made on this lesson was predicted by only 2 of the factors (Language, Visuospatial), and accuracy was not predicted by any of the ability factors. As previously mentioned, the best predictors of Lessons 2 and 3, and the transfer tasks, were the lessons just before them. Whereas Memory was a significant predictor for working time and errors during Lesson 2, Speed and Manual Control significantly predicted working time for Lesson 3. Neither of these factors predicted errors in Lesson 3. Language was the only ability to predict Accuracy, and then only for Lesson 3.

On the Word Processor Integration and Near Transfer tasks, accuracy on the former task was predicted by the presence of a computer in the home and the number of hours of previous computer use. As previously mentioned, it is possible that individuals who either had a computer in their home or had some previous computer experience were more familiar with computer-related concepts thereby providing them with previous domain-related knowledge which helped them to integrate the newly learned information. Accuracy on Lesson 1 was also a significant predictor of accuracy on the near transfer task, suggesting that performance on the more basic concepts of word processor use is critical to performance on more difficult concepts. Working time for the Word Processor Integration task was predicted by one's age and years of education, and none of the individual difference variables predicted the time required to complete the transfer task. Similarly, one's age predicted errors produced during the Word Processor Integration task, but in the unexpected direction.

Attitudes towards computers were also an important predictor, however the direction of the relationship was counter to that which was expected; individuals with worse pre-training attitudes were more accurate, required more working time, and made more errors. The reason for this relationship is unknown, however as previously mentioned, it is possible that those individuals who had more negative attitudes paid more attention to their performance during the exercise in order to compensate for their attitudes. Further research would be required in order to examine this hypothesis.

Expert Survey of the Training Manual and Exercises

Overall, the participants in the study expressed delight in the quality of the manuals and their experience in the study. In order to get a measure of the quality of the manual, seven self-proclaimed experts between the ages of 20 and 49 years ($\underline{M}$ = 32.43 years) who were experienced with computers ($\underline{M}$ = 7.29 years) and word processors ($\underline{M}$ = 6.57 years) were asked to review the manuals, a sample multimedia demonstration, and to provide ratings for each of the lessons (See Appendix U). On a 5-point Likert scale which ranged from 1 (Excellent) to 5 (Terrible) the experts felt that the manual ($\underline{M}$ = 1.86) and practice ($\underline{M}$ = 1.57) were quite good, especially when compared to training manuals in general. Although they felt that the multimedia demonstration was slightly better than adequate ($\underline{M}$ = 2.57), they agreed that such demonstrations would be quite beneficial to individuals learning to use the wordprocessor ($\underline{M}$ = 1.71).

On a 5-point Likert scale which ranged from 1 (very easy) to 5 (very difficult), the experts felt that each lesson was more difficult than its predecessor. For example, they all felt that the Introductory Session ($\underline{M}$ =

1.00) and Lesson 1 (M = 1.29) were very easy, Lesson 2 was neither easy nor hard (M = 3.29) and Lesson 3 was relatively hard (M = 4.00). Furthermore, they felt the Word Processing Integration (M = 4.43) and Near Transfer task (M = 4.57) were significantly harder than each of the training sessions. In addition, when specifically asked how difficult they felt the transfer tasks would be for a novice who just completed the training, they felt that it would be quite hard (M = 4.71). It is therefore possible that the participants' lower performance on the transfer tasks can be related to the relative difficulty of the task.

Limitations and Suggestions for Future Research

There are many problems inherent in studying technology and aging. It is difficult to use past research today because of the radical changes that have occurred in access to the technology as well as in the technology itself. In addition, the rapid adoption of computers by older adults can also be explained to a certain degree by cohort effects. There are a number of limitations that must be examined with respect to this study. First, the study utilized a volunteer sample of older women who in general, were highly educated and reported that they were in good health. They are therefore not representative of the general population of older woman. It is quite possible that the findings from this study would have been different if a more heterogenous sample were obtained. For example, scores on the individual difference variables, which are related to age and education, may have yielded a different pattern of results if a wider range of age and education was represented in the sample. Second, no measure of motivation was included in this study. Past research has shown that learning can be influenced by motivation. In fact, older adults are more likely to develop better and more efficient strategies when they are motivated (Ackerman & Woltz, 1994). Although it can be assumed that the women who participated in this study, and who represent a self-selected sample, were quite motivated, it would have been desirable to have directly measured their level of motivation and to determine its relationship to performance. Third, as discussed in the introduction, gender differences have been documented in the attitudes of men and women towards computers. It would have been interesting to have a sample of men, so that comparisons could be made between men and woman in terms of their performance and attitudes. It is quite possible that, given the increasing prevalence of computers in the home, gender differences no longer exist.

Additional limitations concern the design of the study. Most important is the sample size. Although a sample of 48 individuals for a study such as this is quite good, the sheer number of analyses conducted makes the results questionable, especially for the path analyses. In general, regression analyses require a minimum sample to variable ratio of 5:1 (Cohen & Cohen, 1983). This ratio was not obtained in this study. Before any definitive conclusions can be made, further research needs to be conducted in order to replicate the findings obtained in this study. In addition, the manuals used in the study were based on the Discovery Method of learning. Many manuals that come with purchased applications are poorly written, having been quickly composed by technicians with little training in technical writing. The manuals used in the study are therefore not representative of the manuals that individuals generally use, and may be more representative of a 'state-of-the-art' form of a manual. It is possible that if more traditional manuals were used, a training effect would have been observed. This issue needs to be examined further. Furthermore, in this study, certain commands were blocked and all procedures were executed via menus in order to decrease the difficulty associated with learning to use a word processor. Thus, although the goal was to allow the individuals to use a real word processor, the system used in this study can be considered to be a pseudo-open system due to the fact that certain functions were blocked. According to Charness (1996), although software is being developed with Graphical User Interfaces, there is little research on their usability. This lack of research is most likely due to the difficulty in drawing up parallel interfaces that vary just the interface and not the breadth of command structure. Future research should attempt to examine the positive and negative aspects of these interfaces.

The study of technology and aging is a relatively new field and there are many areas that still need to be explored. As previously mentioned, technology and software are always changing. In addition to issues for further research discussed above, there are a number of additional areas that could be addressed in future research. Typing is currently an inherent part of word processing. Difficulty with typing was cited by Hicks (1976, cited in Ogozalek & Von Praag, 1986) as one of the major problems encountered by older adults using computers. This problem can be alleviated by allowing older adults to use voice recognition software which has recently been introduced as an option to newly purchased computers. Ogozalek and VanPraag (1986) reported that younger and older adults preferred speech recognition input over that of a keyboard, their system consisted of a 'listening typewriter' in which a secretary typed everything that the user spoke in order to create a simulate voice recognition system. Given that voice recognition systems will increase in prevalence over the next few years, research into the usability of these systems should begin now.

In addition, older adults tend to commit far more mouse-related errors than younger adults (Kelley, 1993) and potential problems with older adults' usability of the mouse have been documented (Charness et al., 1995). For example, tremors in the hand and difficulty controlling movements due to arthritis are more likely to affect older adults and in turn affect their ability to control the fine-positioning movements that are necessary for proper mouse use. Second, a computer mouse operates in a plane that is different from the plane of the computer screen. Because older adults tend to have more trouble with spatial relations than do younger individuals, it is likely that they will experience greater difficulties when using a mouse. Researchers should therefore examine alternative input devices which have become prevalent over the last few years. In one study for example, Charness et al. (1995) reported that individuals using a light pen were about twice as fast as those using a mouse and that the gap in speed between young and old was greater for the mouse, suggesting that older adults may benefit from an input device such as a light pen.

New versions of popular software package continuously add new features to increase the usability of the software. One new feature that may be beneficial to older adults is that of the 'shadow cursor'. According to Kelley et al. (1996) older adults tend to make more insertion point errors than younger adults. In the current study individuals made a significant number of these errors. Based on the observations of the experimenter, one reason for the occurrence of the insertion point errors was that the novice had difficulty understanding the relationship between the mouse pointer and the insertion point. The purpose of the shadow cursor is that it helps orient a person to the location where the insertion point would be placed if s/he were to click on the mouse button. Although it is likely that the shadow cursor will be helpful to adults of all ages, it is likely to be even more beneficial to older adults. Research will be required in order to test this hypothesis.

The use of computers has also been shown to increase older adults' self-esteem (Danowsky & Sacks, 1980). Many old age residences are currently integrating computers into the activities of older adults. Given the changes in computer technology that have occurred over the last few years it would be interesting to assess whether these changes would result in similar findings of positive self-esteem. In addition, computer technology (both hardware and software) has generally been geared toward business and educational applications, or for entertainment purposes with children, teenagers, or young to middle-aged adults in mind (Zimmer & Chappell, 1993). Only recently has the computer industry begun to realize the potential benefits of marketing their products to the senior computer user. As older adults continue to purchase computers and continue to become computer literate, the computer industry will pay more attention to this market and develop applications with older adults in mind. Furthermore, industry will focus on older adult's use of computer, especially given that population forecasts suggest that by the year 2025, the global population of older adults will increase threefold (Statistics Canada, 1991). It will be interesting to see how computers and computer software will adapt to this shift in market strategy.

<u>General Conclusions</u>

Word processing has emerged as a highly important skill in numerous occupations and industries, and is the most commonly used application by older adults. This study examined different methods of training older adults to use a word processor. Overall, no differences were observed between individuals who were trained with a manual and those who had the additional benefits of multimedia demonstrations. Individuals who viewed the demonstrations, however, liked them and perceived them as being beneficial. These demonstrations should not be used to replace manuals as a form of training, rather they can serve to help individuals recall the procedures required to execute a command within an application's on-line help facility. Individuals who practiced a command using two different methods performed similarly to those who consistently used only a single technique to do the same thing, suggesting that training individuals how to execute a command using two different methods does not interfere with performance.

Overall, this study supports the old proverb that 'practice makes perfect'. As individuals practiced, their performance increased, while the number of errors, time required to complete the commands, and requests for help decreased. The trainee's performance on a word processing integration task and their ability to transfer what they had learned was equivalent to their performance on each day's first block of trials, possibly due to the fact that these tasks were harder than those performed on each training day. Age, years of education, and attitudes towards computers were important predictors of performance. This study also lends support to the importance of visuospatial skills, memory, and language abilities to the acquisition and retention of word processing skills.

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Appendix A. Methodology of studies that examined age effects and/or training methods in older adults[a].

Study	Age	Training Sessions[b]/ Duration	Task	Instructional Material[c] and Design[d]
Caplan & Schooler (1990a) n = 128	18 - 35 36 - 60	1 Duration Unknown	Graphics Package (FullPaint for Macintosh)	All subjects used a Written manual. Analogical Model Condition - Subjects were also provided with a picture of a desktop with containers labelled as a pencil holder, paint equipment, scissors, etc., and the phrase "You can think of the tools you will learn as tools you might find on your desk". No model condition - No such information was presented.
Charness et al. (1992): Exp't 1 n = 32	25 - 81	2 2 hrs	Word Processing (Microsoft Word for DOS v. 4.0)	All subjects used Interactive Computer-Based Training (CBT). Advance Organizer Condition - Two days before participating, subjects received an organizer which included information on lesson format and content, and a list of keys used in the study. Control Condition - No such information was provided.
Charness et al. (1992): Exp't 2 n = 60	24 - 44 55 - 74	2 2 hrs	Word Processing (Microsoft Word for DOS v. 4.0)	Self-Paced Condition - Interactive CBT. Fixed-Pace Condition - Subjects viewed and read the information presented by the CBT program, but were unable to interact with the computer.
Czaja & Sharit (1993) n = 65	20 - 75	3 1.5 hrs	Data entry, File modification, Inventory tracking	Subjects practiced using the computer until they were able to complete a sample problem without assistance.
Czaja et al. (1986, 1989) n = 135	25 - 39 40 - 54 55 - 70	1 3 hrs.	Word Processing (WordStar)	Interactive CBT Training. Text Training - Edited version of the software manual which used a step-by-step, drill and practice approach. Instructor-Based Training - Lecture format which closely followed the manual used in the Text condition.

(Tables Continues)

Study	Age	Training Sessions[b]/ Duration	Task	Instructional Material[c] and Design[d]
Echt & Morrell (1995) n = **92**	60 - 74 75 - 89	1 3-3.5 hrs.	Basic procedures on a Macintosh computer	Subjects read instructions and performed exercises on a computer. Animated Interactive Multimedia Condition - Textual information on how to perform basic procedures in a step-by-step manner was accompanied by an animated sequence that demonstrated the procedure. Text Condition - The same material as that presented in the Animated Demonstration condition was presented with illustrations to demonstrate each step in the procedure.
Elias et al. (1987) n = **45**	18 - 28 37 - 48 55 - 67	6 3.5 hrs.	Word Processing (Superscript)	All subjects used a self-paced text tutorial and audiotapes. They were also given a command cue-card and were able to ask questions and receive help from the trainer.
Garfein et al. (1988a,b) n = **56**	49 - 57 58 - 69 M=57.9	2 1.5 hrs.	Spreadsheet (Lotus 123)	Instructor-based small group training that contained 5 to 11 subjects. Subjects worked individually on a computer and were provided with a reference guide that contained a summary of commands. The upper (most proficient) and lower (least proficient) quartiles were examined in Garfein et al. (1988b)
Gist et al. (1988) n = **146**	< 45 (n = 96) > 45 (n = 50) M = 40	1 3 hrs.	Spreadsheet	Interactive CBT Training - Subjects received step-by-step instructions with immediate feedback. Behavioural modelling - Subjects viewed a videotape which demonstrated a person using the software. A command was described, each step of it's procedure was enacted, and the outcome was displayed. The subject then practiced the procedure.
Gomez et al. (1983) n = **40**	28 - 62	1 Duration Unknown	UNIX Screen Editor (TED)	All subjects used a written manual to learn four text editing commands.
Gomez et al. (1986): Exp't 1 n = **33**	28 - 62	1 2 hrs.	UNIX Line Editor. (ED)	All subjects used a written manual to learn three text editing commands.

(Tables Continues)

Study	Age	Training Sessions[b]/ Duration	Task	Instructional Material[c] and Design[d]
Gomez et al. (1986): Exp't 2 n = **41**	26 - 63	2 3 hrs.	UNIX Line Editor. (ED)	All subjects used a written manual. Command Names Condition - Subjects learned the actual names for a command. First Letter Condition - Subjects learned names of commands which were matched for first letter, but had no semantic relationship to the text-editing operation to which they were assigned.
Hartley et al. (1984) Hartley & Hartley (1988) n = **24**	18 - 30 65 - 75	6 2 hrs.	Text Editor	All subjects received CBT which presented text editing concepts, commands, and functions, as well as examples and practice.
Kelley (1993) n = **72**	19 - 35 36 - 54 55 +	3 1 - 2 hrs	Word processor (Microsoft Word for Windows v. 1.0)	All subjects received minimal manual training which included a description of commands, including illustrations, followed by a practice trial. Three training conditions varied how one accessed the commands; keystroke combinations, menus, or icons.
Kelley et al. (1994) n = **96**	19 - 35 36 - 54 55 - 72	3 1 - 2 hrs.	Word processor (Microsoft Word for Windows v. 1.0)	All subjects received minimal manual training. Subjects were either novice or experienced (6 months or more experience using a word processor) computer users. Two training conditions varied how one accessed the commands; keystroke combinations or menus.
Kurzman & Arbuckle (1994) n = **38**	56 - 65 66 - 83	3 1 - 2 hrs.	Word processor (Microsoft Word for Windows v. 1.0)	All subjects received minimal manual training. Subjects either worked alone or with a partner (and took turns working on the computer). All commands were executed via menus.
Martocchio (1992): Exp't 2 n = **87**	$\underline{M}$ = 41.7 *SD* = 10.6	1 4 hrs.	Basic computer skills	All subjects received a structured lecture and practice on a computer. Opportunity Condition - 39 subjects received manuals in which the positive, controllable, and gain aspects of microcomputer usage were described. Neutral Condition - Manual was neutral with respect to these issues.

(Tables Continues)

Study	Age	Training Sessions[b]/ Duration	Task	Instructional Material[c] and Design[d]
Ogozalek & Von Praag (1986) **n = 24**	18 - 40 65 - 79	1 20 min	Simulated voice recognition system	A within-subjects design was used. All subjects used a standard keyboard or a simulated voice recognition system (counterbalanced) to write two letters.
Ralls & Klein (1992) **n = 121**	22 - 64	1 6 hrs.	DOS basics or Lotus spreadsheet basics	Instructor-based classroom training. Fundamentals of PC class - Subjects learned basic DOS commands. Spreadsheet fundamentals - Subjects learned how to use Lotus 1-2-3 spreadsheet software.
Sit (1996) **n = 54**	50 - 76	No training provided	On-line library catalogue	Adults with previous library catalogue experience were required to conduct 6 simple and 3 complex information searches.
Webster & Martocchio (1993) **n = 68**	$\underline{M}$ = 41.3 *SD* = 11.6	1 4 hrs.	Word processor (Merge feature of Word Pefect 5.0)	All subjects received a structured lecture and practice on a computer. Play Training - Training was labelled as 'play' and training scripts were designed to include terms reflective of the concepts of play and having fun. Work Training - Training was labelled as 'work' and training scripts were designed to include terms reflective of the concept of work.
Zandri & Charness (1989) **n = 46**	20 - 84	3 3 hrs.	Notepad, Calendar. (Borland Sidekick)	All subjects received a manual that stressed discovery-learning. Memory Reduction Condition - prior to participating, subjects received cue cards and help sheets to reduce memory demands. Control Condition - This information was not provided.

[a] In all of these studies, participants were novices except for; (a) Czaja and Sharit (1993) in which trainees ranged from novice to experienced, (b) Kelley et al. (1994) in which novice and experienced users were examined, (c) Ogozalek and Von Praag (1986) in which all trainees had a minimum of 6 months experience, and (d) Ralls and Klein (1992) in which trainees had an average of 2.28 years of computer experience.

[b] Does not include additional sessions which were used for performance evaluation exercises and/or background data collection.

[c] Text tutorials generally proceeded from less to more complex commands in a consistent manner, building on acquired skills as more complex procedures were introduced.

[d] Unless otherwise stated, participants were randomly assigned to training conditions of equal (or near equal) size.

Appendix B. Findings from computer training studies in which age was examined

		Effect of age on			
Study	**Performance measures**	**Performance**	**Time**	**Errors**	**Help**
Caplan & Schooler (1990a)	Ability to solve problems in multiple ways	Young > Old	Not Examined	Not Examined	Not Examined
Charness et al. (1992): Exp't 1	21-item multiple choice quiz	Young > Old	Old > Young	Old > Young	Old > Young
Charness et al. (1992): Exp't 2	21-item multiple choice quiz	Young > Old	Old > Young	Old > Young	Not Examined
Czaja et al. (1986, 1989)	Speed & accuracy measures	Young > Old	Old > Young	Old > Young	Not Examined
Czaja & Sharit (1993)[a]	Speed & accuracy measures	Young > Old	Old > Young	Old > Young	Not Examined
Echt & Morrell (1995)	30-item multiple choice quiz, error types, help, time	Young-old > Old-old	Old-old > Young-old	Old-old > Young-old	Old-old > Young-old
Elias et al. (1987)	Speed, accuracy measures, 20-item performance test	Young & Middle > Old	Old > Young & Middle	Minimal Overall	Old > Young & Middle
Garfein et al. (1988a,b)	Score on 2 timed exercises	No Effect	Not Examined	Not Examined	Not Examined
Gist et al. (1988)	25-item performance test	Young > Old	Not Examined	Not Examined	Not Examined

(Tables Continues)

		Effect of age on			
Study	Performance measures	Performance	Time	Errors	Help
Gomez et al. (1983)	First try errors, reading time, idle time, cursor movements, execution time	(Based on errors)	(Reading Idle, & Execution Time) Old > Young	No Effect	Not Examined
Gomez et al. (1986): Exp'ts 1 & 2	First try errors, reading time, execution time, finisher vs. non-finisher	Young more likely to finish task than Old	(Reading Time) No Effect (Execution Time) Old > Young	Old > Young	Not Examined
Hartley & Hartley (1988) Hartley et al. (1984)	Recall of trained material, items attempted, time	No effect on recall. Young attempted more items than old.	Old > Young	Not Examined	Old > Young
Kelley (1993)	40-item multiple choice quiz, speed, and accuracy on a computer exercise	(exercise) (quiz) Young & Middle > Old	Old > Middle &> Young	Old > Young & Middle	Not Examined
Kelley et al. (1994)[b]	40-item multiple choice quiz, accuracy, errors and speed on a computer exercise	(exercise, quiz)[c] Young > Middle > Old	Old > Middle > Young	Old > Young & Middle	Not Examined

(Tables Continues)

		Effect of age on			
Study	Performance measures	Performance	Time	Errors	Help
Kurzman & Arbuckle (1994)	40-item multiple choice quiz, accuracy and speed on a computer exercise	(exercise, (quiz) Young-old > Old-old	Old-old > Young-old	Old-old > Young-old	No differences
Ogozalek & Von Praag (1986)	Effectiveness, time, and grammatical errors on 2 short letters (1/condition)	No differences	No differences	No differences	Not Examined
Ralls & Klein (1992)	12-item multiple choice quiz	Young > Old in spreadsheet group. No differences in DOS group	Not Examined	Not Examined	Not Examined
Webster & Martocchio (1993)	10-item multiple choice quiz	No differences	Not Examined	Not Examined	Not Examined
Zandri & Charness (1989)	Speed, accuracy, and help	Young > Old	Old > Young	Not Examined	Old > Young

[a] Effect of age on performance was reduced when amount of previous computer experience was controlled.
[b] It is unknown whether the differences between young, middle and old are significantly different from one another.
[c] This age effect on performance was observed only for novices. No age effects for performance were observed for adults who had a minimum of 6 months computer experience.

Appendix C. Findings from studies in which individual differences were examined

Study	Tests Administered	Significant Findings
Echt & Morrell (1995)	Not Listed	Spatial abilities and verbal working memory were significant predictors of performance, errors and interventions in the Multimedia condition. Text comprehension was a significant predictor of performance, errors and interventions in the Text condition.
Garfein et al. (1988a, b)	Subtests from SRA Primary Abilities (Verbal meaning, number relations, word fluency, spatial orientation, inductive reasoning), figural relations subtests from the Culture Fair Test (figure series, matrices, topology)	Spatial orientation and inductive reasoning were significant predictors of performance. High proficient computer learners outperformed low proficient learners on tests of fluid and crystallized abilities.
Gist et al. (1988, 1989)	Computer-Self Efficacy Measure	Individuals with a high score on computer self-efficacy outperformed those who had moderate and low self-efficacy scores.
Gomez et al. (1983)	Building Memory Test, Diagramming Relations Test, Nelson-Denny Reading Test, Finger Tapping Test, Two Dimensional Space Test	Reading ability was the best predictor of first try errors, execution time, reading time, and idle time. Spatial memory predicted execution time and first try errors. Logical reasoning also predicted execution time. Spatial visualization was a significant predictor of cursor moves.
Gomez et al. (1986): Exp'ts 1 & 2	Controlled Associations, Building Memory, Nelson-Denny Reading Test (Diagramming Relations & Object Numbers added to Exp't 2)	Reading ability was the best predictor of the amount of time subjects spent reading the manual. Spatial memory was a significant predictor of first-try errors and execution time per successful change. Logical reasoning correlated with first-try errors or execution time per successful change
Hartley & Hartley (1984, 1988)	A measure for each of Reading Span, Vocabulary, Abstract Reasoning, & Reading Comprehension	Reading comprehension best predicted performance, items attempted, and efficiency. Vocabulary and reading span also demonstrated substantial correlations with efficiency and items attempted.

(Tables Continues)

Study	Tests Administered	Significant Findings
Kelley et al. (1994)	CARNET Battery tests of working memory, perceptual speed, visuospatial ability, and vocabulary.	After controlling for the effect of age, vocabulary was a significant predictor of performance on the multiple choice quiz. Digit-Symbol significantly predicted performance, errors, and time.
Kurzman & Arbuckle (1994, 1995)	CARNET Digit-Symbol, Digit-Digit, & Vocabulary, WAIS-R Block Design	After controlling for the effect of age, vocabulary and spatial skills were the best predictors of accuracy on a post-training computer exercise and on the multiple choice quiz. None of the ability measures were significant predictors of the number of errors made, requests for help, or time to complete the training.
Sebrechts et al. (1984)	Nelson-Denny Reading Test, Building Memory Test, Picture-Number Test	Reading ability was a significant predictor of performance. Spatial ability was unrelated to performance.
Sein & Bostrom (1989)	Paper-folding test, Learning style (Kolb Learning Style Inventory)	Subjects with higher scores on the spatial ability test performed better on the tasks. Subjects with abstract learning styles performed better than those concrete learning styles.
Sein & Robey (1991)	Learning style (Kolb Learning Style Inventory)	Subjects classified as Convergers and Assimilators performed better when provided with an abstract model (i.e., a schematic diagram). Subjects classified as Accommodators and Divergers performed better *when provided with an analogical model* (i.e., comparing a novel domain to a familiar one).

Appendix D. Studies in which training methods and age or elderly participants[a] were examined

Study	Training Methods Examined	Findings / Conclusions
Caplan & Schooler (1990a)	Analogical model vs. No model	No difference between Y & O when no model provided, but O performed worse than Y when provided with model. (O have greater difficulty in using elaborative techniques to learn new material)
Charness et al. (1992): Exp't 1	Advanced organizer vs. No organizer	No differences. (Availability of pre-training information does not help performance for either Y or O)
Charness et al. (1992): Exp't 2	Self-paced vs. fixed-pace learning	Self-Paced > Fixed-Pace (Self-pacing is equally advantageous for both Y and O)
Czaja et al. (1986, 1989)	Computer, Document, or Instructor-Based Training	Text & Instructor > Computer-based Training (Y perform better than O regardless of method; No method considered truly effective)
Echt & Morrell (1995)	Animated interactive computer-based vs. Illustrated manual	No Differences (Both methods equally advantageous for young-old and old-old)
Gist et al. (1988, 1989)	Interactive computer-based training vs. videotape (behavioural) modelling	Videotaped Modelling > Computer-Based Training (behavioural modelling was more effective than a tutorial for both Y and O)
Gomez et al. (1983)	Screen Editor vs. Line editor (using data from Egan & Gomez (1982)	Screen editor > Line editor When using a screen editor, O required less time to execute a command and made fewer first try-errors then when using a line editor, whereas no differences were observed for younger adults. (Screen editors are less complex and easier to learn than line editors, thus more beneficial for older adults)
Gomez et al. (1986): Exp't 2	Meaningless vs. meaningful command names	No Differences (command names did not affect performance)

(Tables Continues)

Study	Training Methods Examined	Findings / Conclusions
Kelley (1993)	Keystroke combinations, menus, vs. icons to access commands	Menus & Icons > Keystroke (Menus and icons are equally helpful to adults of all ages and are superior to Keystrokes)
Kelley et al. (1994)	Keystroke combinations, vs. Menus to access commands	Menus > Keystrokes for both novice and experienced subjects. (Menus are more beneficial than Keystrokes for adults of all ages)
Kurzman & Arbuckle (1994, 1995)	Individual vs. Dyadic training High versus Low generalized anxiety	No differences (Although those trained in pairs took more time and made more errors than those trained alone, their performance scores were similar. In addition, levels of generalized anxiety were unrelated to performance).
Martocchio (1992): Exp't 2	Opportunity vs. Neutral manual	Opportunity > Neutral (Labelling the training as an opportunity yielded lower computer anxiety, and better learning than when training was labelled as neutral for adults of all ages)
Ogozalek & Von Praag (1986)	Speech input vs. keyboard	No differences (Older performed equally well with both methods)
Webster & Martocchio (1993)	Play vs. Work	Age x Training interaction; Individuals under 40 years of age scored higher on a multiple choice quiz in the play condition than those over 40 years. No differences were observed between individuals in the work condition. (Labelling training as play may have positive effects only for younger adults because older adults have greater amounts of work experiences and see less ambiguity in their jobs)
Zandri & Charness (1989)	Jargon sheet vs. No jargon sheet Individual vs. Dyadic Training	Age x Jargon sheet; Age x Jargon sheet x group size (For older adults, having the jargon sheet resulted in better performance for individuals but had no effect for dyads; For younger adults, the jargon sheet lead to worse performance for individuals, but no difference for partners)

[a] Age was either a categorical variable and was analyzed through an ANOVA model, or a continuous variable and analyzed through a regression design.

Appendix E. Attitudes Towards Computers Questionnaire (ATCQ)

This is a questionnaire which examines your attitudes towards computers. There are no "right" or "wrong" answers. Please read each item carefully and circle the answer which corresponds best to your opinion. Answer every item. If you change your mind please erase. Remember, there are no right or wrong answers.

1. I feel comfortable with computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

2. Using computers is more important for men than for women.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

3. Computers will never replace the need for working human beings.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

4. More women than men have the ability to become computer scientists.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

5. Learning about computers is a worthwhile and necessary subject.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

6. Computers turn people into just another number.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

7. The use of computers is lowering our standard of living.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

8. Computers control too much of our world today.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

9. Reading or hearing about computers would be (is) boring.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

10. I know that if I worked hard to learn about computers, I could do well.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

11. Using computers is more enjoyable for men than it is for women.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

12. Computers are making the jobs done by humans less important.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

13. Computers make me nervous.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

14. Life will be (is) harder with computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

15. I don't care to know more about computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

16. Working with computers is more for women than men.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

17. Computers would be (are) fun to use.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

18. I don't feel confident about my ability to use a computer.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

19. Women can do just as well as men in learning about computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

20. Everyone could get along just fine without computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

21. Computers are dehumanizing.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

22. Computers are not too complicated for me to understand.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

23. Our world will never be completely run by computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

24. I think I am the kind of person who would learn to use a computer well.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

25. It is not necessary for people to know about computers in today's society.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

26. People are smarter than computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

27. Computers are too fast.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

28. People will always be in control of computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

29. I think I am capable of learning to use a computer.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

30. Learning about computers is a waste of time.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

31. Computers are confusing.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

32. Computers make the work done by people more difficult.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

33. Soon our lives will be controlled by computers.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

34. Computers make me feel dumb.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

35. Given a little time and training, I know I could learn to use a computer.

1	2	3	4	5
disagree strongly	disagree	neither agree nor disagree	agree	strongly agree

Note. Scoring for the following items is reversed: 1, 3, 5, 6, 7, 8, 10, 12, 17, 19, 21 22, 23, 24, 26, 28, 29, 33, 35. See original paper for item loadings on specific dimensions.

From "Influence of direct computer experience on older adults' attitudes toward computers" by G. M. Jay and S. L. Willis, 1992. Journals of Gerontology, 47, p. 250-257. Reprinted by permission.

Appendix F. Feelings for Computers Questionnaire (FCQ)

We would like to ask you some questions about your feelings towards computers. Please answer "True" if a statement is true for you and "False" if it does not apply to you.

1.	I am confident that I could learn computer skills.	True	False
2.	I am sure of my ability to learn a computer program.	True	False
3.	I will be able to keep up with important technological advances in computers.	True	False
4.	I feel apprehensive about using a computer.	True	False
5.	If given the opportunity to use a computer, I am afraid that I might damage it in some way.	True	False
6.	I have avoided computers because they are unfamiliar to me.	True	False
7.	I hesitate to use a computer for fear of making mistakes that I cannot correct.	True	False
8.	I have difficulty understanding most technical matters.	True	False
9.	Computer terminology sounds like confusing jargon to me.	True	False

Note. Scoring for the following items is reversed: 1, 2, 3.

Adapted from "Computer anxiety and attitudes towards microcomputer use" by M. Igbaria and A. Chakrabarti, 1990. Behaviour and Information Technology, 9, p. 229-241.

Appendix G. Day 5 Multiple Choice Quiz

For each of the question presented below, please circle the single best response. If you are unsure of the answer to a question, please take a guess. Please do not use any additional resources to help you with this test.

1. Why does the shape of the mouse pointer change?

   a) The shape of the mouse cursor never changes
   b) The shape of the mouse changes to signify different things to the user.
   c) So the user will not get bored.
   d) Every program uses a different shape for the pointer.

2. What normally occurs just before a dialog box appears?

   a) **OK** or **Cancel** is clicked.
   b) A menu command is selected.
   c) A Three-Period Button is Clicked.
   d) Either B or C.

3. What does the selecting of text allow you to do?

   a) Copy the text.
   b) Cut the text.
   c) Change the font.
   d) All of the above.

4. To how much text does the alignment command apply?

   a) All of the paragraphs you select.
   b) Only the lines that you select.
   c) The paragraph in which your insertion point is located
   d) All of the above.

5. Which of the following is <u>not</u> true of Tab Stops in Word?

   a) You can access the Tab Stops dialog box by selecting **Format**, and then clicking on **Tabs** or by choosing **Paragraph** and then clicking on the **Tabs** button.
   b) Tabs are useful for aligning columns of text.
   c) Tabs are markers that are used to position text at specific locations.
   d) All of these statements are true of Tab Stops.

6. What is meant by **Points?**

   a) It is the emphasis that you can add to characters.
   b) It is the size of the characters.
   c) It is the type style or appearance of the characters.
   d) It is the position of the characters, e.g. super or subscript.

7. What happens when you choose **Edit => Cut?**

   a) Selected text is deleted and disappears for good.
   b) Selected text is deleted and copied to the clipboard.
   c) Any previous clipboard information is deleted.
   d) Both b and c

8. What happens when you use the **Enter** key?

   a) The insertion point moves but the text remains unchanged.
   b) A blank line of text is inserted.
   c) A new paragraph is begun.
   d) Both b and c.

9. What is meant by **Clicking** the mouse?

   a) Quickly pressing and releasing the left mouse button with one quick motion.
   b) Quickly pressing and releasing the left mouse button twice.
   c) Holding down the left mouse button while you move the mouse around.
   d) Either a or c counts as clicking the mouse.

10. What is meant by a Right Tab Stop?

    a) Any entered text begins at the right and extends to the left of the tab stop.
    b) Any entered text begins at the left and extends to the right of the tab stop.
    c) Any entered text begins at the left and extends equally to the right and the left of the tab stop.
    d) Any entered text begins at the right and extends to the right of the document.

11. When the mouse is shaped like an hourglass what does it signify?

    a) You have moved the mouse to the wrong area.
    b) You must now click on the mouse.
    c) Wait, something is currently being done by the computer.
    d) Text editing can now be performed.

12. Which of the following best describes the insertion point?

    a) When you move the mouse, the insertion point moves around the screen.
    b) It is the marker shaped like this on the screen: I
    c) It is the place where new text is inserted.
    d) All of the above are true.

13. To how much text does justification apply if you do NOT select some text first?

    a) The current line only.
    b) The entire document.
    c) The current paragraph only.
    d) You must select some text to set justification.

14. Applying italics to a word;

    a) Changes the size of the word on the screen.
    b) Changes the appearance of the word on the screen.
    c) Adds tabs to the paragraph.
    d) Changes the typeface of the characters on the screen.

15. To remove the **Strikethrough** option, which of the following sequences would you follow?

    a) Select the text, click on **Format**, click on **Font**, click on **Strikethrough**, and click on **Cancel**.
    b) Select the text, click on **Format**, click on **Font**, click on **Strikethrough**, and click on **OK**
    c) Select the text, click on **Edit**, click on **Font**, click on **Strikethrough**, and click on **Cancel**.
    d) Select the text, click on **Format**, click on **Strikethrough**, and click on **OK**.

16. Which of the following is true of the **clipboard?**

    a) It is a temporary storage file for cut or copied text.
    b) It is deleted whenever information is pasted.
    c) It is erased and re-written whenever new information is cut or copied.
    d) Both a and c are true.

17. If a file does not yet have a name, which commands will lead to the **Save As** dialog box?

    a) **Save As.**
    b) **New.**
    c) **Close.**
    d) All of the above.

18. Double-clicking is most often used for which of the following?

    a) Starting a program or opening a document.
    b) To select items on the screen.
    c) To move something on the screen.
    d) None of the above.

19. Which mouse button is generally used?

    a) The right mouse button.
    b) The left mouse button.
    c) Either mouse button.
    d) You should not use the mouse, using the keyboard is a more efficient and reliable method.

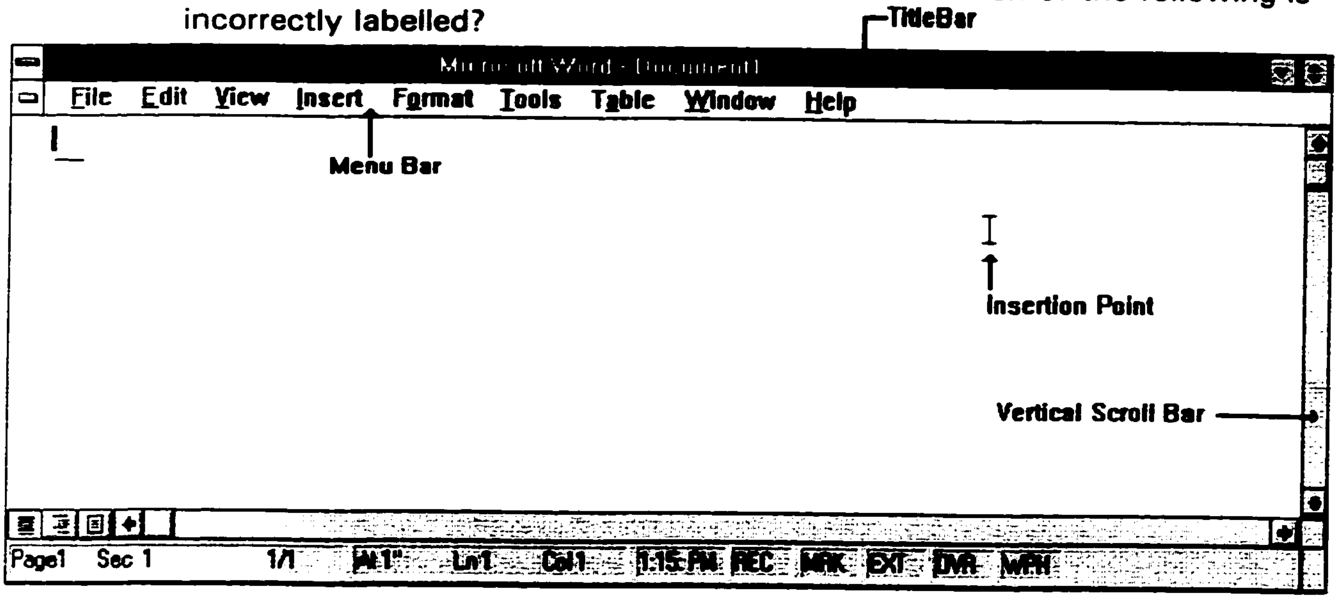
20. Which of the following commands **must** be preceded by the selection of text?

    a) **Copy.**
    b) **Line Spacing.**
    c) **Alignment.**
    d) All of the above.

21. How do you move the insertion point using the mouse?

    a) You can move the insertion point around by moving the mouse on the desk.
    b) You can point to the desired location and click the left mouse button.
    c) You can point to the desired location and double-click the left mouse button.
    d) Hold down the left mouse button and drag the insertion point to the new location.

22. The figure below represents the Word™ screen. Which of the following is incorrectly labelled?



a) The Menu Bar.
b) The Title Bar.
c) The Vertical Scroll Bar.
d) The Insertion Point.

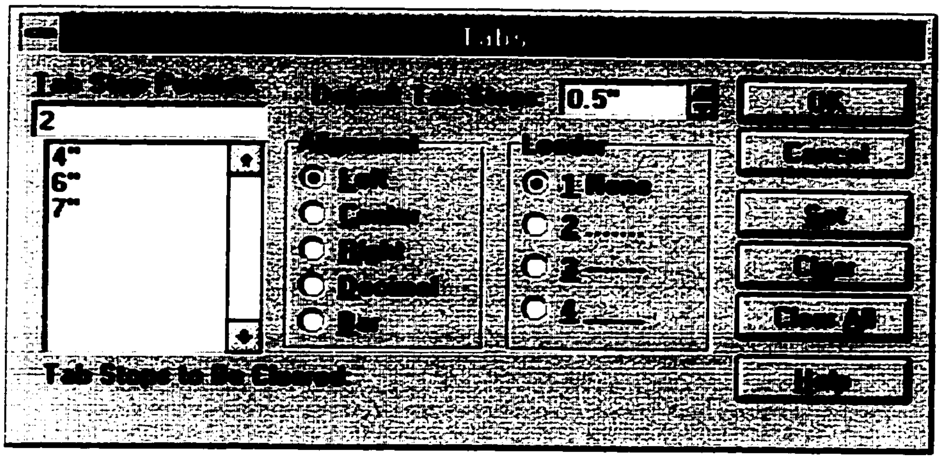
23. Most programs have a menu called:

a) **File**.
b) **Edit**.
c) Every program uses different names for menus.
d) A and B.

24. Why are Dialog Boxes used?

a) To present more information and choices to the user.
b) For the purpose of speed.
c) Dialog boxes are not used in Word™ although they are used in other Windows™ applications.
d) None of the above.

Questions 25 - 26 refer to the following figure.



25. In the dialog box shown above, someone has entered a decimal tab stop at the 2" position. What is the easiest way for this person to add another tab stop to the same block of text?

    a) Click **Set** and then enter the next tab stop.
    b) Click **OK** and then select **Format** = > **Paragraph** again.
    c) Click **Clear** and enter the next tab stop.
    d) Click **Cancel** and then select **Format** = > **Paragraph** again.

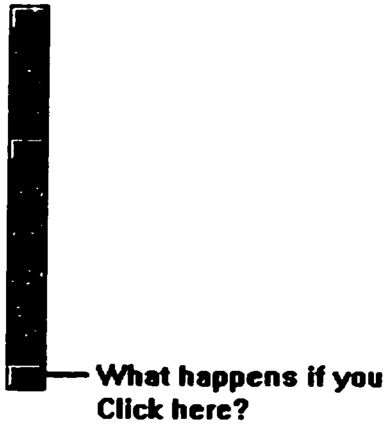
26. What is the easiest way for someone to delete the 4" tab stop?

    a) Select the 4" tab stop and click **Clear All.**
    b) Select the 4" tab stop and click **OK.**
    c) Select the 4" tab stop and click **Clear.**
    d) Select the 4" tab stop and click **Cancel.**

27. How would you move a block of text? Select the text and then...

    a) Click on **Edit** and then **Cut,** place the insertion point in the new location, click on **Edit** and then **Paste.**
    b) Click on **Edit** and then **Copy,** place the insertion point in the new location, click on **Edit** and then **Paste.**
    c) Click on **Edit** and then **Cut,** Click on **Paste,** place the insertion point in the new location, and then press Enter.
    d) Either a or b

28. What happens if you click on this portion of the vertical scroll bar?



a) The document scrolls down one full page.
b) The document scrolls down one full line.
c) The document scrolls up one full line.
d) Nothing; you are already at the top of the document.

29. The term '**Dragging**' means:

a) Clicking the left mouse button.
b) Clicking on the right mouse button, moving it to a new location, and releasing it, and then double clicking the mouse button.
c) Double clicking on the left mouse button while moving the mouse around, and then releasing it.
d) Clicking on the left mouse button while moving the mouse around, and then releasing it.

30. Which of the following is **not** true of the mouse pointer?

a) It is a mechanical device used to help you control the computer.
b) It moves around the screen when you move the mouse on a flat surface.
c) It is always shaped like this: 
d) It is much easier and faster to use than it is to use the keyboard.

31. What does the term 'Double spaced' mean?

a) Double the separation between paragraphs.
b) Double the current separation between words
c) Double the normal separation between lines.
d) None of the above.

32. How are dragging an icon and selecting text the same?

    a) To select text, you click the left mouse button and drag the mouse over the text you wish to select.
    b) To select an icon, you click the left mouse button on an icon and drag the icon to a new location.
    c) Both A and B are true.
    d) Dragging and selecting are NOT the same.

33. Which of the following is <u>**not**</u> a characteristic of a Dialog Box?

    a) A Dialog Box allows you to make choices about how a command is to be executed.
    b) A Dialog Box informs you of the various options available to you.
    c) A Dialog Box displays your document's current settings.
    d) These are all characteristics of a Dialog Box.

34. Which of the following methods can be used to change all instances of the word **He** to **She** in the following text?

    After he went to the store where he bought a drink, he returned home.

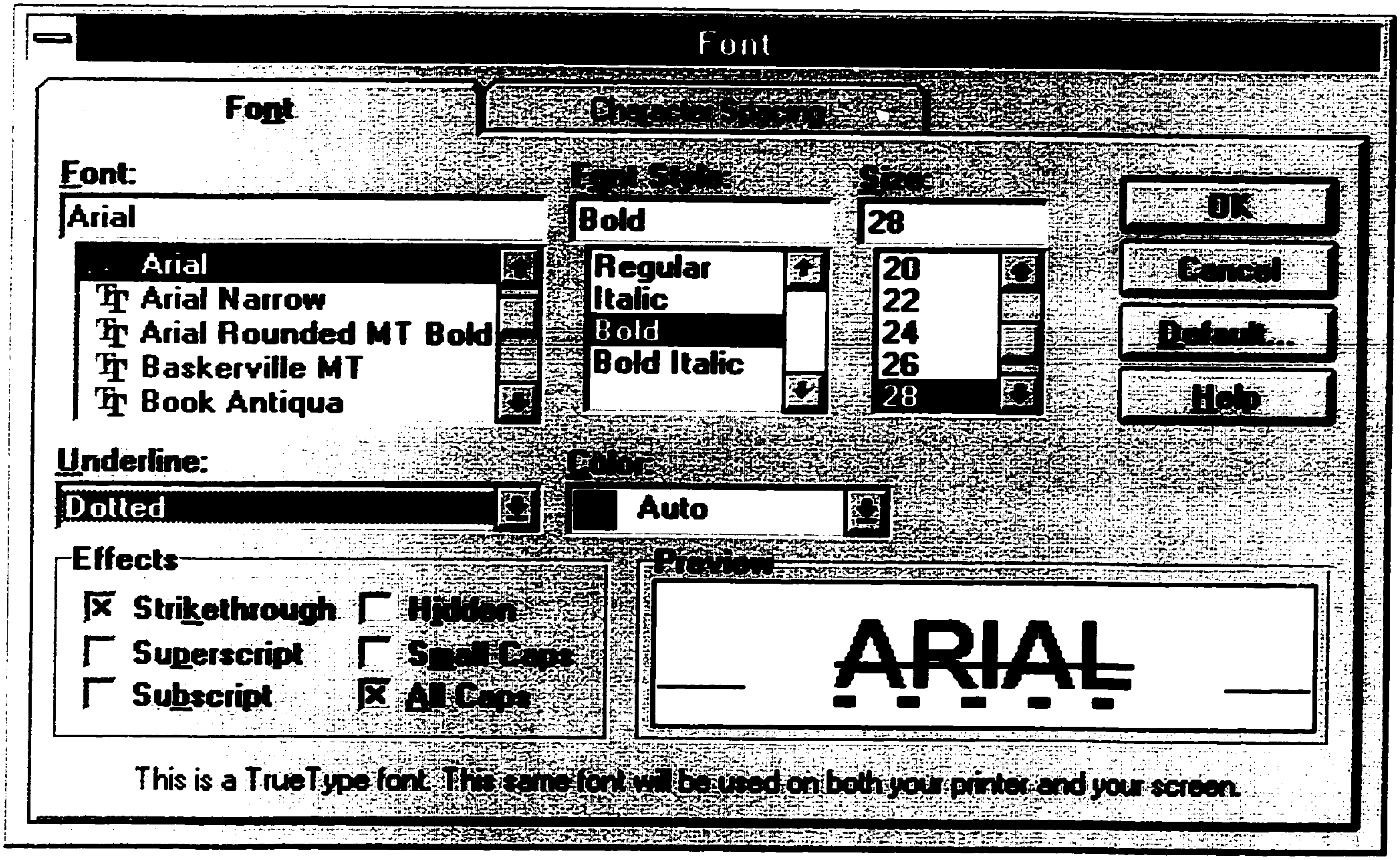
    a) Select **Edit ▸ Replace.**
    b) Select **Edit ▸ Find.**
    c) Position the insertion point before every instance of the word **he** and use the delete key.
    d) Both B and C.

35. How are Cut and Copy similar?

    a) They both require that you retrieve the text via the Paste command.
    b) Both can be used to move text from one location to another.
    c) They both place the selected text in the clipboard.
    d) All of the above.

36. Icons are:

    a) Small graphic symbols with a name below it that represent words.
    b) Small graphic symbols with a name below it that represent an application which you could load.
    c) different shapes that the mouse pointer can change into.
    d) None of the above.



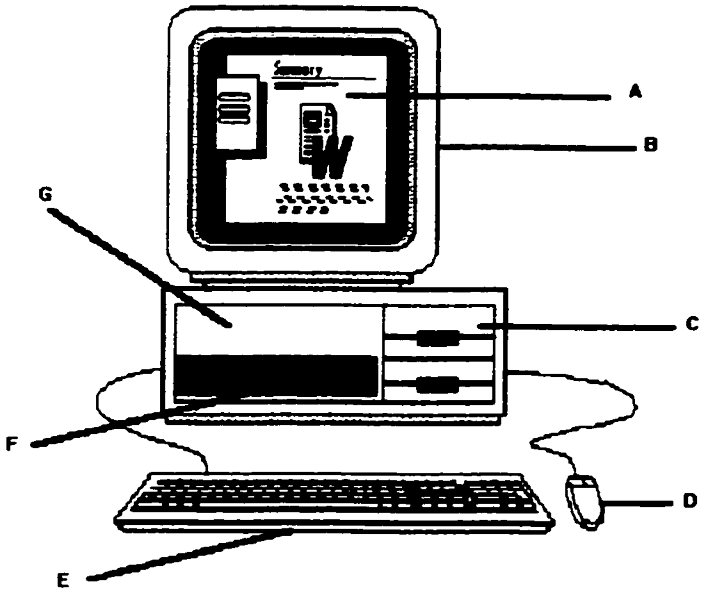
37. In the figure shown above, what best describes the current appearance?

    a) Font: Arial Narrow, Style: Bold, Size: 28, No Underline
    b) Font: Arial, Style: Bold, Size: 28, Word Underline
    c) Font: Arial Narrow, Style: Regular, Size: 28, Dotted Underline
    d) None of the above.

38. You have opened and edited the document called **work.doc**. You select **Close** from the File menu. What happens next?

    a) Nothing.
    b) The **Save As** Dialog Box appears.
    c) A dialog box appears asking you if you want to save changes to your document.
    d) None of the above.

Questions 39 - 40 refer to the following figure.



39. In the figure shown above, what is the correct name for the item labelled as **C**?

    a) CPU.
    b) Mouse.
    c) Monitor.
    d) Floppy Drive.

40. What is the correct name for the item labelled as **G**?

    a) CPU.
    b) Mouse.
    c) Monitor.
    d) Printer.

41. What does **left justify** mean?

    a) Paragraph is aligned with the left margin, so that the right side is jagged.
    b) Paragraph is aligned with the right margin, so that the left side is jagged.
    c) Paragraph is aligned with both margins.
    d) There is no such thing as right justify.

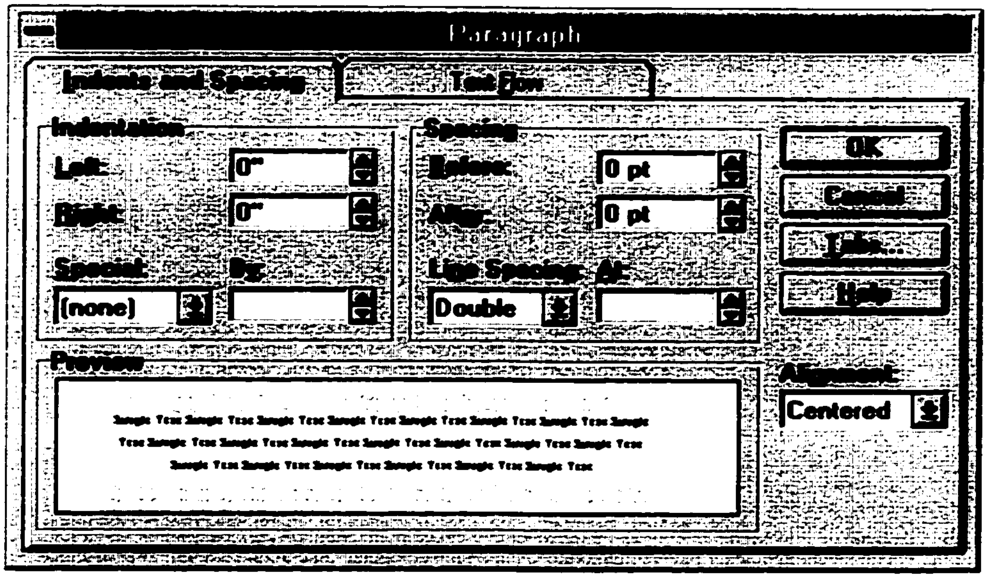
42. What happens to the insertion point when you type?

a) It advances every time you type a character.
b) It goes to the next line.
c) It stays where the mouse is.
d) It stops flashing.

43. What is the fastest way to change every occurrence of the word **Mr.** to **Mrs.** in a document with the exception of the first instance?

a) Using **Edit** ▸ **Replace**, place **Mr.** in the Find What text box and **Mrs.** in the Replace With text box, and click on **Replace All**.
b) Position the insertion point before every instance of the word **he** and use the delete key.
c) Using **Edit** ▸ **Replace**, place **Mr.** in the Find What text box and **Mrs.** in the Replace With text box, click on **Find Next**, click on **Replace All**.
d) Using **Edit** ▸ **Replace**, place **Mr.** in the Find What text box and **Mrs.** in the Replace With text box, click **Find Next**, click on **Replace**.

44. Which of the following operations can be completed directly within the following dialog box?

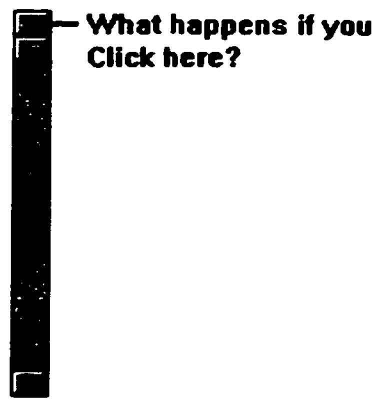


a) Line Spacing.
b) Margins.
c) Tab Stops.
d) Both A and B.

45. Which of the following names are valid file names in Word?

a) **globe.DOC**
b) **GLobe.DoC**
c) **GLOBE.document**
d) A and B are valid file names.

46. What happens if you click on this portion of the vertical scroll bar?



a) The document scrolls down one full page.
b) The document scrolls down one full line.
c) The document scrolls up one full line.
d) Nothing; you are already at the top of the document.

47. What does the **DELETE** key do?

a) Erases text to the left of the insertion point.
b) Erases text to the right of the insertion point.
c) Erases selected text
d) Both B and C are true.

48. How do you select text?

a) Place the insertion point in front of the text and drag the mouse over it.
b) Drag the mouse over the text you want selected.
c) Place the cursor at the beginning of the text and press the arrow keys.
d) Place the mouse arrow over the text and press the arrow keys.

49. What is meant by Font?

    a) It is an emphasis that you can add to the characters.
    b) It is the size of the characters.
    c) It is the type style or appearance of the characters.
    d) It is the position of the characters, e.g. superscript or subscript.

50. To erase a character to the right of the insertion point, you would;

    a) Hit the delete key.
    b) Hit the backspace key.
    c) Hit the space bar.
    d) A & B only.

51. How can you enter information into a dialog box?

    a) By placing the insertion point in the desired text box and typing in the text.
    b) By using the scroll bars and clicking on the option you want.
    c) By clicking on a pull-down menu and clicking on the option you want.
    d) All of the above.

52. What is the best way to change the Font from Univers to Roman? Select the desired text, click on format, and then...

    a) Click on **Font**, click on **Roman**, and then click **OK**.
    b) Click on **Font**, click on **Univers**, and then click on **Cancel**.
    c) Click on **Paragraph**, click on **Roman**, and then click on **OK**.
    d) Click on **Paragraph**, double click on **Univers**, and then click **OK**.

53. How would you apply a Right Tab Stop?

    a) Click on **Format** and then **Paragraph**, click on Tabs, click on Right in the alignment section, and then click **OK**.
    b) Click on **Format** and then **Paragraph**, click on Right in the alignment section, and then click **OK**.
    c) Click on **Format** and then **Font**, click on **Tabs**,click on Right in the alignment section, and then click **OK**.
    d) Click on **Format** and then **Font**, click on Right in the alignment section, and then click **OK**.

54. Which is (are) true of a dialog box?

- **a)** They are boxes that present more information and choices to the user.
- b) They appear only after you select a command from a menu.
- c) They appear only when preceded by a menu item with 3 periods(...).
- d) only a and b are true.

Note. Letters for correct responses are displayed in Bold.

Questions per session are as follows:
Introductory Quiz: 1, 9, 11, 18, 19, 29, 30, 36, 39, 40
Lesson 1: 2, 8, 12, 17, 22, 23, 24, 33, 38, 45
Lesson 2: 4, 7, 13, 16, 20, 28, 31, 32, 41, 46
Lesson 3: 5, 6, 14, 15, 25, 26, 34, 37, 43, 44
Declarative-Based: 21, 27, 48, 50, 51, 52, 53
Procedural-Based: 3, 10, 35, 42, 47, 49, 54

Each day's quiz consisted of 10-items specific to that day's training. The 2-week follow-up quiz was a randomized version of the one presented here.

Declarative and Procedural-based questions were not examined in this study as they were analyzed and presented by Greenberg (1995) and Arbuckle et al. (1996).

Appendix H. Error Categories: Descriptive Definitions

Note. Any specific action can be scored only as one type of error.

1. **MSE** **Mouse errors**

A. Problems positioning mouse pointer.
- Difficulty moving mouse pointer to a desired location.
- Difficulty maintaining mouse pointer at a desired location.

B. Problems using mouse buttons.
- Clicking the wrong button.
- Double clicking too slowly.
- Releases left mouse button too soon or doesn't release it for a long time.

C. Problems clicking and dragging.
- Cannot click and drag at the same time.
- Drags icon when trying to click the mouse button (i.e., icon moves during mouse click).

D. Has trouble clicking the mouse while in a dialog box.

E. Tries to select a menu item but mouse pointer is too low (it is still an I-bar, not an arrow), or tries to place insertion point but accidentally selects text (the I-bar turned into an arrow and therefore selected a line of text).

2. **KEY** **Keyboard errors**

Not a word processing error, i.e., not an error that occurs because they do not know how to execute a particular command. An error that occurs because they are not familiar with the keyboard and how it reacts.

- Releasing a key too quickly, or holding down a key too long.

Note. 1 error per *incident*. That is, if a person holds down the letter 'J' such that 5-J's appear on the screen, this is a single incident and counts as 1 error. If the person stops, and then hold down the 'J' key again, then this counts as a second instance, thus a second error.

- Incorrectly typing something, and fails to correct it before going onto another item. *Note that capital errors are not counted. Spacing errors are counted unless they come immediately after a comma or period.* A single extra space is NOT included as an error. Multiple spaces count as a single error.

3. **SPK** **Errors Using the Backspace, Delete, Enter Keys or the Space Bar.**

Not understanding the function performed by a key or combination of keys.

- Using a key in a way that indicates the function is not understood (i.e., pressing the backspace key at the beginning of the word to be deleted).

- Failure to press the Enter key when required to add a blank line or to end a paragraph.

Note. **Score at the episode level. If person presses the key 5 times, this is a single incident and counts as 1 error. If the person stops, and then hold down the enter, delete, or backspace key again, then this counts as a second instance, thus a second error.**

4. **INP** **Insertion Point**

- Problems distinguishing between the mouse pointer and the insertion point.

<u>Example 1</u>. The participant moves the mouse pointer to where the insertion point should be, but then fails to click the left mouse button.
<u>Example 2</u>. The participant moves the mouse pointer to the location where the Insertion Point is already located, attempting to 'move' or drag the Insertion Point to its new location. The participant fails to understand that the current location is unimportant and that she must simply click the button at the new location.

5. **SEL** **Text Selection** (Improper selection of text or failure to select Text)

Any improper selection (or if text is selected and need not have been) should be coded as an error.

- The participant fails to select, or has difficulty selecting the complete passage of text (e.g., misses first or last line of the paragraph).

- The participant fails to correctly unselect text.

6. **SCR** **Scroll error (using scroll bars incorrectly)**

Examples:

- Not moving the mouse when trying to scroll up or down, so that they end up clicking above/below grey button.
- Not understanding that the location of the grey button on the scroll bar has no relationship to the page number appearing on the Status Bar.

- Not understanding the relationship between moving the grey button and ones position in the document.
  a) Not understanding the effect of clicking before or after the grey button.
  b) Not understanding the effect of dragging the grey button.

- Not understanding the use of the arrows on the scroll bars.
  a) Not understanding the effect of clicking on an arrow.
  b) Not understanding the effect of holding the left mouse button down over an arrow.

Note. 1 error per *incident*. That is, if a person tries to go up when already at the top, it is an incident. If the person stops, and then tries to go up again, this counts as a second instance, thus a second error.

7. **MEN** **Menus Errors**

Difficulties using menus independent of problems with the mouse.

- Selecting the wrong menu label in menu bar.

Note. If the participant picks the wrong menu list altogether (e.g., "Edit" instead of "File"), code as error. If the participant then goes on to select a command from this incorrect list, code it as another error.

- Selecting the wrong command from right menu (e.g., Cut instead of Copy)

Note. **If the participant gets the correct dialog box but doesn't do anything, it is counted as a trial but no errors are given .**

8. **DLG** **Dialog box error** (represents a conceptual misunderstanding of dialog box).

Examples.

- The participant enters the wrong type of information
- The participant attempts to enter the information in an incorrect way.
- The participant attempts to enter information in the wrong place.
- The participant does not understand the meaning of information in the dialog boxes (e.g., misuse/ misunderstanding meaning of "X" in box).
- If the participant makes a change to the wrong dialog box and clicks on OK, it is an error because they have changed the state of the system. If the participant makes a change and then clicks on Cancel, they have not changed the state of the system, thus it is not an error.

<u>Note</u>. **If the participant fails to position the insertion point, code as INP. If the participant makes a mouse error, code as MSE. If the participant opens/saves the wrong file, code as OBJ. If the participant makes a scroll bar error within a dialog box (e.g., click on up when at top or down when at bottom), code as SCR. If the participant tries to execute a command while a dialog box is open, code as MOD. Otherwise, any error in a dialog box counts as a DLG.**

9. **DLGOK** **Dialog Box error associated with either OK or Cancel**

- The participant fails to click on the OK or Cancel button even if in the wrong dialog box.

10. **OBJ** **Wrong object**

The participant is performing the various steps necessary to complete a goal and/or subgoal correctly, but they are applying their actions to the wrong object (i.e., section of text, icon, etc). The error is not one of understanding, they know how to do it, but they are doing it to the wrong object.

- The participant picks the wrong application (wrong *object* icon);
- The participant opens the wrong file or saves it under the wrong name.
- The participant selects the wrong text, **inserts text into the wrong location**, etc.
- The participant clicks on incorrect icon or places it in the wrong location.
- The participant replaces the wrong item.

11. **MOD** **Mode error**

Occurs when the participant does not understand the functional state of the interface. The participant assumes a different state, and tries to do something that would be possible if she were indeed in that state. For example, they want to type something when a dialog box is open.

- The participant tries to execute command w/dialog box displayed.
- The participant types a filename without opening the dialog box.
- The participant tries to access a command that is unavailable (i.e., it is not highlighted).
- The participant minimizes the screen or clicks on the - symbol which activates the Control Menu
- The participant uses the scroll bars within the Save As dialog box and the file does not exist.

- The participant doesn't understand that she is at the bottom or top of a document.
- The participant selects text when trying to use the REPLACE command.
- The participant uses the PARAGRAPH dialog box to type tabs.
- The participant clicks on COPY multiple times and waits for something to happen.

12. **MIS** **Miscellaneous (Other types of Errors)**

- The participant is unable to complete a goal because a previous error has altered the document in such a way that it is no longer possible for them to complete the current goal.
- The participant clicks on Help.
- The participant does an item over again for no apparent reason (after successfully completing it the first time, or after completing successive items).
- The participant clicks on the right mouse button.
- If the participant returns to an item after attempting a subsequent item, the performance on the returned-to item is not scored, rather a MIS error is given.
- Any series of errors that cannot be attributed to a particular task or any error not previously described.

13. **EXP** **Experimenter**

This is not really an error, rather, the experimenter does the task for the participant, or tells the participant how to do a part of it.

Note. **When a participant gets this error the overall performance score for that item decreases by 1 point. If the participant is told how to do more than 1 step or shows the participant how to complete the task, the performance score equals 0.**

14. ATT **Item Not Attempted**

This item is scored only when an item is NOT attempted.

Note that both the Accuracy score and Time for the item equals 0.

Appendix I. Use of New Technologies Questionnaire

Which of the following New Technologies have you ever used? Please check (√) only one choice per item.

New Technology	Never	1 - 5 times	5 - 10 Times	10 - 20 Times	More than 20 Times
Microwave					
FAX Machine					
Photocopier					
A Bank's Automatic Teller System (ATM)					
Direct Payment					
Wireless Telephone					
Cellular Telephone					
Answering Machine					
Multi-line Telephone					
Voice Mail (Automated System)					
Video Cassette Recorder (VCR)					
Video Camera					
Digital Audio Tape (DAT)					
Compact Disk Player (CD)					
Walkman or Personal Stereo					
Extended Telephone Services (e.g., Call ID, Call Waiting, etc.)					
Wireless Headphones					
Video Games (e.g., Nintendo, Sega)					
Library Catalogue System					
A Personal Organizer (e.g., Casio, Sanyo)					

Please rate your level of skill or ability in using the items listed on this page by placing a check mark (√) under one of the 5 levels of Skill (**Very Skilled** to **Not At All Skilled**). If you have never used the item please check **Not Applicable**. In the last two columns to the right, please indicate if you have the specific item your home or if you plan on acquiring it within the next year, otherwise, leave these two columns blank.

New Technology	Very Skilled	Somewhat Skilled	Neither Skilled nor Unskilled	Somewhat Unskilled	Not at all Skilled	Not Applicable	Have	Plan to Get
Microwave								
FAX Machine								
Photocopier								
A Bank's Automatic Teller System								
Direct Payment								
Wireless Telephone								
Cellular Telephone								
Answering Machine								
Multi-line Telephone								
Voice Mail (Automated System)								
Video Cassette Recorder (VCR)								
Video Camera								
Digital Audio Tape (DAT)								
Compact Disk Player (CD)								
Walkman or Personal Stereo								
Extended Telephone Services (e.g., Call ID, Call Waiting, etc.)								
Wireless Headphones								
Video Games (e.g., Nintendo, Sega)								
Library Catalogue System								
Personal Organizer (e.g., Casio, Sanyo)								

How many remote controls do you have in your home? ____________

Appendix J. Follow-up Questionnaire

How would you rate your skill level on the word processor which you have learned?

1	2	3	4	5
Not at all Skilled	Somewhat Skilled	neither Skilled nor Unskilled	Somewhat Skilled	Very Skilled

How would you rate your skill level on wordprocessing in general (i.e., if you were to use a *different* word processor?

1	2	3	4	5
Not at all Skilled	Somewhat Skilled	neither Skilled nor Unskilled	Somewhat Skilled	Very Skilled

Using Word, which of the following function do you think that you can do yourself without assistance? (please check (√) all those that apply)			
Start Word		Open a File	
Save a File		Close a File	
Rename a File		Use the Scroll Bars	
Use the Backspace Key		Move Text to Another Location	
Add Blank Lines		Use the Delete Key	
Copy Text to Another Location		Justify Text	
Select Text		Change Tab Stops	
Change Line Spacing		Make Characters Bold	
Print a File		Underline Characters	
Make Characters Italics		Change the Font	
Change the Font Size		Centre Text	
Add Superscript or Subscript		Exit Word	
Change Margins		Replace One word with a Second word	
Search for a Particular Phrase		Use the Word's Spell Checker or Thesaurus	

Overall, how would you rate the effectiveness of the training and what it taught you about using a word processor?

1	2	3	4	5
Excellent	Good	Adequate	Poor	Terrible

How would you rate the effectiveness of the instructor?

1	2	3	4	5
Excellent	Good	Adequate	Poor	Terrible

Do you have any additional comments you would like to make concerning the study or computers in general?

____

____

____

Thank you for completing these questionnaires.

Appendix K. Telephone Interview

1. Looking back upon your experience during our study, how effective would you say it was in teaching you about computers and how to use a computer?

1	2	3	4	5	6	7
Very effective			Neither effective nor ineffective			Very ineffective

2. Looking back upon your experience during our study, how effective would you say it was in increasing your desire to learn more about computers?

1	2	3	4	5	6	7
Very effective			Neither effective nor ineffective			Very ineffective

3. How useful has what you have learned during the training been for you over the last year?

1	2	3	4	5	6	7
Very Useful			Neither Useful nor Useless			Very Useless

4. During the last year have you used a computer in any way? Yes No

   If Yes, main purpose? ______________________________

5. During the last year have you done anything (e.g., purchased any books, taken additional courses) to further your computer abilities? Yes No

   If Yes, what kind? ______________________________

6. During the last year have you purchased a computer? Yes No

   If Yes, What kind of computer? ______________________________

   What are the two primary functions you use it for?

   1. ____________________ 2. ____________________

   If No, Do you plan on purchasing a computer in the future?

   Yes No DK

7. Would you have preferred to have gone through the training with a second person, who like you, was also a first time computer user?

Yes No DK

8. Do you think you would have learned more or less if you had gone through the training with a second person, and the two of you shared a single computer?

More Less DK

9. Have you ever heard of the Internet (for example, E-mail or the World Wide Web)?

Yes No If No, skip next question.

10. Have you ever used the Internet (for example, E-mail or the World Wide Web)?

Yes No

If yes, for what purpose?

1. ______________________ 2. ______________________

11. How interested would you be in learning more about the Internet?

1	2	3	4	5	6	7
Very interested			Neither interested nor uninterested			Very uninterested

The following questions are hypothetical, in that we are trying to get an idea about what kind of computer related products and training our participants would be interested in, and how much you think they are worth.

Hypothetically, if a 12-week (2-hour per week) computer training course were to be offered, only to adults over the age of 50, how likely would you be to participate?

1	2	3	4	5	6	7
Definitely YES			Unsure			Definitely NO

How much do you think such a course should cost?

< $50	50 - 100	100-150	150-200	200-250	250-300
300-350	350-400	400-450	450-500	> 500	DK

Given the complexity of computer software, (say for example the wordprocessor you learned), if a second modified version of a software program were offered in which some of the fancy 'bells and whistles' were removed, but more detailed tutorials were included, how interested would you be in this modified software?

1	2	3	4	5	6	7
Very interested			Neither interested nor uninterested			Very uninterested

Would you be more willing to purchase the standard version or the modified version?

Standard Modified DK

If a training package for a computer program that interested you were made available for purchase, and this training package included both a computer disk and a manual which contained detailed descriptions of the commands and how to use them, built in practice for each of the commands, and professional on-line animated (Multimedia) demonstrations, how interested would you be in purchasing such a training package?

1	2	3	4	5	6	7
Very interested			Neither interested nor uninterested			Very uninterested

How much would you be willing to pay for such a training package?

< $25	25-50	50-100	100-150	150-200	200-250
250-300	300-350	350-400	400-450	> 450	DK

Thank you and we are now finished the interview. Before I leave you, I would like to ask you whether you would be interested in participating in other (non-computer related) studies being conducted in our labs. If yes, I will provide your name to the person in charge of the other studies and they will telephone you within the next few weeks. Once again, thank you for your time and patience.

Appendix L. General Demographic Information on the Sample[a]

Variable	Full Sample (N = 48)	Training		Practice		F_a/χ^1	F_b/χ^2
		Text	Multimedia	Consistent	Variable		
Age	65.75 (6.00)	65.96 (5.49)	65.54 (6.58)	65.21 (7.03)	66.29 (4.85)	.06	.37
Years of Education	15.42 (2.72)	15.75 (3.12)	15.08 (2.26)	15.08 (3.13)	15.75 (2.25)	.70	.70
Vocabulary Score	34.02 (4.42)	34.21 (4.05)	33.83 (4.83)	34.13 (4.36)	33.92 (4.57)	.08	.03
NAART Correct Responses	36.44 (6.22)	37.92 (5.74)	34.96 (6.44)	36.75 (6.12)	36.13 (6.42)	2.73	.12
Typing Test Performance[c]							
Words Correct	40.83 (25.56)	42.79 (24.80)	38.87 (26.69)	44.62 (29.81)	37.04 (20.42)	.28	1.04
Number of Errors	5.44 (5.75)	4.42 (4.33)	6.46 (6.83)	5.21 (6.73)	5.67 (4.72)	1.46	.07
First Language						.01	1.01
English	35 (72.9%)	17 (70.8%)	17 (75.0%)	16 (66.7%)	19 (79.2%)		
French	3 (6.3%)	2 (8.3%)	1 (4.2%)	2 (8.3%)	1 (4.2%)		
Other	6 (12.5%)	4 (16.7%)	2 (8.3%)	3 (12.5%)	3 (12.5%)		
English & French or Other	4 (8.4%)	1 (4.2%)	3 (12.5%)	3 (12.5%)	1 (4.2%)		
Highest Degree						.91	.07
High School (or less)	11 (22.9%)	5 (20.8%)	6 (25.0%)	7 (29.2%)	4 (16.7%)		
CEGEP or Certificate	13 (27.1%)	5 (20.8%)	8 (33.3%)	5 (20.8%)	8 (33.3%)		
Bachelor's Degree	19 (39.6%)	11 (45.8%)	8 (33.3%)	9 (37.5%)	10 (41.7%)		
Master's Degree or PhD	5 (10.4%)	3 (12.5%)	2 (8.3%)	3 (12.5%)	2 (8.3%)		
Occupation Status						1.58	.39
Employed (Full/Part Time)	14 (29.2%)	9 (37.5%)	5 (20.8%)	8 (33.3%)	9 (25.0%)		
Not Employed	34 (70.8%)	15 (62.5%)	19 (79.2%)	16 (66.7%)	15 (75.0%)		

(Table Continues)

Variable	Full Sample (N = 48)		Training: Text		Training: Multimedia		Practice: Consistent		Practice: Variable		F_a/χ^1	F_b/χ^2
Marital Status												
Never Married	2	(4.2%)	0		2	(8.3%)	1	(4.2%)	1	(4.2%)		
Married	25	(52.1%)	17	(70.8%)	8	(33.3%)	11	(45.8%)	14	(58.3%)	2.78	.22
Divorced/Single	10	(20.8%)	4	(16.7%)	6	(25.0%)	7	(29.2%)	3	(12.5%)		
Widowed	11	(22.9%)	3	(12.5%)	8	(33.3%)	5	(20.8%)	6	(25.0%)		
Circadian Rhythm												
Morning Person	16	(33.3%)	7	(29.2%)	9	(37.5%)	6	(25.0%)	10	(41.7%)		
Intermediate Person	31	(64.6%)	16	(66.7%)	15	(62.5%)	18	(75.0%)	13	(54.2%)	.61	.93
Evening Person	1	(2.1%)	1	(4.2%)	0	(0%)	0	(0%)	1	(4.2%)		
Self-Reported Typing Skill												
< 20 Words per Minute	25	(52.1%)	13	(54.2%)	12	(50.0%)	13	(54.2%)	12	(50.0%)		
20 - 30 Words per Minute	10	(20.8%)	4	(16.7%)	6	(25.0%)	3	(12.5%)	7	(29.2%)	.01	.03
> 30 Words per Minute	11	(22.9%)	6	(25.0%)	5	(20.8%)	7	(29.2%)	4	(16.7%)		
Previous Computer Use												
No	17	(35.4%)	10	(41.7%)	7	(29.2%)	8	(33.3%)	9	(37.5%)	.80	.09
Yes	31	(64.6%)	14	(58.3%)	17	(29.2%)	16	(66.7%)	15	(62.5%)		
Hours Computer Use[d]												
Less than 1 hour	6		3		3		3		3			
1 - 5 hours	10		5		5		6		4		.15	.15
5 - 10 hours	9		3		6		4		5			
More than 10 hours	6		3		3		3		3			
Computer anxiety[e]	3.81	(1.38)	4.00	(1.38)	3.62	(1.38)	3.92	(1.56)	3.71	(1.20)	.85	.26
Computer eagerness[f]	2.04	(1.25)	2.00	(1.38)	2.08	(1.14)	2.29	(1.49)	1.79	(0.93)	.05	1.95
Computer curiosity[g]	1.67	(0.95)	1.58	(0.83)	1.75	(1.07)	1.75	(1.11)	1.58	(0.78)	.36	.36

(Table Continues)

Variable	Full Sample (N = 48)		Training: Text		Training: Multimedia		Practice: Consistent		Practice: Variable		F_a/χ^1	F_b/χ^2
Learning Styles												
Accomodator	10	(20.8%)	5	(20.8%)	5	(20.8%)	5	(20.8%)	5	(20.8%)		
Converger	7	(14.6%)	3	(12.5%)	4	(16.7%)	3	(12.5%)	4	(16.7%)	.60	.05
Diverger	13	(27.1%)	5	(20.8%)	8	(33.3%)	8	(33.3%)	5	(20.8%)		
Assimilator	18	(37.5%)	11	(45.8%)	7	(29.2%)	8	(33.3%)	10	(41.7%)		
Need for Cognition	8.08	(1.84)	8.25	(1.62)	7.92	(2.06)	8.63	(1.84)	7.54	(1.72)	.41	3.29
Health Status[h]												
Compared to same age	1.44	(0.65)	1.54	(0.72)	1.33	(0.56)	1.58	(0.72)	1.29	(0.55)	1.26	2.46
Compared to a perfect state	1.54	(0.77)	1.58	(0.78)	1.50	(0.78)	1.75	(0.94)	1.33	(0.48)	.14	3.57
Dexterity (in Hands)	1.77	(0.72)	1.87	(0.80)	1.67	(0.64)	1.75	(0.74)	1.79	(0.72)	.96	.04
Eyesight	2.23	(0.72)	2.17	(0.64)	2.29	(0.81)	2.29	(0.91)	2.17	(0.48)	.34	.34
Hearing	1.98	(0.91)	1.96	(1.04)	2.00	(0.78)	2.04	(0.75)	1.92	(1.06)	.02	.21
Memory	2.23	(0.66)	2.17	(0.70)	2.29	(0.62)	2.33	(0.70)	2.13	(0.61)	.46	1.27

Notes. No significant differences were observed for any of the variables for the Text or Multimedia training conditions. In addition, no differences were observed when the sample was further subdivided into Consistent vs. Variable practice types. Analyses for continuous variables were based on 2-way ANOVA's which yield an *F* value. Categorical variables were based on Kruskal-Wallis nonparametric tests, which test whether *k* independent samples defined by a grouping variable are from the same population, and which yields a chi-square (χ^2). Unless otherwise stated, brackets refer to standard deviations. Items may not add up to 100% due to missing data.

[a] F or chi-square value for Training condition.
[b] F or chi-square value for Practice condition.
[c] The correlation between actual typing speed and self-reported typing skill was r (46) = .51, $p < .001$.
[d] Based on 'Yes' response from previous question.
[e] Based on a 7-point Likert scale ranging from 1 (Anxious) to 7 (Relaxed).
[f] Based on a 7-point Likert scale ranging from 1 (Eager) to 7 (Reluctant).
[g] Based on a 7-point Likert scale ranging from 1 (Very Curious) to 7 (Totally Disinterested).
[h] Based on a 5-point Likert scale ranging from 1 (Very Good) to 5 (Very Poor).

Appendix M. Intercorrelation Matrix of the Cognitive Variables Analysed with the Factor Analysis

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BFLT - Del	1	1.0																	
BFLT	2	**.89**	1.0																
CVLT	3	**.66**	**.62**	1.0															
CVLT - Del	4	**.53**	**.46**	**.77**	1.0														
DSym - Inc	5	**.48**	**.47**	**.58**	**.51**	1.0													
NAART	6	.25	.25	.34	**.52**	.34	1.0												
Vocab	7	.27	.26	.35	**.44**	.22	**.75**	1.0											
Fluency	8	*.39*	**.45**	*.37*	**.50**	.28	**.54**	**.44**	1.0										
AK Delay	9	.00	-.08	.00	-.09	.07	-.03	-.06	-.20	1.0									
K Delay	10	-.25	-.30	*-.39*	-.30	-.27	-.15	-.14	-.34	**.45**	1.0								
Trail A	11	-.32	*-.40*	-.23	-.06	-.17	-.02	-.04	-.25	.25	.37	1.0							
DSym	12	.35	*.37*	.31	.31	.31	*.39*	*.37*	*.42*	-.23	**-.50**	**-.56**	1.0						
Trail B	13	-.29	*-.40*	**-.44**	*-.41*	*-.40*	*-.38*	-.28	**-.52**	.17	*.40*	**.47**	**-.64**	1.0					
Tapping	14	.28	.35	.11	-.02	.16	.21	.07	.35	-.03	*-.39*	-.29	*.37*	-.32	1.0				
Typing	15	.20	.33	.13	.11	.30	.20	.20	.17	.07	-.10	-.24	.29	-.15	**.48**	1.0			
K Correct	16	.30	.22	.13	.23	.22	.15	.00	.17	-.13	-.19	-.22	.23	-.14	.08	.18	1.0		
AK Correct	17	.30	.21	.32	*.39*	*.39*	.21	.36	.32	.15	-.21	-.02	.28	-.28	.05	.16	.24	1.0	
Block	18	**.51**	*.42*	.32	.23	*.41*	.10	.03	.13	.10	-.10	-.17	.32	-.09	.31	.33	.33	.29	1.0

Note. BFLT - Del = BFLT - Delayed Recall; BFLT = BFLT (Trials 1 - 5); CVLT = CVLT (Trials 1 - 5); CVLT-Del = CVLT - Delayed Recall; Dsym - Inc = Digit Symbol - Incidental Memory; Vocab = Advanced Vocabulary Test; Fluency = Word Fluency; AK Delay = Vigil - 'AK' Latency; K Delay = Vigil - 'K' Latency; DSym = Digit Symbol; Tapping = Finger Tapping; Typing = Typing Test (Words Correct); K Correct = Vigil - 'K' Correct Responses; AK Correct = Vigil - 'AK' Correct Responses; Block = Block Design.
Italics $p < .01$; **Bold** $p < .002$ (based on Bonferroni correction for multiple comparisons)

Appendix N. Model 1: Intercorrelations for all Variables in the Path Analysis for Accuracy

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Age	1	1.0																	
Education	2	-.07	1.0																
Speed	3	-.11	-.30	1.0															
Memory	4	*-.35*	.20		1.0														
Language	5	.03	**.41**			1.0													
Manual	6	.04	.14				1.0												
Visual Spatial	7	-.15	.01					1.0											
ATCQ	8	-.12	.02	.00	-.07	-.08	.11	.14	1.0										
Home Comp[a]	9	-.12	.08	-.16	.00	.25	-.00	.04	-.02	1.0									
Hours Comp[b]	10	*-.35*	.07	-.06	.17	-.19	-.00	.22	-.08	.08	1.0								
Time 1	11	.12	-.19	.17	-.16	-.19	-.16	-.28	-.05	-.15	-.27	1.0							
Time 2	12	.04	-.31	.19	-.15	-.28	-.10	-.19	.07	-.05	-.12	**.77**	1.0						
Time 3	13	.02	-.08	.21	-.14	-.25	-.05	-.21	.04	-.04	-.17	**.73**	**.79**	1.0					
Accuracy 1	14	**-.42**	.26	-.17	.27	.14	.06	.32	.31	.25	.19	**-.44**	*-.37*	*-.36*	1.0				
Accuracy2	15	**-.59**	.25	-.07	.29	.14	.04	.24	.32	.27	.18	-.27	*-.34*	-.32	**.76**	1.0			
Accuracy3	16	**-.49**	.27	-.13	.30	.29	.03	*.34*	.24	.27	.14	.33	-.33	*-.34*	**.78**	**.77**	1.0		
WI Accuracy	17	**-.46**	**.42**	-.18	*.34*	*.38*	-.01	.33	.24	**.43**	.30	**-.44**	*-.37*	*-.36*	**.69**	**.74**	**.86**	1.0	
Transfer Acc	18	**-.42**	.29	.05	.32	.09	-.11	.14	*.35*	.17	.20	-.14	-.10	.01	**.69**	**.62**	**.79**	**.75**	1.0

Note. Time refers to Training Time.

Bold $p < .003$ (based on Bonferroni Corrected critical value $\pm .41$); *Italics* $p < .01$ ($r = \pm .34$).
Shading refers to factor scores which are uncorrelated ($r = 0$) with each other.
[a] Computer in the home was coded as 1, No home computer was coded as 0.
[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).

Appendix O. Model 2: Intercorrelations for all Variables in the Path Analysis for Working Time

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Age	1	1.0																	
Education	2	-.07	1.0																
Speed	3	-.11	-.30	1.0															
Memory	4	*-.35*	.20		1.0														
Language	5	.03	**.41**			1.0													
Manual	6	.04	.14				1.0												
Visual Spatial	7	-.15	.01					1.0											
ATCQ	8	-.12	.02	.00	-.07	-.08	.11	.14	1.0										
Home Comp[a]	9	-.12	.08	-.16	.00	.25	-.00	.04	-.02	1.0									
Hours Comp[b]	10	*-.35*	.07	-.06	.17	-.19	-.00	.22	-.08	.08	1.0								
Time 1	11	.12	-.19	.17	-.16	-.19	-.16	-.28	-.05	-.15	-.27	1.0							
Time 2	12	.04	-.31	.19	-.15	-.28	-.10	-.19	.07	-.05	-.12	**.77**	1.0						
Time 3	13	.02	-.08	.21	-.14	-.25	-.05	-.21	.04	-.04	-.17	**.73**	**.79**	1.0					
Work Time 1	14	.37	-.30	.20	-.30	-.29	-.28	*-.40*	-.29	-.20	-.13	**.66**	**.54**	**.50**	1.0				
Work Time 2	15	.26	*-.37*	.24	-.52	-.23	-.08	-.35	-.20	-.13	-.08	**.56**	**.45**	*.36*	**.72**	1.0			
Work Time 3	16	**.50**	**-.44**	*.35*	*-.37*	-.25	-.25	-.33	-.17	-.29	-.22	**.56**	**.50**	*.40*	**.84**	**.80**	1.0		
WI Time	17	.25	-.19	.22	-.16	-.24	-.14	-.30	-.20	-.17	-.07	**.52**	**.57**	**.52**	**.69**	**.61**	**.76**	1.0	
Transfer Time	18	.26	-.29	.22	-.15	.00	-.22	-.11	-.14	-.09	-.10	*.41*	.37	.26	**.60**	**.54**	**.59**	**.53**	1.0

Note. Time refers to Training Time; Work Time refers to Working Time.

Bold $p < .003$ (based on Bonferroni Corrected critical value ±.41); *Italics* $p < .01$ (r = ±.34).
Shading refers to factor scores which are uncorrelated (r = 0) with each other.

[a] Computer in the home was coded as 1, No home computer was coded as 0.

[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).

Appendix P. Model 3: Intercorrelations for all Variables in the Path Analysis for Errors

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Age	1	1.0																	
Education	2	-.07	1.0																
Speed	3	-.11	-.30	1.0															
Memory	4	*-.35*	.20		1.0														
Language	5	.03	**.41**			1.0													
Manual	6	.04	.14				1.0												
Visual Spatial	7	-.15	.01					1.0											
ATCQ	8	-.12	.02	.00	-.07	-.08	.11	.14	1.0										
Home Comp[a]	9	-.12	.08	-.16	.00	.25	-.00	.04	-.02	1.0									
Hours Comp[b]	10	*-.35*	.07	-.06	.17	-.19	-.00	.22	-.08	.08	1.0								
Time 1	11	.12	-.19	.17	-.16	-.19	-.16	-.28	-.05	-.15	-.27	1.0							
Time 2	12	.04	-.31	.19	-.15	-.28	-.10	-.19	.07	-.05	-.12	**.77**	1.0						
Time 3	13	.02	-.08	.21	-.14	-.25	-.05	-.21	.04	-.04	-.17	**.73**	**.79**	1.0					
Errors 1	14	.32	-.23	.09	-.17	-.25	.03	*-.37*	**-.48**	-.32	-.05	*.38*	*.39*	.30	1.0				
Errors 2	15	**.42**	-.21	-.03	*-.37*	-.12	.11	-.30	**-.41**	-.16	-.08	.25	.16	.17	.32	1.0			
Errors 3	16	**.46**	-.22	.12	-.25	-.13	.07	*-.38*	*-.39*	-.31	-.20	.29	.27	.21	**.75**	**.69**	1.0		
WI Errors	17	.18	-.13	.03	-.10	-.20	.09	-.26	*-.37*	-.20	-.08	.24	.25	.20	**.62**	**.56**	**.78**	1.0	
Transfer Error	18	*.36*	-.24	-.10	-.10	.06	.03	-.12	-.20	-.16	-.15	.02	.11	.00	**.58**	*.39*	**.52**	**.50**	1.0

Note. Time refers to Training Time.

Bold $p < .003$ (based on Bonferroni Corrected critical value $\pm .41$); *Italics* $p < .01$ ($r = \pm .34$).
Shading refers to factor scores which are uncorrelated ($r = 0$) with each other.

[a] Computer in the home was coded as 1, No home computer was coded as 0.

[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).

Appendix Q. Breakdown of Direct and Indirect Effects for Accuracy across Sessions

Path	Bivariate r	Direct	Indirect	Total	Spurious	R^2
On Lesson 1						
From Age	-.403	-.324	--	-.324	-.079	.380
From Computer Attitudes	.310	.251	--	.251	.059	
From Training Time (Lesson 1)	-.441	-.389	--	-.389	-.052	
From Visuospatial Abilities	.319	--	.111	.111	.208	
On Lesson 2						
From Age	-.594	-.348	-.198	-.546	-.048	.665
From Computer Attitudes	.318	--	.153	.153	.165	
From Training Time (Lesson 1)	-.268	--	-.237	-.237	-.031	
From Visuospatial Abilities	.244	--	.083	.083	.161	
From Lesson 1	.751	.610	--	.610	.141	
On Lesson 3						
From Age	-.495	--	-.370	-.370	-.125	.703
From Computer Attitudes	.241	--	.172	.172	.069	
From Training Time (Lesson 1)	-.335	--	-.266	-.266	-.069	
From Visuospatial Abilities	.344	--	.076	.076	.268	
From Lesson 1	.769	.425	.259	.684	.085	
From Lesson 2	.767	.425	--	.425	.342	
From Language Abilities	.293	.172	--	.172	.121	
From Education	.275	--	.071	.071	.204	
On Word Integration						
From Age	-.448	--	-.011	-.011	-.437	.820
From Computer Attitudes	.236	--	.122	.122	.114	
From Training Time (Lesson 1)	-.429	--	-.190	-.190	-.239	
From Visuospatial Abilities	.314	--	.055	.055	.259	
From Lesson 1	.658	--	.489	.489	.169	
From Lesson 2	.734	--	.304	.304	.430	
From Language Abilities	.378	--	.123	.123	.255	
From Education	.421	--	.051	.051	.370	
From Lesson 3	.847	.715	--	.715	.132	
From Computer in the Home[a]	.427	.203	--	.203	.224	
From Hours of Computer Use[b]	.290	.155	--	.155	.135	
On Near Transfer						
From Age	-.396	--	-.145	-.145	-.251	.402
From Computer Attitudes	.334	--	.113	.113	.221	
From Training Time (Lesson 1)	-.120	--	-.192	-.192	.072	
From Visuospatial Abilities	.107	--	.049	.049	.058	
From Lesson 1	.566	.315	.185	.500	.066	
From Lesson 2	.529	--	.115	.115	.414	
From Language Abilities	.075	--	.047	.047	.028	
From Education	.271	--	.019	.019	.252	
From Lesson 3	.552	--	.272	.272	.280	
From Computer in the Home	.153	--	.077	.077	.076	
From Hours of Computer Use	.175	--	.059	.059	.116	
From Word Integration Task	.588	.380	--	.380	.208	

Note. [a] Computer in the home was coded as 1, No home computer was coded as 0.
[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).
Dashes indicate that the direct or indirect effect of the variable was not retained in the final trimmed model.

Appendix R. Breakdown of Direct and Indirect Effects for Working Time across Sessions

Path	Bivariate *r*	Direct	Indirect	Total	Spurious	R^2
On Lesson 1						
From Age	.355	.213	.058	.271	.084	.717
From Education	-.302	--	-.144	-.144	-.158	
From Computer Attitudes	-.290	-.224	--	-.224	-.066	
From Training Time (Lesson 1)	.658	.430	--	.430	.228	
From Speed Abilities	.204	.156	--	.156	.048	
From Language Abilities	-.289	-.234	--	-.234	-.055	
From Memory Abilities	-.301	-.172	--	-.172	-.129	
From Motor Abilities	-.285	-.199	--	-.199	-.086	
From Visuospatial Abilities	-.400	-.212	--	-.212	-.188	
On Lesson 2						
From Age	.261	--	.279	.279	-.018	.612
From Education	-.368	--	-.088	-.088	-.280	
From Computer Attitudes	-.196	--	-.137	-.137	.059	
From Training Time (Lesson 1)	.559	--	.264	.264	.295	
From Speed Abilities	.240	--	.096	.096	.174	
From Language Abilities	-.233	--	-.144	-.144	-.089	
From Memory Abilities	-.518	-.333	-.106	-.439	-.079	
From Motor Abilities	-.084	--	-.122	-.122	.038	
From Visuospatial Abilities	-.353	--	-.130	-.130	-.233	
From Lesson 1	.715	.614	--	.614	.101	
On Lesson 3						
From Age	.501	.298	.115	.413	.088	.873
From Education	-.437	--	-.152	-.152	-.285	
From Computer Attitudes	-.331	--	-.135	-.135	-.196	
From Training Time (Lesson 1)	.565	--	.259	.259	.306	
From Speed Abilities	.349	.213	.097	.310	.039	
From Language Abilities	-.251	--	.141	-.141	-.110	
From Memory Abilities	-.368	--	-.239	-.239	-.129	
From Motor Abilities	-.247	-.124	-.120	-.244	-.003	
From Visuospatial Abilities	-.331	--	-.074	-.074	-.257	
From Lesson 1	.828	.351	.251	.602	.226	
From Lesson 2	.800	.409	--	.409	.391	
On Word Integration						
From Age	.246	-.210	.354	.144	.102	.611
From Education	-.191	.205	-.317	-.112	-.079	
From Computer Attitudes	-.195	--	-.127	-.127	-.068	
From Training Time (Lesson 1)	.508	--	.244	.244	.274	
From Speed Abilities	.225	--	.289	.289	-.064	
From Language Abilities	-.242	--	-.137	-.137	-.105	
From Memory Abilities	-.158	--	-.226	-.226	.068	
From Motor Abilities	-.141	--	-.105	-.105	.036	
From Visuospatial Abilities	-.290	--	-.069	-.069	-.221	
From Lesson 1	.653	--	.566	.566	.087	
From Lesson 2	.608	--	.385	.385	.223	
From Lesson 3	.746	.941	--	.941	-.195	

(Table Continues)

Path	Bivariate r	Direct	Indirect	Total	Spurious	R^2
On Near Transfer						
From Age	.245	--	.020	.020	.235	
From Education	-.270	--	-.159	-.159	-.111	
From Computer Attitudes	-.133	--	-.048	-.048	.085	
From Training Time (Lesson 1)	.356	--	.091	.091	.265	
From Speed Abilities	.183	--	.109	.109	.074	
From Language Abilities	.002	--	-.050	-.050	.052	
From Memory Abilities	-.116	--	-.084	-.084	-.032	.139
From Motor Abilities	-.207	--	-.086	-.086	-.121	
From Visuospatial Abilities	-.083	--	-.026	-.026	-.057	
From Lesson 1	.412	--	.211	.211	.201	
From Lesson 2	.477	--	.144	.144	.333	
From Lesson 3	.469	--	.351	.351	.118	
From Word Integration	.373	.374	--	.374	-.001	

Note. [a] Computer in the home was coded as 1, No home computer was coded as 0.
[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).
Dashes indicate that the direct or indirect effect of the variable was not retained in the final trimmed model.

Appendix S. Breakdown of Direct and Indirect Effects for Total Errors across Sessions

Path	Bivariate *r*	Direct	Indirect	Total	Spurious	R^2
On Lesson 1						
From Education	-.230	--	-.091	-.091	-.139	
From Computer in the Home	-.320	-.263	--	-.263	-.057	
From Language Abilities	-.246	-.222	--	-.222	-.024	.462
From Visuospatial Abilities	-.360	-.282	--	-.282	-.078	
From Computer Attitudes	-.478	-.463	--	-.463	-.015	
On Lesson 2						
From Age	.422	--	.104	.104	.318	
From Education	-.214	--	-.041	-.041	-.173	
From Computer in the Home	-.160	--	-.120	-.120	-.040	
From Language Abilities	-.118	--	-.101	-.101	-.017	.480
From Memory Abilities	-.374	-.310	--	-.310	-.064	
From Visuospatial Abilities	-.303	--	-.128	-.128	-.175	
From Computer Attitudes	-.408	-.212	-.211	-.423	-.196	
From Lesson 1	.611	.455	--	.455	.156	
On Lesson 3						
From Age	.465	.179	.034	.213	.252	
From Education	-.225	--	-.056	-.056	-.169	
From Computer in the Home	-.390	--	-.165	-.165	-.225	
From Language Abilities	-.129	--	-.138	-.138	.009	
From Memory Abilities	-.255	--	-.101	-.101	-.154	.654
From Visuospatial Abilities	-.379	--	-.176	-.176	-.203	
From Computer Attitudes	-.386	--	-.357	-.357	-.029	
From Lesson 1	.729	.475	.148	.623	.106	
From Lesson 2	.691	.325	--	.325	.366	
On Word Integration						
From Age	.177	-.225	.045	-.180	.357	
From Education	-.128	--	-.048	-.048	-.008	
From Computer in the Home	-.197	--	-.143	-.143	.054	
From Language Abilities	-.203	--	-.120	-.126	-.006	
From Memory Abilities	-.102	--	-.088	-.080	-.014	.624
From Visuospatial Abilities	-.251	--	-.153	-.153	-.098	
From Computer Attitudes	-.370	--	-.310	-.311	-.006	
From Lesson 1	.583	--	.541	.541	.042	
From Lesson 2	.549	--	.282	.282	.267	
From Lesson 3	.764	.869	--	.869	-.105	
On Near Transfer						
From Age	.345	--	.056	.056	.289	
From Education	-.224	-.233	.015	-.218	-.006	
From Computer in the Home	-.150	--	-.116	-.116	-.034	
From Language Abilities	.050	.274	-.200	.074	-.024	
From Memory Abilities	-.076	--	-.027	-.027	-.049	.323
From Visuospatial Abilities	-.091	--	-.124	-.124	.033	
From Computer Attitudes	-.191	--	-.284	-.284	.093	
From Lesson 1	.442	.278	.164	.442	.000	
From Lesson 2	.375	--	.086	.086	.289	
From Lesson 3	.448	--	.264	.264	.184	
From Word Integration	.440	.304	--	.304	.136	

Note. [a] Computer in the home was coded as 1, No home computer was coded as 0.
[b] Ranges from 0 (never used a computer) to 4 (more than 11 hours computer use).
Dashes indicate that the direct or indirect effect of the variable was not retained in the final trimmed model.

Appendix T. Regression Analyses of Individual Differences and Accuracy, Working Time, and Errors.

		Accuracy			Working Time			Errors		
Predictor		Beta	r	S_r	Beta	r	S_r	Beta	r	S_r
Lesson 1	Age	-.48	-.48	-.48	.38	.38	.38	.29	.34	.29
	Speed				.25	.21	.25			
	Language				-.33	-.32	-.33	-.34	-.29	-.34
	Motor				-.30	-.28	-.30			
	ATCQ				-.30	-.36	-.30	-.44	-.45	-.43
		R^2 = .23			R^2 = .50			R^2 = .40		
Lesson 2	Age	-.30	-.49	-.27						
	Visuospatial	.24	.32	.23						
	Memory	.36	.45	.34	-.54	-.54	-.54	-.39	-.36	-.39
	ATCQ	.26	.31	.25				-.43	-.40	-.43
		R^2 = .47			R^2 = .29			R^2 = .31		
Lesson 3	Age	-.34	-.50	-.31	.37	.44	.35	.43	.46	.42
	Education	.25	.34	.32	-.27	-.48	-.25	-.30	-.35	-.30
	Memory	.30	.45	.35	-.27	-.46	-.25			
	Speed				-.34	.37	.31			
	Motor				-.24	-.26	-.24			
	ATCQ	.25	.28	.25						
		R^2 = .46			R^2 = .61			R^2 = .30		
WI	Age	-.31	-.45	-.28						
	Visuospatial	.23	.31	.23	-.29	-.29	-.29			
	Memory	.24	.34	.23						
	Language	.41	.38	.41						
	ATCQ	.22	.24	.21				-.37	-.37	-.37
		R^2 = .23			R^2 = .08			R^2 = .14		
NT	Age							.34	.34	.34
	Education	.26	.27	.26						
	ATCQ	.33	.33	.33						
		R^2 = .18						R^2 = .12		

Note. All analyses included the following variables; age, education, attitudes towards computers, and the 5 factors (memory, visuospatial, language, motor abilities). Only those variables that had a standardized beta ≥.10 and a probability ≤ .05 are included here. Shaded areas refer to variables that did not reach criterion. WI = Word Processor Integration Task; NT = Near Transfer Task; ATCQ = Attitudes Towards Computers.

Appendix U. Manual Survey

Recently, a study was conducted that looked at different methods of training adults to use a wordprocessor. I would appreciate it if you would review this manual and respond to the following questions concerning it's strengths and weaknesses. Please note that the manuals were not meant to be exhaustive, rather to they were designed to train individuals on just some of the basic word processing procedures. In addition, the attached floppy disk contains a sample multimedia demonstration which some of the participants received as part of their training. Please view it by running SAMPLE.EXE from within windows.

Thank you for taking the time to respond to this survey. Please note that all responses are confidential.

About You

Age:	Occupation:
Years of Education:	Years of computer experience:
Preferred computer setup:	
Years of Word Processing experience:	
Preferred Word Processor	

Introductory Session

How difficult were the commands and procedures trained within this session?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

Lesson 1

How difficult were the commands and procedures trained within this session?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

Lesson 2

How difficult were the commands and procedures trained within this session?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

Lesson 3

How difficult were the commands and procedures trained within this session?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

Transfer

How difficult do you think the **Word Integration task** would be for a novice who just completed the training manual?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

How difficult do you think the **WordPerfect task** would be for a novice who just completed the training manual?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

How difficult do you think the **Transfer tasks** would be for a novice who just completed the training manual?

1	2	3	4	5
Very Easy	Easy	Neither Easy Nor Hard	Hard	Very Hard

The Manual

When considering training manuals in general and their suitability to the task, how would you rate the manual in general?

1	2	3	4	5
Excellent	Good	Adequate	Poor	Terrible

How would you rate the practice associated with each day's session?

1	2	3	4	5
Excellent	Good	Adequate	Poor	Terrible

Multimedia Demonstration

How would you rate the on-line demonstration that you watched and heard?

1	2	3	4	5
Excellent	Good	Adequate	Poor	Terrible

I thought the demonstration was too quick to view (Circle one): True False

I thought the demonstration was difficult to hear (Circle one): True False

Do you think that demonstrations such as the one you just viewed would be helpful to someone learning to use Word^{tm}?

1	2	3	4	5
Very Beneficial	Beneficial	Neither Beneficial nor Detrimental	Detrimental	Very Detrimental

Comments

____

____