The role of multimedia in training the elderly to acquire operational skills of a digital camera

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D-Y. M. Lin, C-T. J. Hsieh, The role of multimedia in training the elderly to acquire operational skills of a digital camera. Gerontechnology 2006; 5(2):68-77. Universal access has been a central issue in enhancing digital welfare for the elderly. The present study approached this goal by examining the role of multimedia as a training tool for older adults in learning to use a digital camera. Thirty older subjects aged over 65 participated in an experiment that employed multimedia training and task complexity as a within- and between-subject factor, respectively. Displaying operation procedures with animation, narration and static visuals defined the three treatments of multimedia, while task complexity varied by simple and difficult levels of operations. Training performance was evaluated by the time required to successfully complete the operations and the number of requests for help, both assessed by hands-on tests. Results indicated that animation and narration enabled the older subject to complete the tasks significantly faster than the static visuals but only when complex tasks were trained. Animation also resulted in the lowest need for the subjects to resort to hints during successful completion of the hands-on operations. It was suggested that computer-aided training for the elderly should be towards the use of multimedia presentation particularly when complex tasks are to be learned.

Keywords: multimedia, cognitive aging, computer-aided training

The current trends of population aging and pervasive use of computers have drawn the importance of designing living environments where senior citizens can equally access digital resources[1]. This pursuit of digital welfare for the elderly has its scientific concern as literature in cognitive aging has shown that increased age is normally associated with declining cognitive abilities. For example, older adults appear to have difficulty in natural language comprehension, a typical daily task that involves information construction, integration and reasoning[2]. Older adults are vulnerable to loss of memory for source so that they tend to be overconfident over their witness responses that are in fact prone to be erroneous[3]. Older adults are also less able to keep original and delayed recalls consistent due to susceptibility to decline of memory for context[4].

Cohen[5] and Park[6] summarized four basic mechanisms that account for the disadvantages of older adults in cognitive activities. First, older adults are generally slower than their younger counterparts in processing mental operations[7].

Secondly, older adults are deficient in engaging in mental processing that requires immediate storage, retrieval and transformation of information such as the use of working memory[8]. In addition, older adults are less accurate in sensory acuity[9], and tend to have more trouble inhibiting attention to trivial events[10].

Research in human-computer interaction has found that these age-related cognitive deficits impede older adults from effective learning and use of information systems[11]. For example, a menu-based interface should avoid a deep data structure for older users as older adults are particularly slow for later selections in such an information retrieval task[12]. Older adults are likely to become disoriented particularly in computerized tasks where data are represented by a network of cross references, such as hypertext perusal[13] and www-navigation[14]. Older adults have difficulty in completing as many inquiries as their younger counterparts in information search or retrieval from a database[15]. In a vehicle navigation study, it was found that older drivers relied more heavily than young drivers on an in-car digital map that provided track-up orientation information for successful path-finding and error recovery[16].

To assist the elderly to achieve desired performance in using technology, a systematic training approach was proposed that comprises integral considerations such as training needs assessment, task and user analysis, design and evaluation of training programs[17]. In line with this approach, the present study intends to examine the appropriateness of multimedia as a training tool to help older adults and facilitate learning the use of a digital camera. The motivation is twofold. A digital camera represents a typical electronic commodity older adults may depend on for daily living, and operating an interface such as this often requires a certain level of cognitive effort, which justifies the training needs of technology for older people. Secondly, also the central concern of the present study, multimedia has become a mainstream information platform adopted in most computer-aided training systems. Examining the role of multimedia in assisting elderly learning should receive attention.

Multimedia is a class of computer technology that presents information through various displaying channels such as text, still pictorial images, animation, and narration, etc.[18]. The rich variety of presentation by multimedia enables a level of information processing that a traditional single medium would never achieve[19]. For example, animated visuals are capable of demonstrating movements and trajectory, which lend themselves to a very helpful presentation strategy for those tasks that are inherently procedural or abstract. Through the dynamic relations between displayed components, animation can also gain attention from the readers and clarify those concepts that are difficult to understand.

Mayer[20] proposed a multimedia learning theory, which advocates the idea that comprehension and transfer of learning can be strengthened to the extent whether training material is presented with different displaying channels. This theory draws on three assumptions, namely, the dual coding assumption, the limited capacity assumption, and the active learning assumption. The dual coding assumption refers to the notion that humans possess two separate information processing channels for visual (for instance, animation) and verbal (for instance, narration) representations[21,22]. The limited capacity assumption is that the amount of mental resources within each information-processing channel is restricted[23]. The active learning assumption is that meaningful learning occurs when readers actively process trained material by paying attention to the presented stimuli, mentally organizing and integrating the verbal and pictorial messages[24]. Better transfer has been found in a number of studies where multimedia were employed to present training material in how tire pumps work[25], how brakes work[26] and how electrical generators work[27].

Despite the above empirical evidence, however, research on how multimedia learning can actually assist older adults is still lacking and a number of issues remain to be resolved. These queries begin with a fundamental one: Can the positive effects of multimedia training override the older adults' reduced cognition in learning? If yes, what is the specific type of training media that would most benefit older adults? Does this training effect of multimedia interact with task variables such as operational complexity? By addressing these issues, the objective of the present study is to investigate the role of multimedia in assisting learning for older adults as a function of task complexity.

METHODOLOGY

Experimental design

The present study employed a 3 x 2 factorial experiment where multimedia and task complexity were the two independent variables. Multimedia was designed as a repeated-measures factor, and displaying training contents with static visuals, animation, and narration defined the three levels of training treatment. Task complexity was defined as a between-subject factor, which was varied by simple and complex levels of operations.

Subjects

Thirty older adults recruited from a computer-learning class of a local social welfare program participated in the experiment. These senior participants were from 65 to 83 years old with a mean of 71.1 and a standard deviation of 3.8. To avoid a potentially extraneous effect of familiarity, we selected on purpose those participants who were inexperienced in the use of a digital camera. Of the 30 subjects who were all Mandarin literate, 18 participants were high school graduates and the remaining 12 received college degrees. None of the participants had cognitive disorder problems but some of them had vision and hearing difficulties. Appropriate adjusting measures, including vision-correcting glasses and volume-adjusting speakers, were adopted. Each subject was paid at an hourly rate of 300 New Taiwan dollars (approximately 9 US dollars) for participation.

Material / The training systems

According to the training media defined above, three training systems that were able to demonstrate virtual operations of a digital camera were developed, by using Flash (version MX2004) and Photoshop (version CS2.0). The static system displayed the training material in such a manner that the procedures for operating the digital camera were illustrated by printed instructions and still pictures (*Figure 1*).

With respect to the animation system, animated visuals that dynamically exhibited how to use the procedures replaced those still pictures in the static training system. For example, when demonstrating how to equip the digital camera with a memory card, the animation media were capable of exhibiting the actual movements of push-in and pull-out of the card by animated visuals (*Figure 2*). The displaying speed was set at six frames per second. In contrast to the an-

Figure 1. Training media in text plus static pictures; Chinese text reads: 'Slide the memory card in until it is firmly in place and the eject button pops up'

Figure 2. A snapshot of the animated visuals dynamically exhibiting the push-in and pull-out of a memory card; Chinese text reads: 'Hold the memory card with the arrow facing towards you and insert the card in the direction of the arrow'

Figure 3. Display of the narration media where the printed instructions are narrated; Chinese text reads: 'Press the bottom three times and highlight "Date" in the menu to set correct date'

imation training system, the narration system supplemented the training contents with narrated messages that were originally displayed by printed instructions in the static system (*Figure 3*).

Two sets of the training systems were developed, one for the simple task and the other for the difficult one, so that each participant of both task groups received three training examples presented by static visuals, animation and narration. Major functions for operating the digital camera were characterized by a task analysis in terms of procedural complexity. Based on the average seven-chunk human working memory[28], it was assumed that every single procedure would require one chunk of memorization. Therefore the simple tasks were operationally defined as those tasks that consisted of six to eight operational procedures and the difficult tasks as those comprising ten to twelve procedures. The procedures associated with the six media-complexity manipulations were displayed to the subject one at a time in the sequence determined in the task analysis.

Performance measures

The present study concerned the extent to which the subject could recall the trained procedures and transfer the effect to a hands-on situation. To do so, the present study reversed the hit-rate paradigm by allowing one hundred percent completion of the task instead, during which we also allowed the subject to request for a hint when needed. Given this design, two performance measures were defined. One evaluated how soon (i.e., completion time) the subject was able to complete the operations just trained successfully. The other assessed how often the subject requested assistance (i.e., request frequency) in such a completion. Shorter completion time and fewer requests for assistance implied better recall and stronger transfer.

Procedures
First, the experiment administrator randomly assigned all subjects to the two task groups, with each task group receiving 15 subjects. The administrator then briefed the subject regarding the purpose of the experiment and provided the subject with three warm-up exercises. Following the preliminary exercises, the administrator instructed the subject to undergo the training session by watching the training material presented by the three media. The training session allowed the subject to repeat watching the same category of training presentation three times at the most. This level of exposure to the stimuli was derived from a pilot study in which the subjects reported such an allowance would be sufficient. In both tasks groups, the order of presenting the static visuals, animation and narration media was randomized. A one-minute and a five-minute break between alternations of the three training media were used for the simple and difficult tasks groups, respectively. Following each training example, a physical digital camera of the same type as displayed in the training session was provided to the subject, and the subject was required to perform in a hands-on manner the operations just trained. The administrator recorded the time each subject spent in completing the hands-on tests by a stopwatch. However, the test session allowed the subject to resort to the administrator for a hint if appropriate procedures could not be recalled. The time spent in consulting by the subject was excluded from his or her completion time. The administrator tallied the frequency of the subject's requests for assistance. Those subjects who requested assistance more than five times were considered to produce invalid data.

Results and Analysis

None of the 30 subjects produced invalid data. Table 1 shows the descriptive statistics of the experimental data. Data normality and equal variances were examined prior to the ANOVA analysis. The Shapiro-Wilk test indicated that for both performance measures, the null hypothesis of normality for the distributions of the six (3 x 2) treatment populations could not be rejected as evidenced by the p values that were all larger than 0.10. Neither could the null hypothesis of equal variances be rejected as the Bartlett's statistics for completion time (0.90) and request frequency (2.56) indicated p values larger than 0.64 and 0.18, respectively.

The analysis treated subject as a random-effect variable nested within the two groups of task complexity [subject(task)]. Therefore, the test of task complexity used the variance of subject(task) as the error term, and the tests of training media and the media x task interaction used the variance of media x subject(task) as the error term.

Table 1. Means and (standard deviations) of performance measures under manipulation of training media and task complexity

Performance measures	Training media		
	Static visuals	**Narration**	**Animation**
Completion time (seconds)			
Simple	17.20 (6.19)	16.27(5.97)	16.73 (6.87)
Difficult	62.33 (10.01)	52.53 (10.91)	49.33 (11.67)
Request frequency			
Simple	1.53 (0.45)	1.33 (0.31)	1.06 (0.26)
Difficult	3.03 (0.72)	2.80 (0.55)	2.58 (0.48)

For the measure of completion time the ANOVA indicated that both main effects of training media and task complexity were significant ($F[2,56]=3.54$, $p < 0.04$ for training effect and $F[1,28]=199.80$, $p < 0.0001$ for task effect). However, both significant effects need to be further justified as the training media x task interaction was also significant ($F[2,56]=3.73$, $p < 0.03$). Figure 4 depicts the interaction pattern. As shown in the figure, when at the simple-task level, the means of completion time resulting from the three training media were close to each other; however, when the task complexity increased, all the three media resulted in longer completion time accordingly but at differentiated rates of change. Specifically, despite the fact that it required more time for the subject to finish the difficult tasks, animation and narration enabled significantly faster completion of the tasks than the static visuals. A post-hoc simultaneous Tukey test confirmed this data pattern, which indicated that the differentiated effects of training media at the difficult task level was the only source that led to the significance of the interaction. A further examination on this significant variance source by the Tukey test revealed that at the difficult task level the mean difference between static visuals and animation (62.33 vs. 49.33 seconds) and the difference between static visuals and narration (62.53 vs. 52.53) were both significant ($T=3.39$, $p < 0.01$ and $T=2.58$, $p < 0.05$, respectively). The difference of mean completion time between narration and animation (52.53 vs. 49.33) was only a chance result nevertheless.

With respect to the frequency of requesting assistance, the ANOVA showed that the main effects of training media and task complexity were both significant ($F[2,56]=15.53$, $p < 0.001$ for training effect and $F[1,28]=39.13$, $p < 0.001$ for task complexity) but no interaction existed between the two factors ($F[2,56]=2.07$, $p < 0.07$). The basic statistics show that static visuals resulted in the highest frequency for request of hint, followed by narration and animation in a descending order. A post hoc simultaneous Tukey test indicated that the significance was mainly derived from the mean difference between static visuals and animation (2.28 vs. 1.82, $T=2.93$, $p < 0.01$); however, the mean differences between narration and animation (2.07 vs. 1.82), and static visuals and narration (2.28 vs. 2.07), were due to a chance result.

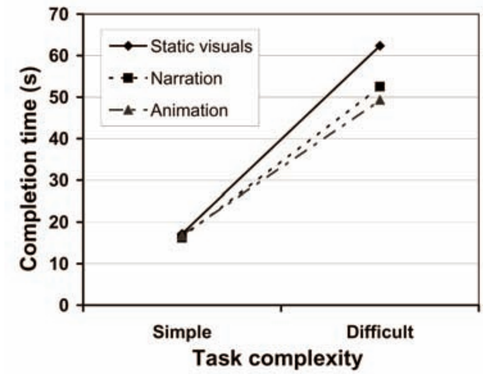

Figure 4. Interaction pattern for completion time

Discussion

The results of the present study pointed to a general data pattern where multiple channels of presentations (i.e., narrated speech and animated visuals) appeared to produce the most favorable training outcome. While this media effect held unchanged regardless of task complexity for request frequency, the benefit of narration and animation was true only when at the difficult task level in terms of completion time.

The discussion will begin with the interactive effects of training media with respect to completion time. It has been well documented that multimedia learning supports the use of narrated speech at least over static illustrations[20]. The present study is consistent with the literature, showing that for difficult tasks, participants who received the narration treatment have a better chance of accurately recalling the procedures and therefore successfully transferring the skills to real-world operations. It appears that providing redundant verbal codes through the auditory channel could assist older adults in reinforcing the memory for those stimuli simultaneously received from the visual modality. This finding may suggest that when learning skills that involve complex rule chaining, older adults could substantially benefit from a training method that simply reiterates printed learning material.

Perhaps more interesting is the role animation plays in the context of learning complex procedure-based knowledge. Although animation and static illustrations share the same presentation modality, animated visuals outperform the static counterpart on one hand, and on the other uphold the performance to a level comparable to that by the multiple-channel narration treatment. We postulate that the positive training impact very likely stems from the presentational characteristics inherent in animated coding. First, people who receive dynamically exhibited stimuli tend to heed the information more strongly and this investment of cognitive energy would bring about a larger amount of mental resources, which would in turn foster a deeper level of processing. People who engage in deeper cognitive activities are likely to have stronger recall, which accounts for the shorter time spent by the subject who received the animation treatment.

Secondly, successfully completing the various functions of the camera requires the subject to memorize continuous connections between the procedures. Animation enables these dynamical relationships to be coherently displayed and facilitates effective chunking of the procedural knowledge as a result, particularly when the task involved consists of a large number of procedures[19,29]. It is thus reasonable to speculate that the effect of animated presentation would be more pronounced for those training conditions that demand mental resources beyond the averaged capacity of human working memory. Thirdly, the complex task involved certain operational components requiring the subject to understand the functionality underlying these operations (for instance, how to release a safety lock in order to turn a knob). Animated visuals can make the functionality more salient by virtually displaying how these mechanisms work, which enables the subject to forge better comprehension of these operational skills[19] and therefore to develop a compatible mental model[30]. This positive impact was evidenced in the hands-on test where not only rote memorization performance, but also actual skill acquisitions were evaluated. Provided that older people are generally disadvantaged at cognitive abilities, utilizing animation as a training medium appears to provide an effective approach to improving their interaction with technology. One example of such benefits may be the situation where product manuals are digitized (for instance, on a CD) so that animated programs demonstrate those functional operations that require complex processing.

In contrast to the supportive impacts of animation for the elderly, static coding of training material appears to be less effective when a complex task is encountered. One explanation is that static illustrations, although presented with instructional text and virtual pictures of the camera, seems to do little in assisting the subject to develop an accurate mental model concerning the chaining activities and functionality of the procedures. It is also possible that the reading ability of the participants contributes to the extraneous results considering that over half of the recruited older subjects were only high school graduates. This possible cause is important for designing media for elderly learning as the educational background among an aged population in some societies may vary significantly.

The result suggesting whether training material is displayed in static or dynamic codes could make a difference may lead to a potential reappraisal of the dual coding theory. It has been argued that since information is coded in two different cognitive subsystems (i.e., visual and auditory), whether the graphics, a visual code, are static or animated is irrelevant[30]. If this hypothesis is true, the theoretical basis for using animation will be the same as that for using static pictures accordingly. Nevertheless, the empirical evidence of this experiment showed otherwise. It seems from the results that animation lends itself as a unique training medium perhaps fundamentally different from static visual presentations. This finding may call for further investigation because animated programs have increasingly become a mainstream platform in computer-based training.

The superiority of animation and narration disappeared for the simple tasks condition, with the three training media not differentiated from each other. It is possible that the cognitive demand for manipulating these activities is still within the limit that older people can handle so that the benefits of animation and narration become marginal. The implication of this interpretation may be twofold. First, older people are not absolutely disadvantaged. They can manage a satisfactory training output as long as the demand of technology interaction falls within the average capacity of human cognition. Secondly, older adults do not necessarily need to resort to a sophisticated way of training if the interaction task does not involve a complex level of operations. Text coupled with static pictures, a very common means of knowledge dissemination, may already be sufficient for older people under such circumstances. By employing a cost-effective training method, desired performance of the elderly can be expected when skills of less-demanding tasks are to be trained.

As compared with the data pattern for completion time, the results of request frequency indicated no interaction, but with the effects of training media and task complexity being significant. One possible reason for the non-significant interaction is that people tend to exhibit a stable need as to whether they should resort to a helping resource. For example, the subjects would probably not bother to ask for assistance if they feel the task can be handled quite well. Following this account, the relative needs for requesting a hint resulting from the three training media would be invariant across the two task conditions, which explains the absence of interaction.

The need of requesting assistance by the subjects to complete a task reflects their inability to recall and transfer those procedures that had just been trained. The subjects who underwent the animation and static visuals exhibited the least and the strongest tendency of asking for help, respectively, with those receiving narration standing in the middle. These performances are similar to those observed in the completion time and again provide evidence supporting the use of animation for developing a coherent mental model and in turn better training effects. It is reasonable to expect that the subject equipped with a more coherent mental model on the functions has a better chance to transfer these demonstrated procedures into practical manipulations and therefore finds less need to resort to assistance as indicated by the results.

As for the main effect of task complexity, the difference between the difficult and the simple conditions implies that older adults' training performances are indeed subject to the increased number of procedures involved in a task. This data pattern again demonstrates how the processing speed hypothesis and the on-line resources theory account for the older adults' learning behavior. The complex tasks would probably cause the older subject being unable to deal with each individual procedure in time and therefore produce a longer queue in later stages of processing. The situation may turn worse given the limited reservoir for the real-time information older adults can store. This interpretation suggests that older adults are vulnerable to those tasks that require demanding chunking of procedures when using technology and attention to the need of appropriate training for elderly users should be paid.

Conclusions

To enhance digital welfare for the elderly, appropriate training methods that consider age-mediated decline in cognition should be proposed. The current study suggested that such a training scheme should be prioritized towards the use of animated visuals and narrated speech to present training material. While this design consideration would benefit the elderly particularly for learning complex tasks, plain text coupled with still pictorials could suffice for tasks demanding only a simple level of complexity. Despite these guidelines, a number of caveats should be noted. First, operating a digital camera in essence involved procedural knowledge. However, this represents only one example of a wide array of training tasks bearing universal access meaning to older adults. Interpretation of the above results thus should not be applied unconditionally until a richer variety of training applications is examined. Likewise, a wider variety of multimedia techniques should be further investigated so that an optimal combination of training media and task factors can be identified. Finally, the present study considered the cognitive deficits of older adults as a priori and a control group that enables age-difference quantification should preferably be adopted in future research.

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