The Display Medium, Academic Major and Sex Effect of High School Students on Visuospatial Abilities Test Performance

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Abstract. The objective of this study is to evaluate the spatial ability differences and fatigue between three different students on different interface. An experiment was design to compare the differences between using the convention book (C-book) and using tablet computer, and compare the differences between three department students. Fifty-four vocational high school students, age sixteen to eighteen, participated in the study. Response measure included task performance, eye fatigue (measured by critical flicker fusion, CFF), and wrist fatigue (measured by subjective borg 10-CR scale). The result indicate that using the C-book had higher performance and less wrist fatigue than using tablet computer. In addition, on score sequence of task performance, interior design student is first, architecture student is second, and general student is last.

Keywords: Tablet Computer, display.

1   Introduction

In the past, knowledge is often transferred and stored in books form, but with the development of technology, knowledge preservation and presentation have a breakthrough, under the technology advances, rising of environmental consciousness, and promotion of government policies, electronic reader will become the mainstream to get the message in the near future, personalized e-reader is regarded as the most convenient tool in reading [7].

When the obtainment and using of the information is gradually changing towards electronic, computerized tests have gradually been applied in many areas, such as a variety of license test, it may include education entrance exam in the future.

Many studies have pointed out that the level of spatial ability may affect some learning effectiveness, the maturity of the human mind, the computing ability, and language logical thinking ability [1, 2, 3, 4], so spatial ability is also be used as indicator of student ability.

In the past, many research in exploring spatial ability, assume that spatial ability is innate. However, in recent, the related study show that the past experience of

individual may affect spatial ability, or through the strategy or method with elaborately planning can also improve spatial ability [5, 6].

But whether the interface differences cause differences of operating performance is also worth discussing. There are many factors affect the differences between reading a displays and reading a book, there were studies showed that reading performance and efficiency of the books are better than the reading a display.[7]

Belmore (1985)[8] found that, compared to paper reading, poor reading comprehension on the screen, and Mayers et al (2001)[9] pointed out that the screen reader and reading a paper had the same understanding, but the screen reader still spent more time to read, the two studies have different results, this may be because with the advances in technology, also improved the quality of the reading screen.

Therefore, reading conventional book is completely different than reading electronic reader, the reason may includes differences habits, and personal experience of different. Because of the develop of the computerized, whether the different interface will cause operating difference is worth to be investigated. The objective of this study is to evaluate the spatial ability differences and fatigue between three different students on different interface, by using objective measures including task performance, critical flicker fusion, and subjective fatigue.

2   Method

2.1   Subject

Twenty-seven male and 27 vocational high school students participated in the experiment. They average come from three different departments. Someone majors in architecture. Another majors in interior design, others study in general education. Each department student comprised equal female and male. Their age ranged from 16 to 18 years (mean=17.3, SD=0.45). The mean age of male subject was 17.4(SD=0.6). The mean age of female subject was 17.2(SD=0.32). They were required to have at least 20/25 visual acuity with corrective lenses and to be without physical or mental problems. They were also requested not to stay up late, take medicine, alcoholic drinks and any other substance that might possibly affect the test results. All subjects had no previous experience using an E-book.

2.2   Experimental Design

This study employs analysis of variance. The three independent variables are interface type (tablet computer and C-book), departments (architecture, interior design, and general education), and gender (female and male). Subjects were requested to use a tablet computer and a C-book respectively. The tablet computer used in this study is Ipad2 which made in Apple inc., and had the following characteristic: (1) view screen: 241.2mm × 185.7mm, (2) resolution: 1024 × 768(132ppi), and (3) font size: headline: 24-point, content: 18-point. A C-book was prepared in the same format as the E-book so as to minimize differences between the two, it illustrated in Fig. 1.

The aspect ratio and paper size of the C-book was similar to the viewing screen of the tablet computer. The font of both books was Ming type Chinese characters that is the most frequently used font for Chinese textual information and is also known as the standard writing type. The size of each Chinese character was similar to the size of Chinese characters used in the tablet computer. The main difference between reading the tablet computer and the C-book was the interface manipulation. For manipulating the tablet computer, the subjects slide the screen to go to the next page and, used his or her fingers to turn pages in the C-book. The response measures included Task Performance (spatial shorten-memory and spatial ability.) and eye fatigue measure (CFF), and wrist fatigue measure.
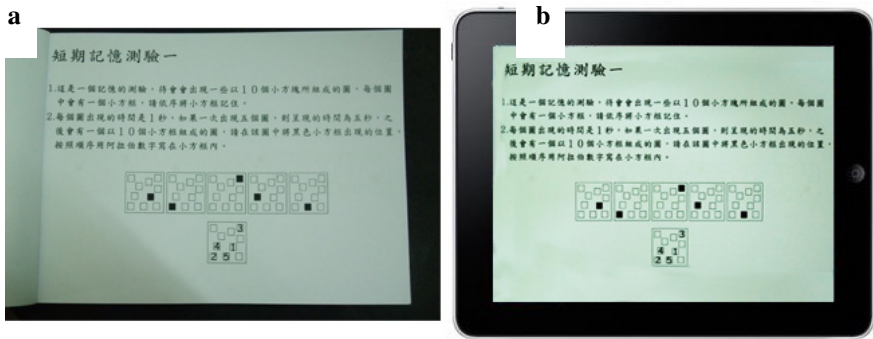

Fig. 1. The Illustration of: (a) C-book and (b) Tablet computer (ipad2) used in this study

Task Performance. In the experiment all subjects had spatial shorten-memory test and spatial ability test. They have both same tests on a tablet computer and C-book, but different quiz sorting. All tests would spend about fifty to sixty minutes. The spatial shorten-memory test contains Corsi block task, arrow span task, and dot memory task, the objective of those tests is to recall position and sorting for each mark. Those test materials is illustrated in Fig. 2.

The spatial ability test contains spatial relation test, card rotation test, and hidden figures test, the objective of spatial relation test is try to match the plane figure to correct three-dimensional figure; the objective of card rotation test is try to figure out the correct card in those rotation card; the objective of hidden figure test is try to cognized correct figures which have the Benchmark line. The test material is illustrated in Fig. 3.

Both score of spatial shorten-memory test and spatial ability test were taken as performance measures.

Eye Fatigue. CFF is a common used measure of visual fatigue because of its characteristic of effective and easy to operate and [10, 11]. It measures the minimal number of flashes of light per second at which an intermittent light stimulus no longer stimulates a continuous sensation. As a highly sensitive and easy-to-use measure, CFF is applied here to evaluate eye fatigue.
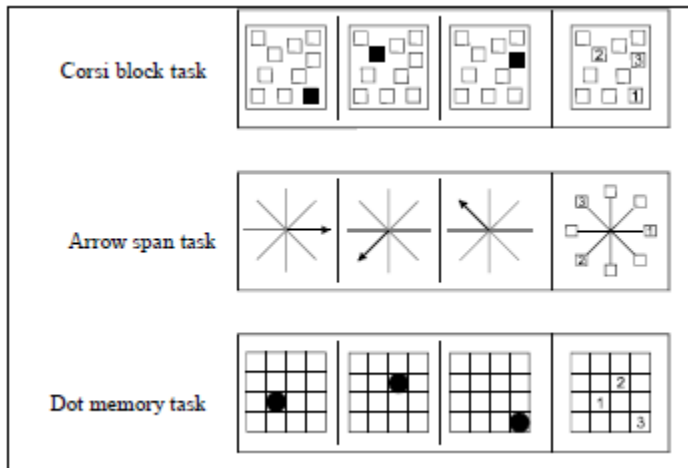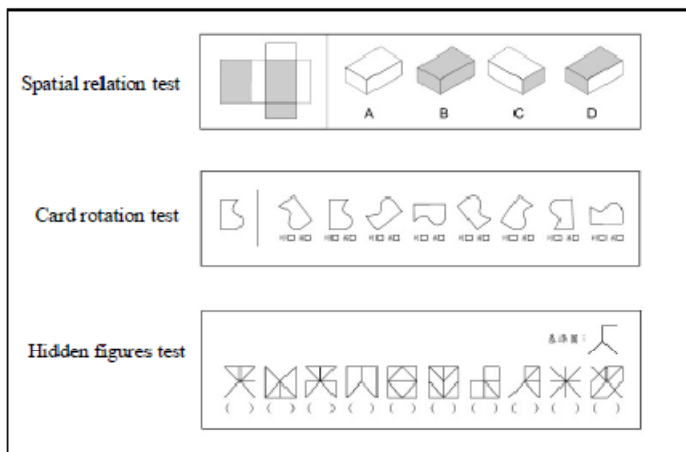
Fig. 2. Spatial shorten-memory test

Fig. 3. Spatial ability test

Wrist Fatigue. At the beginning of each experiment session, the subject was required wrist fatigue measure as a baseline for comparison. The subject was asked status of their wrist by their subjective feeling, evaluated it by Borg CR-10 scale.

2.3 Experiment Procedure

A standard classroom desk and chair were provided for experimentation. The experiment environment was standardized. Prior to the experiment each subject was instructed about the purpose and procedure of the study. At the beginning of each experiment session, the subject's CFF was measured as a baseline for comparison. Then, the subject asked to finish the spatial shorten-memory test and spatial ability test,

proportion of correction answer for those test were taken as score. Last, each subject was measured CFF again for comparison. Each subject was required to participate in two performance experiment sessions. After completing one performance experiment, another one was scheduled for one week later.

3   Results and Discussion

The summarized ANOVA results are shown in Table 1. The interface type effect was significant both on task performance and wrist fatigue. The department's background effect was significant on all measure. The gender effect is not significant on this study.

Table 1. The ANOVA results

factor	task performance		eye fatigue	wrist fatigue
	spatial shorten-memory	spatial ability	CFF	wrist subjective measure
interface type	**	*		*
department	**	***	*	
gender				

3.1   Task Performance

Task performance was measured by score of spatial shorten-memory and spatial ability. The interface type had a difference affect significantly. Fig.4 shows the performance difference for both interface type. For the C-book the average performance of spatial shorten-memory was 52.95, and the average performance of spatial ability was 51.71. For tablet computer the average performance of spatial shorten-memory was 47.05, and the performance of spatial ability was 48.29. On performance of spatial shorten-memory, using the C-book get 5.9 score more than using the tablet computer. On performance of spatial ability, using the C-book get 3.42 score more than using the tablet computer. The result shows that using C-book had higher performance than using tablet computer. This may be attributed to manipulate habit that people used to take a test by C-book interface type.

The department effect was significant on both task performances, and there was no significant interaction effect. The subjects who major in interior design get 53.63 score on spatial shorten-memory, and get 54.10 score on spatial ability. The subjects who major in architecture get 49.55score on spatial shorten-memory and get 49.81 score on spatial ability. The subjects who study in general education get 46.82 score on spatial shorten-memory and get 46.09 score on spatial ability. The performance differences shows in Fig.5. The subjects who major in interior design had better performance both than the subjects who major in architecture, and the subjects who major in architecture had better performance both than the subjects who study in general education. This may be explained that past experience of individual may affect spatial ability, included of education background.
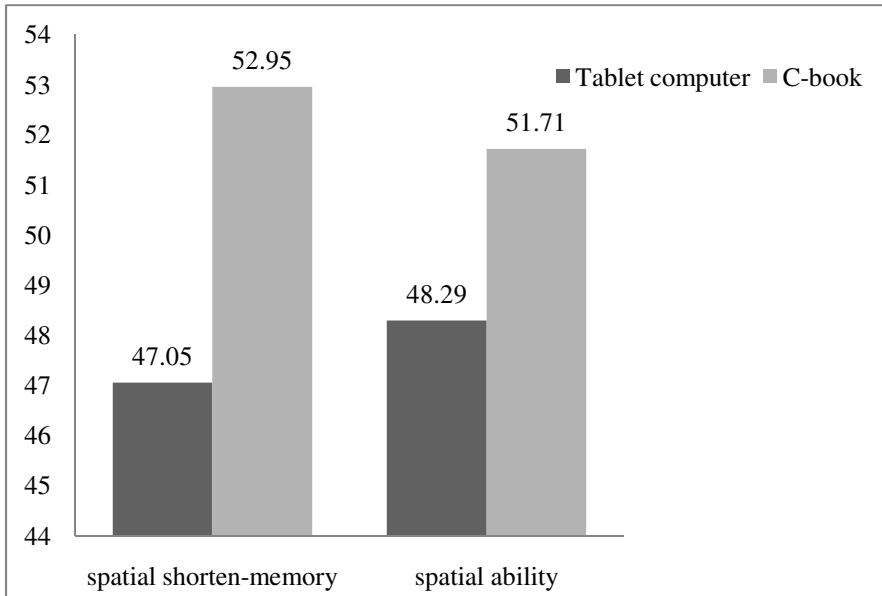
Fig. 4. The task performance for both interfaces
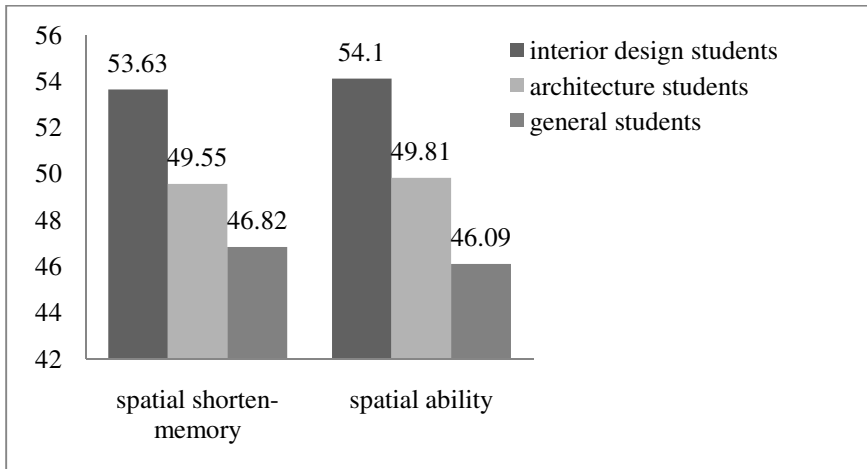

Fig. 5. The task performance for three different background students

3.2 Eye Fatigue

This study measured eye fatigue by CFF. Only department difference had significant influence on eye fatigue, but there was no significant interaction effect to interface. The CFF comparison result of three department show in Fig.6. After using the

C-book, the CFF of subjects who major in interior design had an average reduction of 0.77 Hz, the CFF of subjects who major in architecture had an average reduction of 0.53 Hz, and the CFF of subjects who study in general education had an average reduction of 0.30 Hz. After using the tablet computer, the CFF of subjects who major in interior design had an average reduction of 0.87 Hz, the CFF of subjects who major in architecture had an average reduction of 0.81 Hz, and the CFF of subjects who study in general education had an average reduction of 0.27 Hz. It seems significantly that subjects who major in interior design had more eye fatigue than subjects who major in architecture, and subjects who major in architecture had more eye fatigue than subjects who study in general education. The result may be related to task performance. The better performance who get, the more eye fatigue who had.
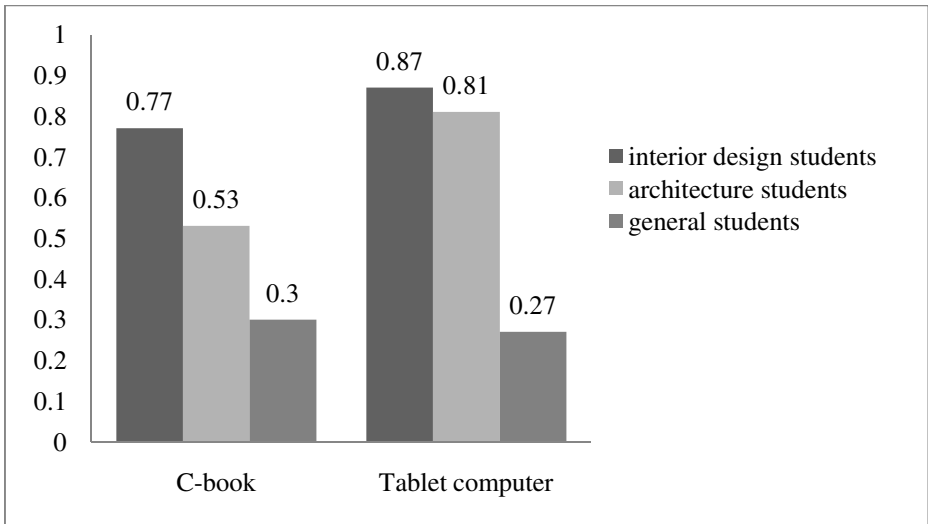
Fig. 6. The department effect on CFF changes for both interface

3.3   Wrist Fatigue

Wrist fatigue was measure by subjective borg CR-10 scale. Only interface type had a significant influence on wrist fatigue. The fatigue change for both interfaces is showed in Fig.7. After using the C-book, subjects' subjective fatigue had an average raise of 0.28. After using the tablet computer, subjects' subjective fatigue had an average raise of 0.81. It seems that using tablet computer would cause more wrist fatigue than using C-book. This may be attributed to usability of computer stylus. In the experiment procedure, many subjects mentioned that they were not accustomed to using the stylus.
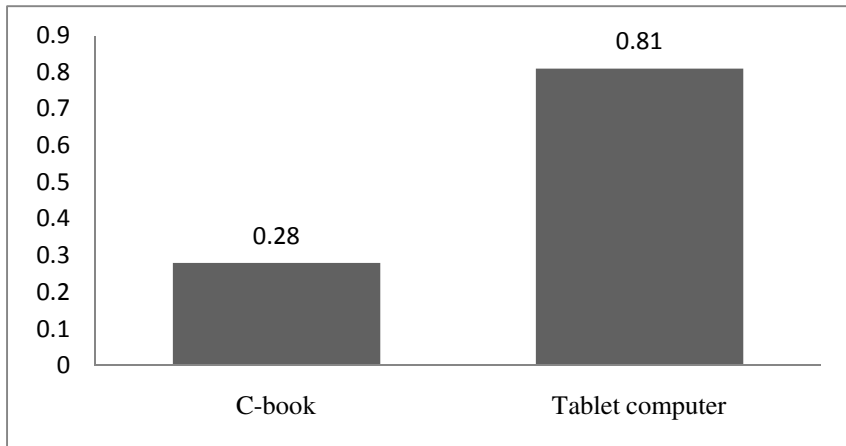
Fig. 7. The wrist fatigue for both interfaces

4   Conclusion

This study is evaluated the spatial ability differences and fatigue between three different students on using the C-book compared with using the tablet computer. The result indicated that using the C-book had higher performance and less wrist fatigue than using tablet computer. This is mainly attributed to using habit. People had more experience of using the C-book on test than using the tablet on test. In addition, on score sequence of task performance, interior design student is first, architecture student is second, and general student is last. The performance difference is due to education al background, the course would create the spatial ability difference, just like past studies said [5,6].

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