

A New Audio Testing System for the Newly Blind and the Learning Disabled to Take the National Center Test for University Admissions

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Abstract. A new audio testing system was developed for the newly blind and the learning disabled (dyslexia) who have difficulties with reading braille or print-format tests. The system enables them to take the National Center Test for University Admissions. The system was developed primarily on a tablet PC and presents not only speech sound but also document structures and figures from the test.

1 Introduction

The National Center Test for University Admissions is the joint achievement test for admissions into all national and local public universities as well as many private universities in Japan. Every year, about 600,000 students take the National Center Test. As for test-takers with disabilities, special arrangements regarding test media such as large print test and braille-format test have been administered [7]. Audio tests, however, have not been administered yet. There are difficulties in administering ordinary types of audio tests for the National Center Test because the documents are very long and the document structure very complicated. This study contributes to the development of a new audio testing system for the newly blind and the learning disabled (dyslexia) who have difficulties with reading braille or print-format tests.

Ordinarily, audio tests are administrated by means of readers [4], audio cassettes [2,9,10], DAISY (Digital Audio Accessible Information System) [3] or computers [1]. The simplest procedure is to recruit readers and have them read out a test booklet to a test-taker directly, but it is not easy to find enough well-trained readers for each test-taker. And for fairness and security reason, it might be necessary to supervise such readers by another person. Audio cassettes make it easy for test-takers to listen to the test sequentially, but it is inconvenient to go directly to a particular section of the test unless rewinding and fast-forwarding can be done easily. Recently, it has become possible to design audio tests by means of DAISY, which is a world standard audio system for people with

visual disabilities, taking the place of audio cassettes. DAISY offers audio tests in CD quality, and test-takers can listen to the test from any point, such as from an underlined or blank part, without delay. They can also use the talk-speed-control function, by which the speech sound can be adjusted from 1/2 to 3 times normal speed. As a result of the experiments with the Law School Aptitude Test [6] and the National Bar Examination [5] of Japan, we found that the DAISY tests were almost equal to braille-format tests for the blind in design and administration. However, DAISY is not convenient enough for tests which have complicated document structure. A computer test is also inappropriate for tests written in Japanese even with advanced screen-reader software for the blind because of the ambiguity of the reading of Kanji in Japanese sentences. Screen-reader software can not always convert Japanese sentences into correct Japanese speech.

We developed a new audio testing system utilizing a tablet PC which enables the newly blind and the learning disabled to take the National Center Test for University Admissions. This system presents the document structure of test problems with characters or icons on a computer screen for the learning disabled and on braille paper for the newly blind. Test-takers can take a variety of tests by using the electronic pen of a tablet PC.

This paper is organized as follows: Section 2 contains a summary of the system; Section 3 provides a system evaluation by experiment; and Section 4 is the conclusion.

2 The Tablet PC Audio Testing System

2.1 Composition

We developed a new audio testing system utilizing a tablet PC. The composition of the system for the newly blind is slightly different from the one for the learning disabled.

For the newly blind, the composition of the system is illustrated in Fig. 1. The system consists of a PC (FMV STYLISTIC, Fujitsu Inc.), an A3 tablet (Intuos3, Wacom Inc.), a ten-key pad (NT-1U, Sanwa Supply Inc.), and a speaker with amplifier (SRS-T88, Sony Corp.). On the A3 tablet, a sheet of braille paper, on which the document structure for each problem or figure has been embossed by a braille printer, is mounted. With just an electronic pen, test-takers can listen to speech sound from any part of the document and answer the questions. The ten-key pad is used to adjust the speed and volume of speech sound.

For the learning disabled, the system consists only of a tablet PC (VAIO PCV-LX80, Sony Corp.). On the LCD (Liquid Crystal Display) screen of the tablet PC, the document structure is displayed. Speech sound comes from speakers mounted on both sides of the LCD screen.

The software was exclusively developed at the National Center for University Entrance Examinations to run on Windows XP Tablet PC Edition with Visual C++ 6.0 and Windows Media Player SDK 10 (Microsoft Corp.).

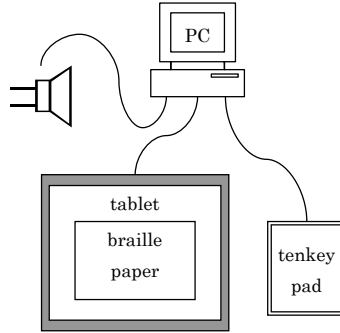


Fig. 1. The composition of the system for the newly blind

2.2 Usage

The system displays the document structure of each problem, which enables a test-taker to confirm the document structure throughout the answering process and to point to any position of document to listen to the speech sound.

Fig. 2 is an example of the document structure displayed on the LCD screen for the learning disabled. For the newly blind, on the other hand, only the character part of the document structure was embossed by a braille printer, which is mounted on the tablet. In Fig. 2, the first line shows the subject name 'Gensha 1' and the problem number 'Q1'. The upper part shows the document structure of the theme document of the problem. Each line 'p1'-'p4' corresponds to a paragraph in the theme document. The symbol 's' represents a sentence in a paragraph, and the symbols 'a'-'g' represent underlined parts of the theme document. The lower part shows the document structure of the questions of the problem. Each line 'q1'-'q7' corresponds to a question. The symbols '□1'-'□7'

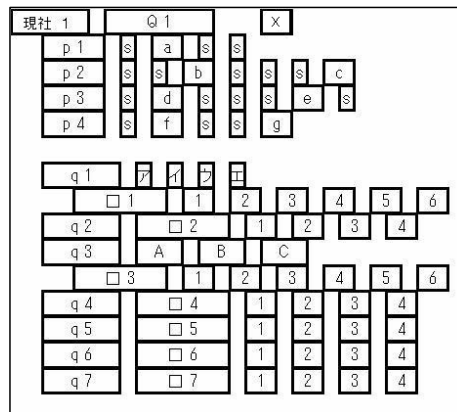


Fig. 2. An example of the document structure displayed on the LCD screen

represent answer items, and the symbols ‘1’-‘6’ represent possible answers for an answer item.

To produce speech sound, a test-taker just touches the symbol of either a paragraph, a sentence, an underlined part of theme document, an answer item or a possible answer with the electronic pen. To stop the sound, a test-taker touches the blank part of the screen with the electronic pen.

To answer a question, the tail switch of the electronic pen is used. When a test-taker successively touches the symbol of an answer item and the symbol of a possible answer with the tail switch of the electronic pen, an answer is recorded by the system, and a confirmation message is produced, for example, “On answer item No. 1, choice No. 2 was selected.”

The ten-key pad is used to start the test, to suspend the test, to end the test, and to adjust the speed and volume of speech sound. When the ten-key pad is used, a confirmation message is produced.

The answering process of a test-taker is automatically recorded with the time whenever the electronic pen or the ten-key pad is used.

3 Evaluation Experiment

In order to evaluate the tablet PC audio testing system, an experiment was conducted by comparing the tablet PC audio test with other test media such as the braille-format test, the DAISY test, and the multimodal test of braille-format and tablet PC audio test.

3.1 Method

Two subject groups were assigned in this experiment, namely, a blind group and a non-disabled group. The blind group consists of 12 students from a high school for the blind, and the non-disabled group, 28 average high school students.

The experimental design for the blind group was a repeated 4x4 Latin-square method [8] because we could not use the same problem in different test media for the same person. The image of the experimental design for the Latin-square method is shown on Table 1. There were 4 test media: the braille-format test, the DAISY test, the tablet PC audio test, and the multimodal test for braille-format and tablet PC audio test. There were 4 subject groups, i.e., the blind group was evenly divided into 4 subgroups. Four problems were prepared from tests in “Contemporary Social Studies” previously used in the National Center Test. The allotment of marks, number of characters, size of figures, and quantity of problems are shown on Table 2. The size of a figure is converted to a number of characters (the density of characters in the document \times the area of the figure).

The test procedure was administered without time limits. Blind subjects took the braille-format test by braille booklets, the DAISY test by a DAISY player (Plextalk Portable Recorder PTR1, Plextor Inc.), the tablet PC audio test by our system, and the multimodal test by using both the braille booklets and the tablet PC audio testing system. The behavior of blind subjects was observed by

Table 1. Image of the experimental design for the Latin-square method

		Subect Groups			
		Group 1	Group 2	Group 3	Group 4
Test Media	Braille	Problem 1	Problem 2	Problem 3	Problem 4
	DAISY	Problem 2	Problem 1	Problem 4	Problem 3
	Tablet	Problem 3	Problem 4	Problem 1	Problem 2
	Multi	Problem 4	Problem 3	Problem 2	Problem 1

Table 2. Allotment of marks, number of characters, size of figures, and quantity of problems

	Marks	Characters	Figures	Quantity
Problem 1	20	3550		3550
Problem 2	20	3314	1196	4510
Problem 3	20	4374		4374
Problem 4	20	4141	177	4318
Total	80	15379	1373	16752

test monitors, and the answer-process time of blind subjects was recorded by the monitors using stop watches. On the other hand, the non-disabled subjects answered the same 4 problems using print-format tests. They recorded their own time using stop watches.

3.2 Result

Score Distribution: For the blind group, the score distribution of the tablet PC audio test was almost the same as those of the braille-format test, the DAISY test and the multimodal test. The Box-and-whiskers plots [8] in Fig. 3 represent the score distribution of each test media for the blind group, the distribution of the total score of the four test media for the blind group, and the distribution of the total score of the print-format test for the non-disabled group. The vertical lines in the middle of the box plots indicate the median. The ‘+’ symbols in the boxes are the mean. Table 3 is the result of the analysis of the variance of the score using the repeated Latin-square design [8]. There were no significant main effects on score regarding all three factors: test media, subject group and problems. The three-dimensional interaction was not significant.

Though the median of the total score for the non-disabled group was about 6 marks out of 80 higher than that for the blind group, there was no significant difference compared to the Mann-Whitney test [8].

Distribution of the Answering Speed: For the blind group, the distribution of the answering speed for tablet PC audio test was also similar to those for the braille-format test, the DAISY test and the multimodal test. The Box-and-whiskers plots in Fig. 4 represent the distribution of the answering speed of each test media for the blind group, the distribution of the total answering speed of the

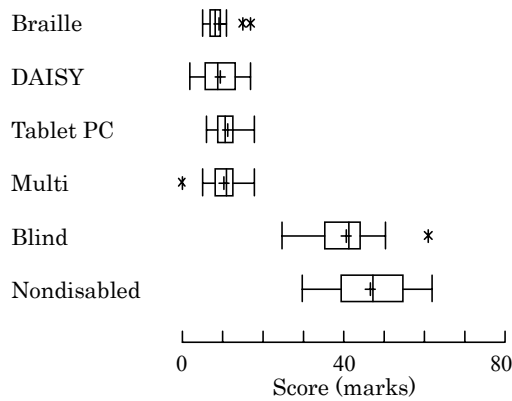


Fig. 3. Box-and-whisker plots for the score

Table 3. Result of the analysis of the variance of the score using the Latin-square design

Source	DF	Sum of Square	Mean Square	F Value	Pr > F
Group	3	59.165	19.722	1.05	0.383
Media	3	41.379	13.793	0.74	0.538
Problem	3	112.716	37.572	2.01	0.133
Group×Media×Problem	6	39.067	6.511	0.35	0.906
Error	32	599.415	18.732		
Corrected Total	47	851.741			

four test media for the blind group, and the distribution of the total answering speed of print-format test for the non-disabled group. Here, answering speed is defined as the number of characters of problems (‘quantity’ in Table 2) per minute to answer the problems for each person. Table 4 is the result of the analysis of the variance of the answering speed for the repeated Latin-square design. There were no significant main effects on answering speed regarding all three factors: test media, subject group and problems. The three-dimensional interaction among the three factors was not significant.

We found that the median of the total answering speed for the non-disabled group was about 2.4 times faster than that for blind subject group. There was a significant difference in the distribution of the total answering speed between the blind group and the non-disabled group according to the Mann-Whitney test ($p < 0.0001$).

3.3 Discussion

The result of the evaluation experiment shows that the tablet PC audio test and the DAISY test are almost equal to the braille-format test for the blind in terms of score and answering speed without time limits. We also found that the

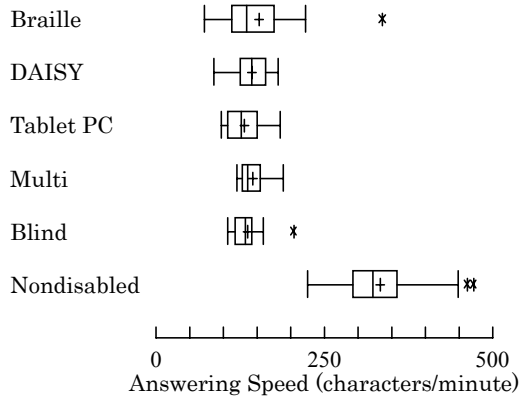


Fig. 4. Box-and-whisker plots for the answering speed

Table 4. Result of the analysis of the variance on the answering speed using the Latin-square design

Source	DF	Sum of Square	Mean Square	F Value	Pr > F
Group	3	3457.613	1152.538	0.57	0.640
Media	3	3013.639	1004.546	0.50	0.688
Problem	3	4256.247	1418.749	0.70	0.559
Group×Media×Problem	6	6435.548	1072.591	0.53	0.782
Error	32	64877.108	2027.410		
Corrected Total	47	82040.156			

answering speed of the print-format test for non-disabled test-takers is about 2.4 times faster than of the four test media for blind test-takers provided that both have the same achievement level. These findings are consistent with our previous results for the DAISY test in the Law School Aptitude Test [6] and the National Bar Examinations [5].

The tablet PC audio testing system can be introduced to the National Center Test if the system is improved. Though the blind subjects were not trained well, they could take the tablet PC audio test with similar scoring ability and answering speed as with the braille-format test.

With time limits, audio test may be more useful because audio test such as the tablet PC audio test and the DAISY test have a talk-speed-control function. The tablet PC audio test may be a more effective test media than the DAISY test when the document structure is complicated.

The tablet PC audio testing system enables the newly blind and the learning disabled with reading difficulties to take tests effectively. It is, however, advisable that blind test-takers without reading difficulties choose test media from among audio tests and a braille-format test because they have studied with braille textbooks and taken braille-format tests in quizzes and term examinations.

4 Conclusion

We developed this new audio testing system utilizing a tablet PC for the newly blind and the learning disabled who have difficulty reading long documents. In most advanced countries, audio tests are prepared for the newly blind and the learning disabled [2,9,10]. Ordinarily, they are administered with readers, audio cassettes, DAISY players or computers. Those methods, however, are inappropriate for the National Center Test for University Admissions because of complicated document structure. Therefore, we designed this new audio testing system that presents the document structure of a test.

As a result of the experiment for evaluation, we found that a tablet PC audio test was almost equal to a braille-format test for the blind in terms of score and answering speed.

To put the tablet PC audio testing system to practical use, we still have two challenges: improvement of the management software for the electronic pen; and development of an authoring system for the tablet PC audio tests so that anyone can easily produce material for audio tests.

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