New Testing Method for the Dyslexic and the Newly Blind with a Digital Audio Player and Document Structure Diagrams

Mamoru Fujiyoshi[1], Akio Fujiyoshi[2], and Toshiaki Aomatsu[3]

[1] National Center for University Entrance Examinations
2-19-23 Komaba, Meguro, Tokyo, 153-8501 Japan
fujiyosi@rd.dnc.ac.jp
[2] Department of Computer and Information Sciences, Ibaraki University
4-12-1 Nakanarusawa, Hitachi, Ibaraki, 316-8511 Japan
fujiyosi@mx.ibaraki.ac.jp
[3] National School for the Blind of Tsukuba University
1-2 Namiki, Tsukuba, Ibaraki, 305-8564 Japan
aomatsu@nsfb.tsukuba.ac.jp

Abstract. A new testing method with a digital audio player and document structure diagrams is developed for the dyslexic and the newly blind, who have difficulties with reading in braille or print. Since documents in the National Center Test for University Admissions are very long and have very complicated document structure, ordinary auditory testing media such as human reader or audio cassette are not appropriate. The new testing method can be administrated only with a digital audio player with 2-dimensional code reader and sheets of paper on which document structure diagrams and corresponding invisible 2-dimensional codes are printed.

Keywords: university admissions, testing method, the newly blind, the dyslexic, auditory testing media.

1 Introduction

It is almost impossible for the dyslexic and the newly blind, who have difficulties with reading in braille or print, to take the National Center Test for University Admissions. The National Center Test 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 550,000 students take the National Center Test. As for test-takers with disabilities, special arrangements regarding testing media such as large-print-format test and braille-format test have been administered [6]. However, auditory testing media have not been available yet. Moreover, it is considered to be difficult to take the National Center Test with ordinary types of auditory testing media because the documents are very long and the document structure very complicated. This study introduces a new testing method for the dyslexic and the newly blind with a new auditory testing medium.

K. Miesenberger et al. (Eds.): ICCHP 2010, Part I, LNCS 6179, pp. 116–123, 2010.
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In most advanced countries, auditory testing media such as human readers [4], audio cassettes [2,8,9] or computers with a screen reader [1] are available for test-takers with disabilities. The simplest method 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. Computers are also inappropriate for tests written in Japanese even with an advanced screen reader because of the ambiguity of reading Kanji in Japanese sentences. A screen reader often fails to convert Japanese sentences into correct Japanese speech.

For auditory testing media for the National Center Test, the utilization of DAISY (Digital Audio Accessible Information System) and Tablet PC has been studied [5]. DAISY [3] is a world standard audio system for people with visual disabilities, taking the place of audio cassettes. DAISY offers speech sound in CD quality, and test-takers can listen to the document 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. However, DAISY is not convenient enough for tests which have complicated document structure. Tablet PC has been identified as appropriate testing media [5]. However, there are difficulties in administration because prevention of machine trouble cannot be ensured.

A new testing method with a digital audio player and document structure diagrams is developed. In Fig. 1, an image of administration of the new testing method is shown. Tests can be administrated only with a digital audio player with 2-dimensional code reader and sheets of paper on which document structure diagrams and corresponding invisible 2-dimensional code have been printed. For the dyslexic, the document structure diagrams are printed with ordinary characters, while, for the newly blind, they are printed with braille characters.

2 New Testing Method

A new testing method that can be administrated only with a digital audio player and sheets of document structure diagrams is developed. The introduction of invisible 2-dimensional codes and a digital audio player with 2-dimensional code reader enable us to develop the method.

2.1 Document Structure Diagrams

Document structure diagrams are sheets of paper on which the document structure of each problem is illustrated. The document structure and corresponding invisible 2-dimensional codes are printed on white paper by an LED printer (OKI Data Corporation). For the newly blind, the braille document structure is also embossed overlappingly by a braille printer (ESA721; JTR Corporation).

Fig. 1. An image of administration of the new testing method

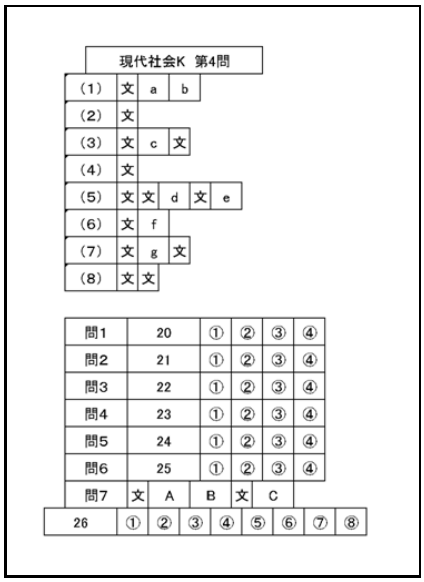

Fig. 2. An example of the document structure diagram printed on a paper

Fig. 2 is an example of a document structure diagram. Each document structure diagram of a problem can be arranged within a sheet of paper.

On the same paper of a document structure diagram, invisible 2-dimensional codes can be printed overlappingly. For an evaluation experiment, we employ 'GridOnput', an invisible 2-dimensional code system developed by Gridmark Solutions Co.,Ltd. Fig. 3 is an image of dot pattern of GridOnput. Dots are arranged at intervals of about 0.25mm. The size of a code is about 2mm square.

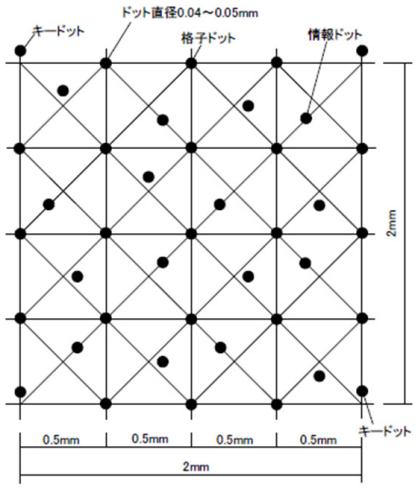

Fig. 3. An image of dot pattern of GridOnput

Fig. 4. Speaking Pen (Gridmark Solutions Co.,Ltd.)

2.2 Digital Audio Player with 2-Dimensional Code Reader

As a reading device for the new testing method, we employ 'Speaking Pen' developed by Gridmark Solutions Co.,Ltd. Fig. 4 is a picture of Speaking Pen. Speaking Pen has a 2-dimensional code reader at its top. When a 2-dimensional code is scanned with Speaking Pen, the corresponding digital sound will be reproduced. We can listen to the sound through a headphone or built-in speaker. The sound volume can be adjusted with its buttons mounted at the front side. The sound data is stored in an SD memory card. 1G byte is enough to store all sound data of 1-year amount of the National Center Test.

3 Evaluation Experiment

In order to evaluate the new testing method, an experiment was conducted by comparing new audio tests with three different speaking speeds and a normal-print-format or braille-format test. For experimental subjects, non-disabled high-school students and blind high-school students were recruited.

3.1 Method

The experimental design was a repeated 4x4 Graeco-Latin square method because we could not use the same problem in different testing media for the same person. The image of the experimental design for the Graeco-Latin square method is shown on Table 1. The non-disabled subjects are 20 students from ordinary high schools. The blind subjects are 16 students from a high school for the blind (some are graduates of the same school), who are familiar with both braille and audio learning materials. There were 4 subject groups, i.e., the subjects were evenly divided into 4 subgroups. There were 4 testing media: normal-print-format test (for the non-disabled subjects) or braille-format test (for the blind subjects), audio test of normal (1.0×) speaking speed, audio test of 1.5× speaking speed, and audio test of 2.0× speaking speed.

Four problems were prepared from tests in 'Contemporary Social Studies' previously used in the National Center Test. The allotment of number of characters and number of braille cells are shown on Table 2.

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

	Subect Groups			
	Group 1	Group 2	Group 3	Group 4
1st	Print/Braille Problem 1	Audio 1.0× Problem 3	Audio 1.5× Problem 4	Audio 2.0× Problem 2
2nd	Audio 1.0× Problem 2	Print/Braille Problem 4	Audio 2.0× Problem 3	Audio 1.5× Problem 1
3rd	Audio 1.5× Problem 3	Audio 2.0× Problem 1	Print/Braille Problem 2	Audio 1.0× Problem 4
4th	Audio 2.0× Problem 4	Audio 1.5× Problem 2	Audio 1.0× Problem 1	Print/Braille Problem 3

Table 2. Allotment of number of characters and number of braille cells

	Characters	Braille
Problem 1	2,255	4,866
Problem 2	2,000	4,543
Problem 3	1,796	3,996
Problem 4	2,410	5,247
Total	8,461	26,190

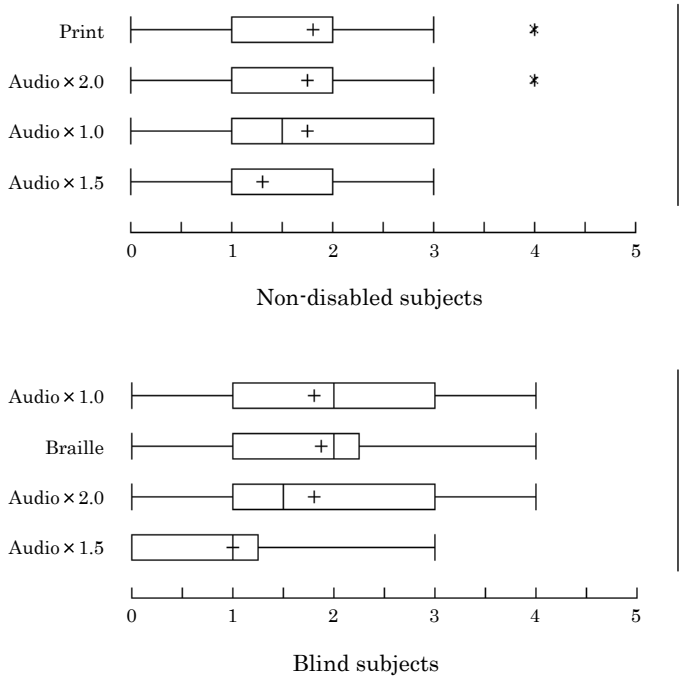

Fig. 5. Distributions of score (marks)

The test procedure is administered without time limits. The behavior of blind subjects was observed by test monitors, and the answer-process time of blind subjects was recorded by the monitors using stop watches.

3.2 Result

The distributions of score of the four testing media were almost same for both non-disabled subjects and blind subjects. In Fig. 5, the box-and-whiskers plots of distribution of score of the four testing media are shown. The vertical lines in the middle of the boxes indicate the median, and the '+' symbols in the boxes are the mean. The vertical lines on the right side of the plots are the results of Scheffe's grouping among the four testing media. For both non-disabled subjects and blind subjects, there were no significant differences among the four testing media.

As a result of Mann-Whitney test on the distributions of score, there were no significant differences between non-disabled subjects and blind subjects for each testing media.

There were some significant differences concerning answering speed in Scheffe's grouping test. In Fig. 6, the box-and-whiskers plots of distributions of answering speed of the four testing media are shown. The vertical lines on the right side of the plots are the results of Scheffe's grouping among the four testing media. For non-disabled subjects, the answering speed of normal-print-format test is significantly faster than audio tests of all speaking speed, and the answering speed

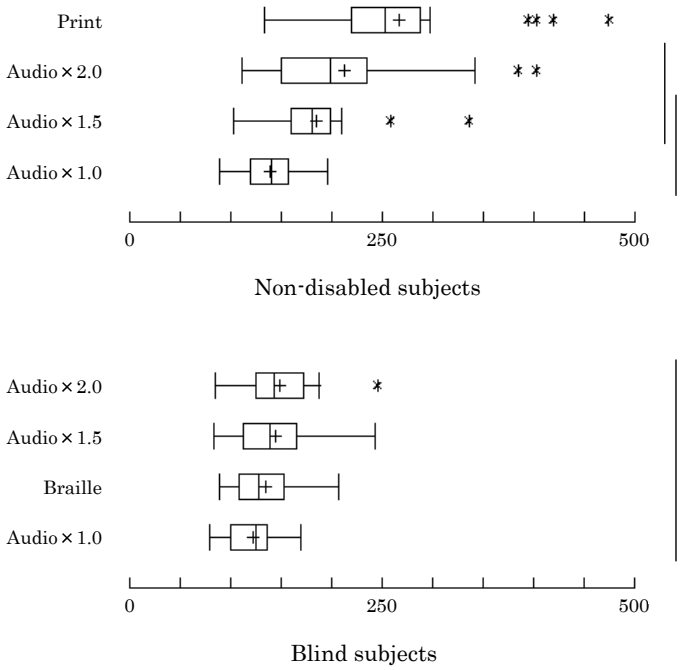

Fig. 6. Distributions of answering speed (characters/minuites)

of audio tests of 2.0× is significantly faster than audio test of normal speaking speed. For blind subjects, there were no significant differences among the four testing media.

As a result of Mann-Whitney test on the distributions of answering speed, the answering speeds of non-disabled subjects are significantly faster than blind subjects except audio test of normal speaking speed.

We found that the answering speed becomes 29% faster for non-disabled subjects and 10% faster for blind subjects if audio test of 1.5× speaking speed is used comparing to normal speaking speed. If audio test of 2.0× speaking speed is used, the answering speed becomes 41% faster for non-disabled subjects and 13% faster for blind subjects.

4 Conclusion

The new testing method enables the dyslexic and the newly blind to take the National Center Test for University Admissions since the administration of the new testing method is easy, and test-takers can handle problems with complicated document structure. We can administrate tests only with a digital audio player with 2-dimensional code reader and sheets of paper on which document structure diagrams and corresponding invisible 2-dimensional code have been printed. The use of testing materials is considerably easy. After brief training,

test-takers can start reading problems at any point of their preference. Studies about auditory explanation of figures [7] might be applied to this testing method. If we print 2-dimensional codes on figures, we can set problems with figures.

As a result of evaluation experiment, the new audio tests are almost equivalent to normal-print-format and braille-format tests in score. Since we can estimate fair extension ratios of testing time for students with disabilities [6], the new audio tests can be fairly administered.

Acknowledgement

This work was partially supported by Grant-in-Aid for Scientific Research (B) (20300282) of Japan Society for the Promotion of Science (JSPS).

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