

Evaluation of Two Types of New Auditory Testing Media with Paper Booklets and Digital Audio Players for the Active Reading of Test-Takers with Print Disabilities

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Abstract

Utilizing invisible 2-dimensional codes and digital audio players with 2-dimensional code scanner, two types of new auditory testing media were developed in our previous works. This paper presents the result of experimental evaluation of the new testing media. The result shows that, in addition to existing special arrangements such as large-print-format test and braille-format test, the introduction of the new auditory testing media enables all test-takers with print disabilities, including the newly blind, the severely partially sighted and the dyslexic, to take the National Center Test for University Admissions.

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 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 [1]. However, auditory testing media have not been available yet.

In most advanced countries, auditory testing media such as human readers or audio cassettes are available for test-takers with disabilities [6, 7]. However, 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.

For auditory testing media for the National Center Test, the utilization of DAISY (Digital Audio Accessible Information System) and Tablet PC has been studied [3]. DAISY 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 (Fujiyoshi and Fujiyoshi, 2006). However, there are difficulties in administration because prevention of machine trouble cannot be ensured.

Utilizing invisible 2-dimensional codes and digital audio players with 2-dimensional code scanner, two types of new auditory testing media were developed for the active reading of test-takers with print disabilities. In 2009, auditory tests of speech sounds on document structure diagrams were developed [4], and, in 2010, multimodal tests of speech sounds on ordinary texts were developed [5].

This paper presents the result of experimental evaluation of the two types of new auditory testing media. The result shows that, in addition to existing special arrangements such as large-print-format test and braille-format test, the introduction of the new testing media enables all test-takers with print disabilities, including the newly blind, the severely partially sighted and the dyslexic, to take the National Center Test for University Admissions.

2 Two Types of New Auditory Testing Media

Tests with the two types of new auditory testing media can be administrated only with digital audio players and paper booklets. The introduction of invisible 2-dimensional codes and a digital audio player with 2-dimensional code scanner enable us to develop the new testing media.

2.1 Auditory Tests of Speech Sounds on Document Structure Diagrams

Utilizing invisible 2-dimensional codes, auditory tests of speech sounds on document structure diagrams were developed [4].

We employ 'GridOnput', an invisible 2-dimensional code system developed by Gridmark Solutions Co.,Ltd. Dots of GridOnput are arranged at intervals of about 0.25mm. The size of a code is about 2mm square. Since the intervals are large enough for the size of dots themselves, dots are almost invisible. If we use invisible ink, which absorbs only infrared light, instead of black ink, dots become totally invisible.

Document structure diagrams represent the organization of test documents. Fig. 1 is an example of a document structure diagram in the Japanese language. Each document structure diagram of a problem can be arranged within a sheet of paper. The first line shows the subject name '国語 1' and the second line the problem number '第 2 問'. The upper part shows the document structure of the theme document of the problem. Each line '(1)'-'(3)' corresponds to a paragraph in the theme document. The symbol '-' represents a sentence in a paragraph, and the symbols 'a'-'e' represent underlined parts of the theme document. The lower part shows the document structure of the questions of the problem. Each line '問 1'-'問 2' corresponds to a question. The numbers '3'-'4' represent answer items, and the number symbols '1'-'4' represent multiple-choice answers for an answer item.

Document structure diagrams and corresponding invisible 2-dimensional codes are printed on white paper by an LED printer (OKI Data Corporation). Braille characters and Braille lines may also be embossed on the same paper overlappingly for newly blind test-takers.

When any part of a document structure diagram is touched by a digital audio player with 2-dimensional code scanner, the invisible code is scanned, and the corresponding speech sound is reproduced.

2.2 Multimodal Tests of Speech Sounds on Ordinary Texts

For dyslexic test-takers and partially sighted test-takers who can read some characters, multimodal tests of speech sounds on ordinary texts were designed [5].

In a test-booklet of multimodal tests of speech sounds on ordinary texts, normal characters or large-print characters are printed overlappingly with corresponding invisible 2-dimensional codes. Fig.2 is an example of a page of a test-booklet.

Similarly to the document structure diagrams, when any part of the texts is touched by a digital audio player with 2-dimensional code scanner, the invisible code is scanned, and the corresponding speech

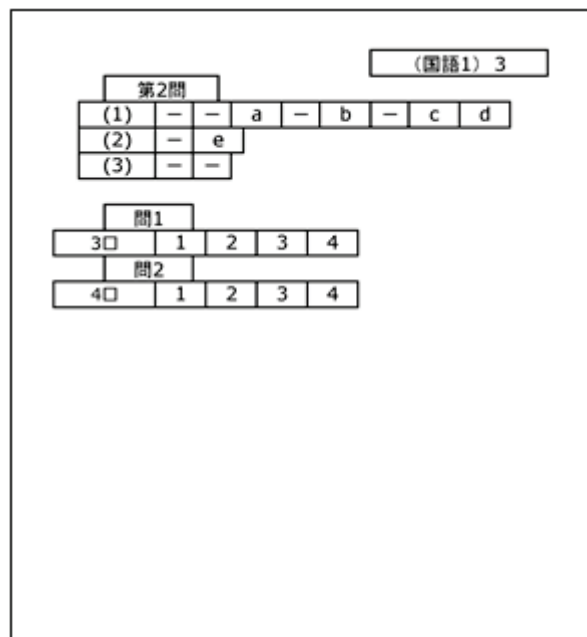


Figure 1: Document structure diagram

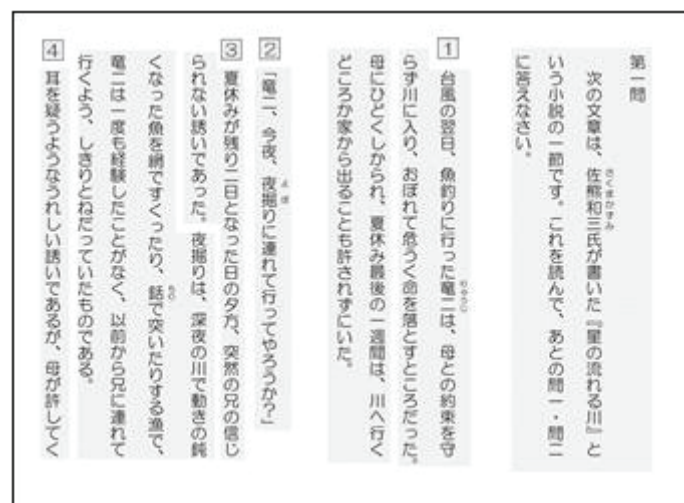


Figure 2: Ordinary Text with 2-Dimensional codes

sound is reproduced. Paragraph numbers are prepared so that test-takers can reproduce the speech sound of each paragraph.

2.3 Digital Audio Player with 2-Dimensional Code Scanner

As a reading device for the new auditory testing media, we employ 'Speaking Pen' developed by Gridmark Solutions Co.,Ltd. Speaking Pen has a 2-dimensional code scanner at its top. When a 2-dimensional code is scanned with Speaking Pen, the corresponding speech sound is reproduced. We can listen to the sound through a headphone or built-in speaker. The sound volume and speed 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

3.1 Method

3.1.1 Experimental design for partially sighted subjects and dyslexic subjects

The experimental design is a repeated 3x3 Graeco-Latin square method. The partially sighted subjects are 9 partially sighted high school students including some fresh graduates. The median of their corrected eyesight is 0.08. They are divided into three subject groups. The dyslexic subjects are 9 dyslexic adults. Only one of them is a high school student because it was difficult to invite dyslexic high school students. They are also divided into three subject groups. There are three testing media: large-print-format test, auditory test of speech sounds on document structure diagrams, and multimodal test of speech sounds on ordinary texts. The speech sounds are recorded as natural voice. Problems are from three study subjects: Japanese, English, and mathematics. The test procedure is administered without time limits.

3.1.2 Experimental design for braille user subjects and non-disabled subjects

The experimental design is the same except that testing media are different. The braille user subjects are 15 students from a school for the blind. The non-disabled subjects are 21 high school students. Both of them are divided into three subject groups. There are three testing media: braille-format test, auditory test of speech sounds on document structure diagram with recorded natural voice, and auditory test of speech sounds on document structure diagram with computer-synthesized voice. Problems are from the same three study subjects: Japanese, English, and mathematics. The test procedure is administered without time limits.

3.2 Result

3.2.1 Distributions of score

In Fig. 3 (1), Fig. 3 (2), and Fig. 3 (3), the box-and-whiskers plots of distributions of score of the testing media for each study subject are shown. The box-and-whiskers plots are sorted by the median of score. The vertical lines on the right-hand side of plots mean the non-existence of significant difference by Scheffe's method of pair wise multiple comparison.

As a result of Scheffe's method of pair wise multiple comparison, there are no significant differences among the distributions of score concerning the testing media for each subject group in each study subject except the distributions of score for non-disabled in English. We can see similar tendencies of the testing media among the three study subjects.

3.2.2 Distributions of answering speed

In Fig. 4 (1), Fig. 4 (2), and Fig. 4 (3), the box-and-whiskers plots of distributions of answering speed of the testing media for each study subject and the results of Scheffe's method of pair wise multiple comparison are shown. The box-and-whiskers plots are sorted by the median of answering speed.

As a result of Scheffe's method of pair wise multiple comparison, the answering speeds of auditory tests of speech sounds on document structure diagram are significantly slower than the other testing media for each three study subjects. We can see similar tendencies of the testing media among the three study subject.

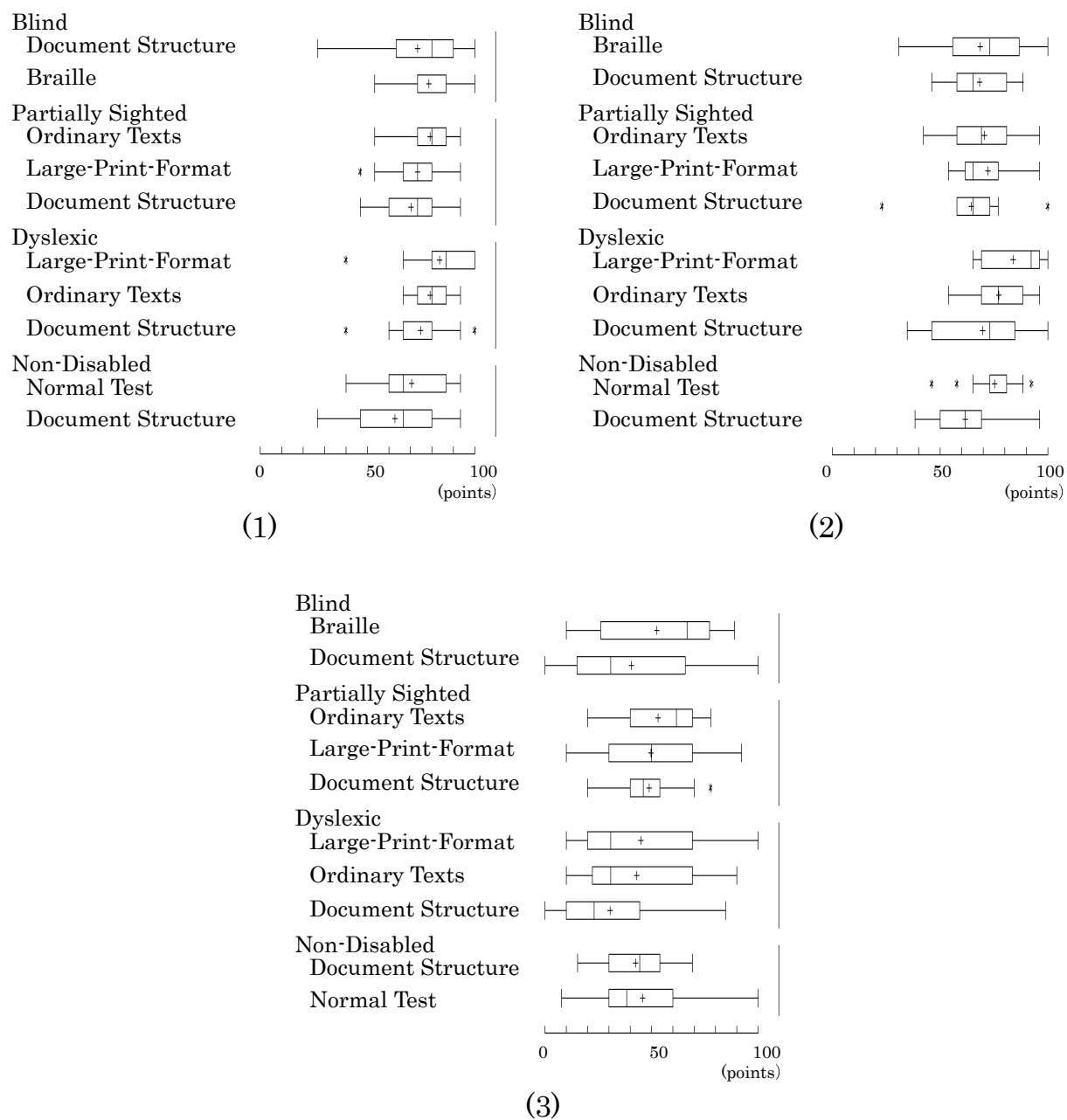


Figure 3: (1) Distribution of Score of Japanese, (2) Distribution of Score of English, and (3) Distribution of Score of Mathematics

4 Conclusion

Utilizing invisible 2-dimensional codes and digital audio players with 2-dimensional code scanner, two types of new auditory testing media are introduced for the active reading of test-takers with print disabilities: auditory tests of speech sounds on document structure diagrams [4] and multimodal tests of speech sounds on ordinary texts [5].

The result of the experimental evaluation shows that, in addition to existing special arrangements such as large-print-format test and braille-format test, the introduction of the new testing media enables

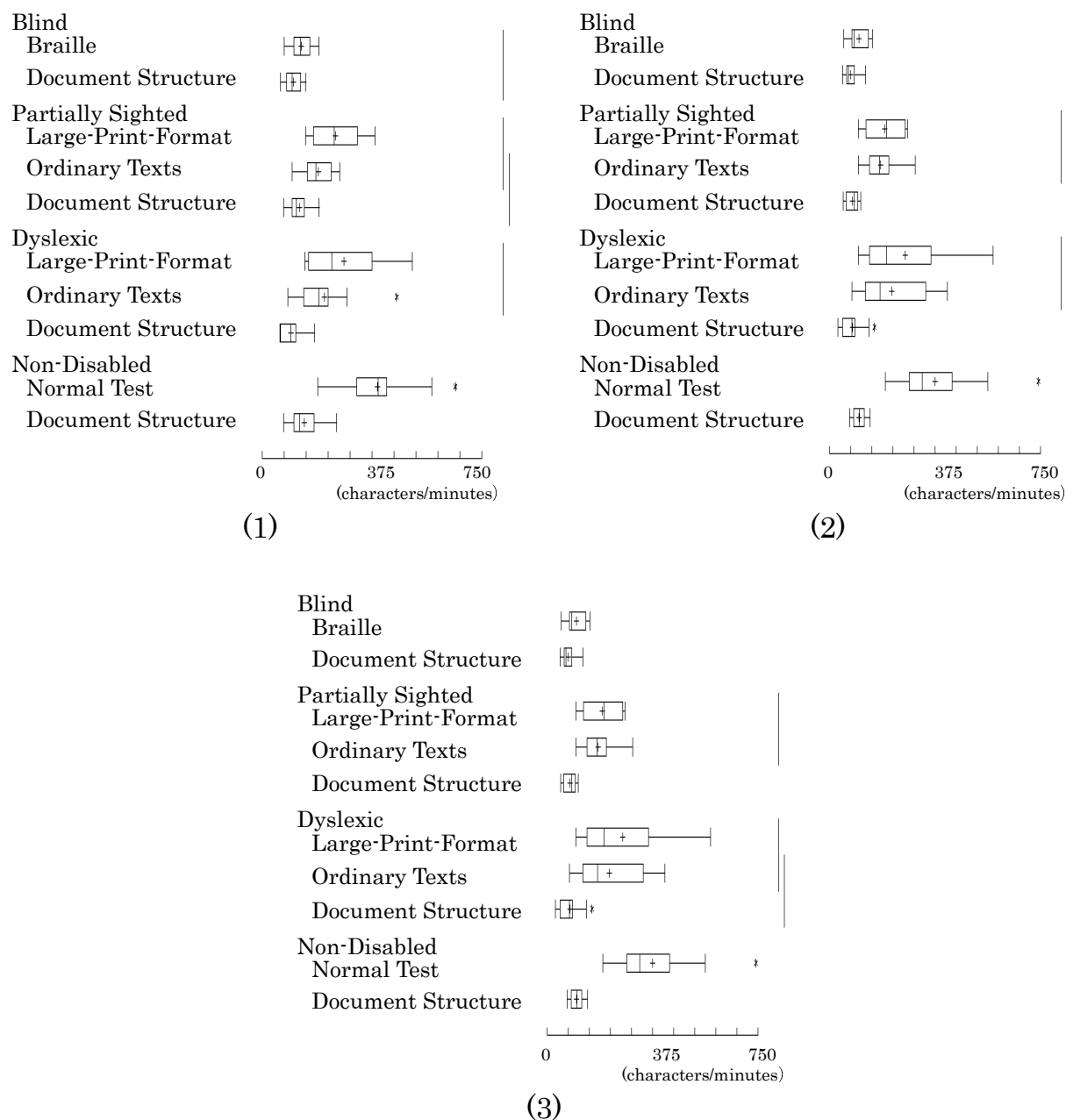


Figure 4: (1) Distribution of Answering Speed of Japanese, (2) Distribution of Answering Speed of English, and (3) Distribution of Answering Speed of Mathematics

all test-takers with print disabilities to take the National Center Test for University Admissions.

When auditory tests of speech sounds on document structure diagrams become practical, the newly blind and the severely partially sighted can take the National Center Test. Test-takers do not have to be able to read braille to take auditory tests of speech sounds on document structure diagrams because the shape of the document structure diagrams helps enough to guide the positions of 2-dimensional codes to scan. Actually, such newly blind students can take the test in the experimental evaluation.

With multimodal tests of speech sounds on ordinary texts, the partially sighted and the dyslexic can actively and efficiently read texts taking advantage of the modality characteristics of speech sounds and

ordinary texts.

In addition, the easiness of administration and security management of the new testing media is noteworthy. Tests can be administrated only with a digital audio player with 2-dimensional code scanner and sheets of paper on which document structure diagrams or ordinary texts and corresponding invisible 2-dimensional codes have been printed. When machine trouble happens, tests can be continued with a replacement of a digital audio player.

As a future work, the automatic production of computer-synthesized speech voices and test-booklet with invisible 2-dimensional codes should be developed. We want to make the two types of new testing media practical within 3 years.

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