Pilot study of Usability of Optical Mark Reader Answer Sheet with Assistive Devices

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Abstract. Optical Mark Reader Answer Sheet (OMR_AS) has been universally used in the education field. As marking OMR_AS needs physical skill of both hands, some students have difficulty to finish it within a limited time. To improve this situation, two assistive devices were developed, and an evaluation experiment was carried out by 6 non-disabled students and one student with physical disability in upper limbs. As indicated in the results, some of the non-disabled students could mark OMR_AS in a shorter time, but each student's workload increased. As the reference data, the disabled student could mark OMR_AS with these assistive devices, without increase of workload. There was significant difference in workload between the non-disabled students and the disabled student (P=0.01).

Keywords. Optical Mark Reader Answer Sheet, Assistive device, workload, NASA-TLX

Introduction

Optical Mark Reader has been used as the typical technique of capturing human-marked data from document forms such as surveys and examinations. In the educational field, Optical Mark Reader Answer Sheet (OMR_AS) has been used as one of the typical answer sheets of the examination. Pre-defined numbers and signs are printed on OMR_AS, and a student marks one or a few of them using blue/black pen or pencil as a correct answer. Marked positions on OMR_AS are optically read, and the score of the examination is calculated automatically by computer. As time for scoring has been shortened by using OMR_AS, it has been used as a general tool for written examinations so far.

It is, however, indicated that the task to mark numbers and signs correctly in a short time is not easy. In addition, students with physical disabilities may have difficulty to do these kinds of tasks. On the other hand, students with or without disability can mark a target (number or symbol) correctly by using assistive devices that have a hole which corresponds to each number and sign printed on OMR_AS. Although these kinds of assist devices with holes that correspond to the OMR_AS can be made easily, evaluation of physical and mental potential of these assistive devices is necessary to determine if they can be used without increase of workload. In other words, it is necessary to evaluate whether OMR_AS with the assistive devices is designed for all students or not.

The purpose of our research is to confirm whether the assistive devices can improve usability of OMR_AS for students, from the view point of universal design. In this paper, the result of the experiment on the usability of OMR_AS with assistive devices is described.

1. Method of experiment

1.1. OMR_AS used for the Experiment

In generally used OMR_AS, the number of choices (number and signs) for each problem in the examination is 10 at the maximum. As the OMR_AS used in our university has 10 choices, it was used as a sample one for the experiment. Figure1 (A) shows the OMR_AS. OMR_AS has 50 lines (problems), and numbers from 1 to 10 were printed on each line (problem) as possibilities of correct answers.

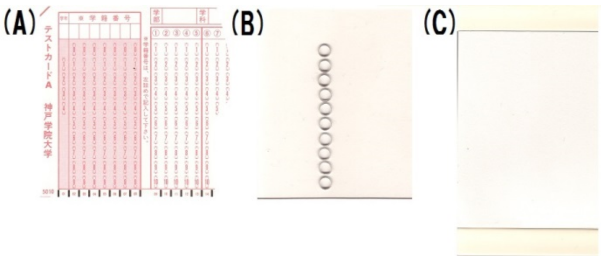

Figure1. OMR_AS (A) and Assistive Devices (B) & (C)

1.2. Assistive Devices

Two types of assistive devices were developed for the experiment. The first assistive device has 10 holes that are in the same position and dimensions as OMR_AS. In addition, these assistive devices must be transparent because a student uses this on OMR_AS. Figure 1(B) shows the 1st assistive device which was made from transparent acrylic board.

On the other hand, a student must put the 1st assistive device correctly on OMR_AS to mark without a gap. Although the 1st device has the same width as OMR_AS, some students have difficulty to put the 1st device on OMR_AS correctly in a short time. Therefore, the 2nd device was made for aligning the 1st device and OMR_AS exactly. Figure 1(C) shows the 2nd assistive device which has the same width with OMR_AS. Figure 2 is an example of the above.

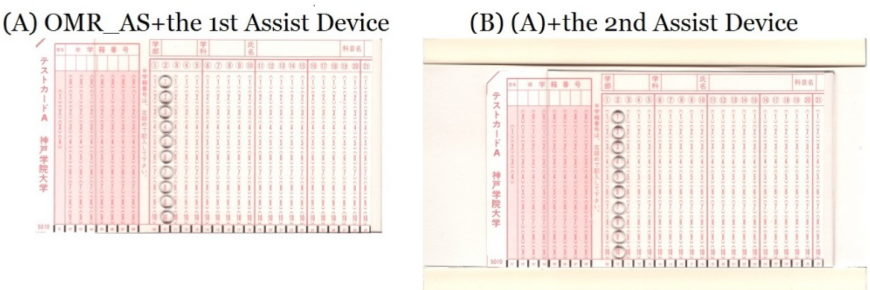

Figure2. Example to Use Assistive Devices with OMR_AS

1.3. Subjects

Subjects were 6 university students without a disability (2 males and 4 females, age=21-22). In addition, a student (female, age=22) with a physical disability participated as a subject to get reference data. Her disability is cerebral palsy and she used the electric wheelchair. She could not write with the right hand but writes slowly with her left hand. The research ethics committee in our university approved the experiment and the subjects' participation. All the subjects accepted to participate in the experiment.

1.4. Procedure of the Experiment

Figure 3 and 4 shows a picture of the experiment. In the computer, software to display a random number for examples of answers is installed. According to the key pressed by the subject, a number from 1 to 10 is displayed as the next answer on the screen. Then subject sees the number on the screen, and marks the same number on OMR_AS.

The experiment for each subject was composed of 2 phases, and the content of each phase was the same. In each phase, a subject was asked to mark as follows.

1) Mark OMR_AS without any assistive device
2) Mark OMR_AS with the 1st assistive device
3) Mark OMR_AS with the 1st assistive device and the 2nd device

In each marking, time from the display of a number to the marking the number was recorded automatically by computer (sampling time =1/60sec). After each marking from 1) to 3), the subject was asked to answer on the questionnaire. The evaluation of the questionnaire was made based on the principle of NASA-TLX (described in the next section).

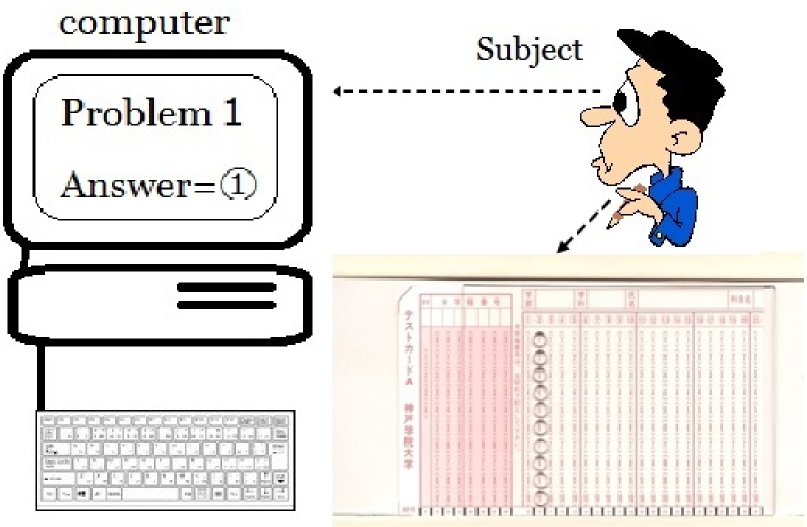

Figure3. Picture of the Experiment

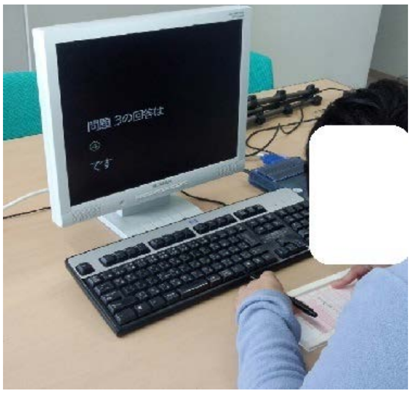

Figure 4. Picture of the Experiment

1.5. Measurement of Workload

As human workload in a human-machine system cannot be measured directly, it should be inferred from quantifiable parameters. In this experiment, NASA-TLX (National Aeronautics and Space Administration-Task Load Index) was used to measure workload in each marking task. NASA-TLX had two stages. In the 1st stage, a subject is asked to give points (0 - 100) of workload to 6 sub-scales of Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort and Frustration respectively. In the 2nd stage, the subject was also asked to give a weight number (1 to 6) to these 6 sub-scales in order of importance from the subject's view point. These answers were collected in a questionnaire form. Each weight number was multiplied by the level of its sub- scale, and AWWL (Adaptive Weighted WorkLoad) was calculated. The AWWL indicates the degree of the workload in each marking.

2. RESULT AND DISCUSSION

Figure 5 shows the result of the experiment. Figure 5(A) shows AWWLs in each task of marking. The vertical-axis is the score of each AWWL. In Figure 5(A), AWWL over 50 means heavy workload, and AWWL under 50 means light workload. On the other hand, Figure 5(B) shows the time used for marking the displayed number after the pressing of a key. The vertical-axis is the time required, and unit is 1/60 second.

In Figure 5(A), most of the AWWLs in "OMR_AS" were under 50. This indicates that the marking on OMR_AS without assistive devices was the task with the least workload. In contrast, AWWLs in tasks with assistive devices were larger than AWWLs without assistive devices. Especially in "OMR_AS + AD1", the subjects had a lot of workload. It is hypothesized that this is caused by necessity of correct alignment of OMR_AS and 1st assistive device. AWWLs for the disabled student were significantly lower than the non-disabled subjects ($p=0.01$). As the disabled student had the disability in her upper limb, writing in examinations is the task with a lot of workload. On the contrary, tasks of marking in the experiment were easier and had no time limit. It is considered that this situation made the tasks easier in spite of requiring much time as shown in Figure 5(B).

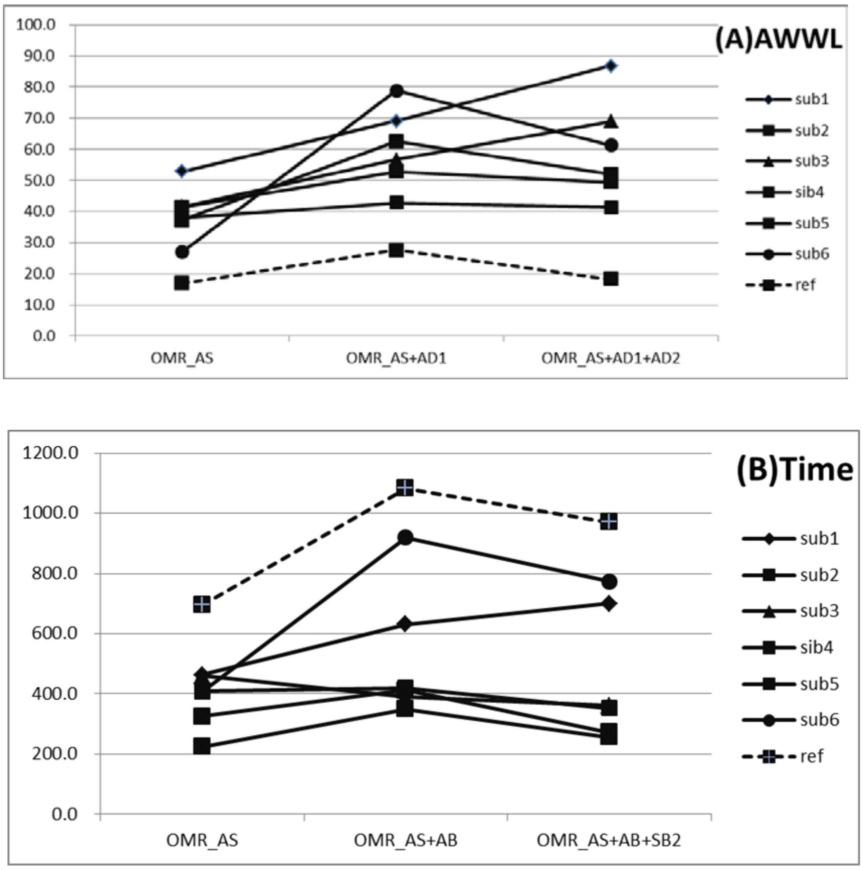

Figure 5. Result of the Experiment

In Figure 5(B), it is hypothesized that the subjects can be are divided into two groups. One group is students who needed more time when they mark OMR_AS with assistive devices, and the other group is students who need less time when they mark OMR_AS with assistive devices. At a glance these results of the two groups seem to contradict each other. It is, however, thought that this is caused by the difference of the skill of the subjects in marking tasks. As shown in Figure 5(A), AWWLs were increased by the use of assistive devices, in spite of the difference of skill. It is suggested from this result that marking skill may not decrease workload even if assistive devices are used. It is suggested from this result that high skill for marking doesn't lead to decrease of the workload. In other words, there is the possibility to increase workload when additional devices are used in marking, even if the devices were useful for decreasing marking time.

3. CONCLUSION

In this paper, assistive devices for OMR_AS were experimentally evaluated. The result indicates that the assistive devices have potential to reduce workload of the physically disabled student who has difficulty to write at normal speed.

In the future, it is considered that experiments with some improvements will be necessary. First, the number of subjects in this experiment was not enough to do statistical analysis. In addition to this, some conditions should be added in our study to get realistic data by giving the feeling of stress to the subjects. For example, time limit in experiment is considered necessary to reproduce the real situation in the marking. Although the number of problems in this experiment was 10, more problems will be necessary to reproduce the real situation.

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