Development of a Handwritten Note-Taking System for the Support of Hard-of-Hearing Students Participating in Lectures

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Abstract. Objective Note-taking can be used during lectures to make reasonable accommodation for hard-of-hearing students. Focusing on handwritten note-taking, we have developed a new system aimed at providing better support in terms of reasonable accommodation.
Main Content In Japanese higher education, there is an increasing awareness of the importance of reasonable accommodation for students with disabilities. Hard-of-hearing students are provided with note-taking support that helps ensure understanding by providing them with note-takers who write down the lecture content. Usually, two note-takers are assigned to sit together with a hard-of-hearing student. This three-person group typically sits in the first row of the classroom, away from the rest of the class. The eyes of the assisted student are often focused on their notes and tend to miss the subtle facial expressions of the teacher as well as any visual aids that may be projected on the classroom screen. These classroom conditions may decrease the sense of involvement or participation in the class for hard-of-hearing students. To address these issues, the author developed a handwritten note-taking system.
Results and Conclusion The results from experimental use of the device in a classroom environment suggests that it can help hard-of-hearing students regain a sense of involvement or participation in their class, because they are able to sit away from their note-takers and find seats of their own and can choose to sit closer to their classmates.

Keywords. Hard-of-Hearing, Reasonable Accommodation, Note-taking, Digital Pen, Assistive Technology.

Introduction

There are two types of note-taking: handwritten note-taking and computer-based note-taking[1][2]. For handwritten note-taking, a hard-of-hearing student (hereinafter, the assisted student) sits next to note-taking assistants (hereinafter, assistants) and accesses information by viewing the content that has been written in pen on notepaper. For reasonable accommodation in university lectures, there are normally two assistants for one assisted student, and support is generally provided by having the three people sit together in a row, with an assistant on either side of the assisted student[2].

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Computer-based note-taking is becoming more prevalent because more information can be provided per unit time than is possible with handwritten note-taking.

When 20 hard-of-hearing students were asked whether they preferred handwritten or computer-based note-taking, 7 replied "handwritten," 6 replied "computer-based," and 7 indicated no preference. From this result, we can see that there is persistent demand among students for reasonable accommodation based on handwriting. On the other hand, observing the situation from the standpoint of the teaching staff, there was a strong impression that, with handwritten note-taking, the assisted student is stretched to full capacity just looking at the notepaper because of the positional relationship between the assisted student and the assistants. The assisted student does not have sufficient spare capacity to direct their gaze toward the facial expressions of the lecturer or toward the writing on the blackboard and slides being projected (Figure 1).
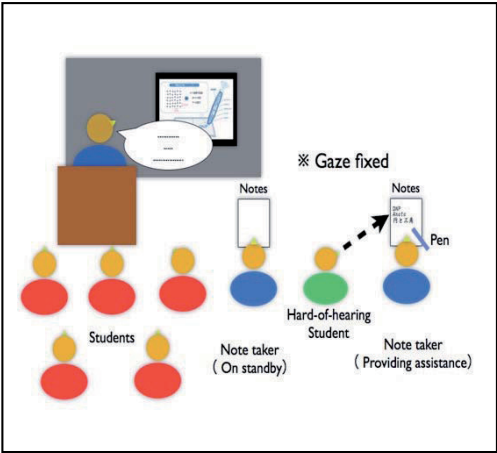

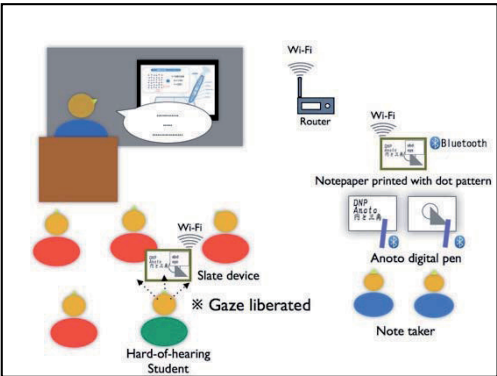**Fig. 1.** Schematic diagram of support based on handwritten note-taking.

Fig. 2. Schematic diagram of proposed system.

Generally, reasonable accommodation for hard-of-hearing students is envisioned as providing the words spoken by the lecturer as text information as accurately as possible. However, we believe that genuine reasonable accommodation is possible only by providing support in a way that enables hard-of-hearing students to take classes with a sense of participation and inclusiveness, in a way that includes other students and

teaching staff, as well as the environment that surrounds them. We also believe that a key point is to produce relationships that make it possible to perceive the facial expressions of those present and the atmosphere of the venue[3].

1   Proposed Handwritten Note-taking System

Figure 2 shows a schematic diagram of the proposed system. The assistants use digital pens (manufactured by Anoto Group AB) to record the content of the lecture on special notepaper printed with a dot pattern. The handwriting data from the digital pens are sent to a Windows OS 7 computer. The assistants can use the computer screen to check whether the data is being transmitted correctly.

The assisted student receives information support on the screen of a slate device such as an Apple iPad that is connected to the computer via wireless LAN (Wi-Fi). Splashtop Streamer is installed on the computer and Splashtop Remote Desktop (Splashtop Inc.) is installed on the iPad, so that the content displayed on the screens of the computer and the iPad mirror one another.

With note-taking situations in mind, we tested several digital pens that are currently commercially available in Japan, and found that the digital pen manufactured by Anoto (a Swedish company) allowed for a normal writing speed. Figure 3 shows the mechanism of the Anoto digital pen[4]. A digital pen with a camera embedded in its tip is used to write on paper printed with a fine dot pattern. Real-time handwriting data is sent to a computer via a wireless Bluetooth connection.
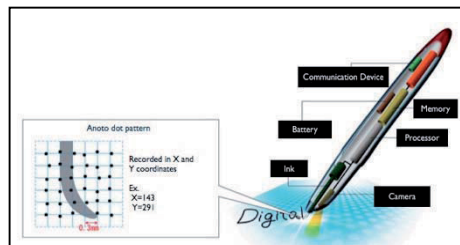

Fig. 3. Mechanism of the Anoto digital pen (Source: Dai Nippon Printing Co., Ltd.).

With this system, multiple digital pens can be used simultaneously (up to four at a time). For example, one way in which the system could conceivably be used when support is provided by two assistants would be to prepare two identical sets of notepaper printed with dot patterns and then have one of the assistants transcribe the content of the lecture while the other assistant fills in supplementary explanations or diagrams. Furthermore, by providing the assisted student with a digital pen and paper printed with a dot pattern, the assisted student can transmit messages to the assistants via the computer display. Because the assistant's computer and the assisted student's iPad are connected via a wireless LAN, the assisted student is able to sit next to their friends or anywhere they like, even in a large lecture theatre, and still participate in the lecture.

Fig. 4. Scene from a classroom trial run In the image above, the assisted student is located at the far right, where they can access information via a slate device that is readily at hand.The two people on the left in the foreground are the assistants.

2   Trial Run of the Development System

Figure 4 shows a scene from a classroom trial run. The assisted student decides for his or herself where to sit, so that they can see the lecturer and the screen easily. The two assistants sit on either side taking notes (Figure 4).

After each lecture, we sought feedback from the assisted student and the assistants, and made modifications where possible if there were aspects that needed improvement. Assistants swap roles when they reach the end of each notepaper page, so that the primary note-taker becomes the secondary note-taker and vice versa. Because of this, we devised a design for the notepaper so that assistants are clearly aware of whether they are the primary or secondary note-taker. Figure 5 shows the content displayed on the assisted student's slate device (iPad).

The handwritten information from the two assistants is unified in a single screen.

3   System Assessment

We conducted a four-month assessment of the note-taking system in an actual classroom environment with the cooperation of 4 hard-of-hearing students (A, B, C and D; "assisted students"), all of whom have sensorineural hearing loss and had received assistance from handwritten/computer-based note-taking systems in the past. We also enlisted the cooperation of 3 note-taking assistants (E, F and G; "assistants"), all of whom had at least one year of note-taking experience.

We asked the assisted students to assess the system with regard to three aspects: (1) utility ("Is this system useful?"), (2) reliability ("Can the system be trusted to work when needed?"), and (3) expectation ("Are you looking forward to the system being put into common use?"). We also asked the assistants to assess the system with regard to three aspects: (1) operability ("Is the system easy to use?"), (2) reliability ("Did the system work when needed?"), and (3) expectation ("Are you looking forward to the system being put into common use?"). We rated each item on a five-point scale from 1 (lowest) to 5 (highest).
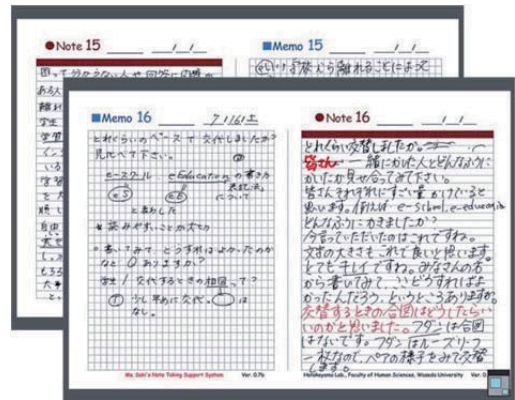
Fig. 5. Example of content displayed on the assisted student's slate device (iPad).

The results of these surveys are presented in Figure 6 using a rader chart. In the free-response question section, we asked the assisted students and assistants what they considered were the benefis of the system and what points they would like to see improved.
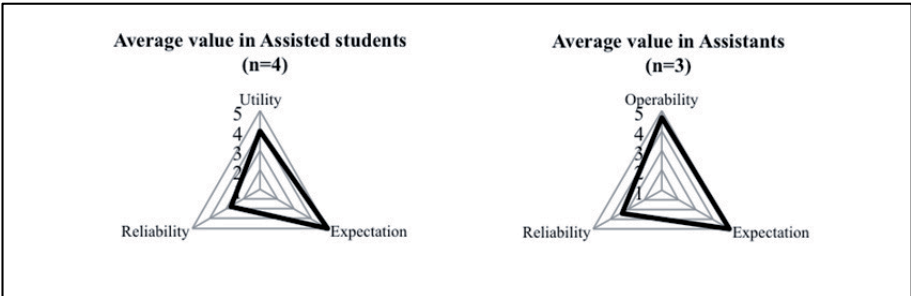

Fig. 6. Survey results.

3.1   Benefits

a) Comments from assisted students
  - It's nice to be able to sit with my friends instead of next to an assistant.
  - It's much easier to pick up information now that the assistant's hand is no longer in the way.
  - I like the way that the assistant can use various colors to emphasize certain points; it makes things much easier to understand.
  - It's easier on my neck, now that I don't have to keep looking back and forth between the notes and the lecturer's screen, or to keep peering down at the notes.
b) Comments from assistants
  - I can immediately see what the other assistant has written, so it's much easier to fill in the gaps.
  - Because the assistant and assisted student setup the devices together, there is more two-way interaction, it is no longer a case of us simply helping them.

- Physically speaking, it makes note-taking quite a bit easier, in that we no longer have to contort ourselves into strange postures so that the assisted student can see what we write.

3.2 Points for Improvement

a) Comments from assisted students
   - I felt somewhat uneasy, because if something goes wrong and you are seated away from the assistant, there is no way to let him or her know.
   - I wonder if you can't make the system lighter; I feel bad when I see the assistants lugging around so much equipment.
   - It would be nice if it were possible to input the lecture notes beforehand so that we could see exactly where the lecturer is within his or her presentation at any particular time.
   - It would be great if you could combine the handwritten text with the keyboard input sometime in the future.

b) Comments from assistants
   - The grip on the digital pen is too thick. It would be nice if it were thinner, so our hands don't get tired after writing over a period of time.
   - The system is heavy with a weight of about 3 kg including the carrying case. On rainy days, it's hard to make it to the classroom with that in one hand and an umbrella in the other.

4   Discussion

The results of these assessments show that both assisted students and assistants generally think well of the note-taking system. Furthermore, everyone seems to be looking forward to the day when the system is put into common use. With regards to its strong points, we note that the system does indeed contribute toward our efforts to promote participation and inclusiveness on both sides, with the assisted student taking a more active role in the learning process and the assistant freed of some of the burden of providing assistance.

Some trouble was encountered early in the trial when the assistants found themselves unable to enter handwritten notes. Although this problem was later resolved by correcting a software bug, it did act to diminish the general sense of system reliability. The lesson drawn from this is that, even with one case of system trouble ,it can produce considerable anxiety on the part of the assisted student, who is generally seated away from the assistant and thereby unable to communicate with him or her, thus raising serious doubts about overall reliability.

5   Conclusions

In our ongoing efforts to develop a note-taking system to help hard-of-hearing students participate in lectures, we have proposed such a system and tested its applicability within actual class situations. We found that our system is indeed effective within such classroom environments and that both assisted students and note-taking assistants are eagerly looking forward to the time when the system is put into common use. We have

identified several issues for improvement and will seek to resolve them as we work towards that goal.

Acknowledgements

References

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