2019

THE JOURNAL ON TECHNOLOGY AND PERSONS WITH DISABILITIES

# Communication App for Children with Hearing and Developmental Difficulties

Kuniomi Shibata, Akira Hattori, Sayaka Matsumoto.
Tsuda University, Komazawa University, Otsuma Women's University.
kuniomi_shibata@yahoo.co.jp, hattori@komazawa-u.ac.jp,
matsumotosayaka@gmail.com

## Abstract

The purpose of this article is to examine a mobile application to support children and students with hearing difficulties or/and developmental disorders in interacting, understanding, and preparing for transitions between activities in their daily, school, and social lives. We think that a communication support technique using a combination of characters, pictograms, and photographs is effective for these types of persons with disabilities. This application recognizes words spoken using a speech recognition system and arranges the pictures corresponding to the speech-recognized words in a sequence. By showing a sequence of pictures corresponding to a conversation, our application enables children with hearing difficulties and developmental disorder to understand their situations.

The results of two demonstration experiments show that the application promotes mutual understanding between students with hearing difficulties and those who have developmental disorders by utilizing pictograms and photographs in combination with speech. Although it is just basic line and still has problems as platform, the study suggests that it is clearly useful and that present issues could be improved. We suggest that the application could support visualization and feedback for planning as a new way of communication for children and students with hearing difficulties and developmental disorders.

## Keywords

Hearing Difficulties, Developmental Disorders, Mobile App, Voice Recognition, Picture-based Communication

## Introduction

When people with disabilities attempt verbal and nonverbal communication, they have many disadvantages. Moreover, they have difficulty when they are aware of their thinking. Listening comprehension is difficult for persons with hearing difficulties and, furthermore, people with developmental disorders are not flexible in grasping the contexts of conversation. Various obstacles hinder their everyday communication and learning. As a result, there is a negative influence on the construction of self-affirmation and human relations.

So far, we have investigated problem creation as a subject for discussion related to people with disabilities. Mobile terminals, such as a smartphones and tablets, have become widespread in recent years. We think that a communication support technique using a combination of characters, pictograms, and photographs is effective for this type of disability. It has already been established that visualization and feedback of a schedule or action are effective.

We propose an application that supports visualization and feedback for planning and communication with a mobile terminal. Audio input is suitable for such an application. Prior to this research, we developed a prototype of this application. We designed the interface to support communication and an action schedule understanding of persons with disabilities.

Hence, we used the prototype of the communication support application for children with hearing difficulties and with developmental disorders in everyday situations. The collaborators in this experiment were students with knowledge about people with disabilities and communication. We clarified the following through an experiment.

1. Do people experience results in communication or the prospect of understanding by using an application? What are the requirements for feeling a result?
2. What are the requirements for upgrade of the application?

## Related Work

Over the past few years, many studies on the use of mobile-platform devices, such as smartphones and tablets, have been conducted in the field of Argumentative and Alternative Communication (ACC). However, there seem to be few regarding tablet applications that involve sequences of pictures for people with hearing difficulties.

Sennott and Bowker examined a mobile AAC system running on iPhone and iPod touch called Proloquo2Go, considering best practices in AAC for people with autism spectrum disorders (ASD) regarding symbols, visual support, voice output, and inclusion (138). They observed that the application appears to be appropriate for such people. Pat gave an overview of AAC mobile technologies (35). These studies have focused on the use of the mobile aids for persons with developmental disorders and ASD.

Flores et al. compared an iPad that had a communication application installed with a non-electronic symbol-based AAC system (78). They reported that the communication behaviors of elementary school students with disabilities either increased with the use of the iPad or remained at the same level as when using the AAC system. Dolic et al. examined the potential of using smartphones and tablets for symbol-based AAC and proposed a model of an adaptive symbol-based AAC application for them (252). The model allows adjustment of the display of symbols and user interface not only to the specifications of the mobile platform device, but also to the user's capabilities and preferences. Patil et al. provided a mobile application to support persons with hearing difficulties by using speech-to-image translation (450). They have not implemented or evaluated their application, although their proposal is similar to our study. It is important that the common problems in communication for persons with hearing difficulties and developmental disorders are discussed.

Sorgini et al. revealed that a lack of acceptance emerged from the discussion of capabilities and limitations of assistive technologies (395). In this article, we would like to develop a custom-designed, symbol(image)-based, and voice-recognizing application that will support disabled children's capabilities for fluent communication and enhanced learning.

## Development of the Application

### *Features*

It is common practice to use symbols and pictures as a means of supporting both children with hearing difficulties in communicating and those with developmental disorders in seeing situations clearly. However, it is difficult to always carry non-electronic communication boards and printed picture cards. Our application: PICTONGUE is characterized by usability in everyday life because it runs on a mobile device. It is also characterized by showing topics of a conversation or activities within a schedule using a sequence of pictures. Fig. 1 depicts a conceptual image of PICTONGUE. By showing a sequence of pictures corresponding to a conversation, our application enables children with hearing difficulties and developmental disorder to understand their situations. It has a communication mode and a schedule mode. The former helps children with hearing difficulties to communicate with their communication partners, while the latter assists children with developmental disorders in seeing situations clearly. In the communication mode, it recognizes words spoken by communication partners and searches for pictures corresponding to the recognized words. Users can create a brief sentence by arranging pictures in a sequence and can have a conversation while pointing to the sequence. They can save and use the sequence as a record of the conversation. In the schedule mode, they can create a schedule for a date by arranging the pictures in the same manner.

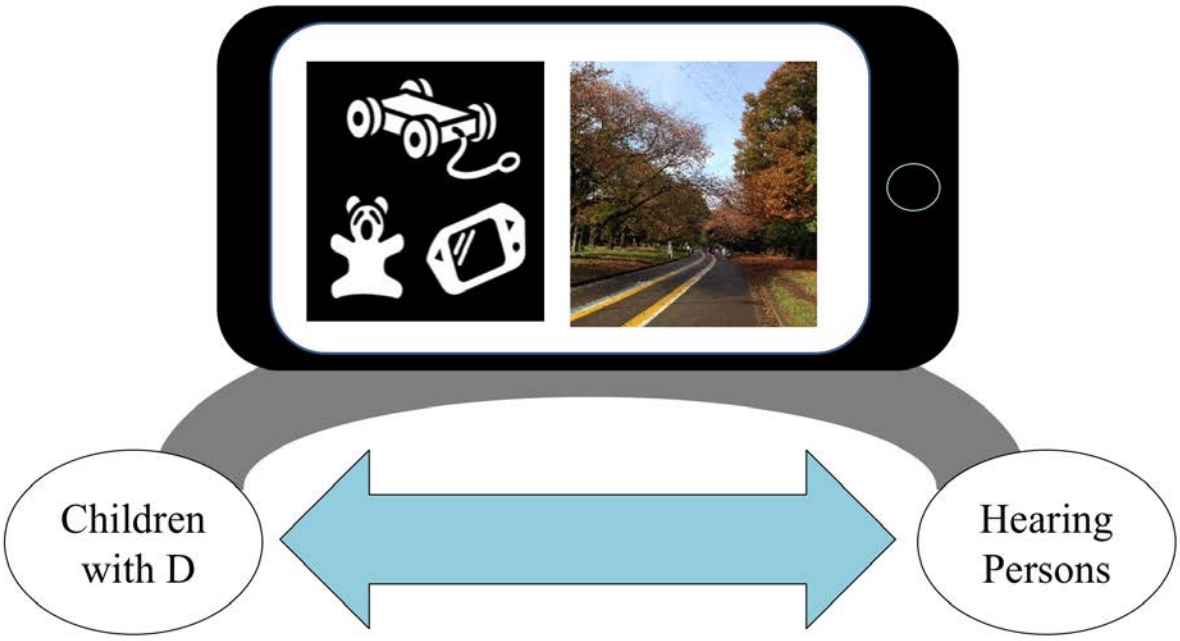


Fig.1. Concept of the App.

*Functions*

PICTONGUE consists of four functions: registering a new picture, creating a sequence, browsing the sequence, and assessing the user's achievement in performing the activities of a schedule. The application uses a camera, a speech recognition system, and a location service on a mobile device. The database is organized into four tables. Two of them are for managing pictures and the other two are for managing sequences. One of the two tables for pictures stores the names of their image files, while the other stores the tags assigned to them. PICTONGUE searches for pictures with the same tag as the speech-recognized word. The tags are stored in the database. The tables for sequences store the titles, times, locations, and orders of the pictures contained in each sequence. In this study, we developed a prototype of PICTONGUE running on an Android tablet device.

*Management of Picture*

We incorporated more over 1000 (including all pictograms of International Organization for Standardization, ISO) pictures into PICTONGUE in advance. To enable children with hearing difficulties and developmental disorders to use it in their daily lives, the pictures contain everyday concepts; for example, friends, food, greetings, hours, school, and home. We assigned tags to these pictures. However, because it is impractical to incorporate all types of pictures in advance, PICTONGUE provides a function for users to register a new picture by tagging it with a keyword. The same tag can be assigned to multiple pictures, and multiple tags can be assigned to a picture. To locate the place where the activities of a schedule are performed on a map, users can also add a map image acquired from a web mapping service by using the function to register a new picture. Fig. 2 shows the function to register a new picture. The registered photograph is shown at the center of the device display.

*Making a Sequence*

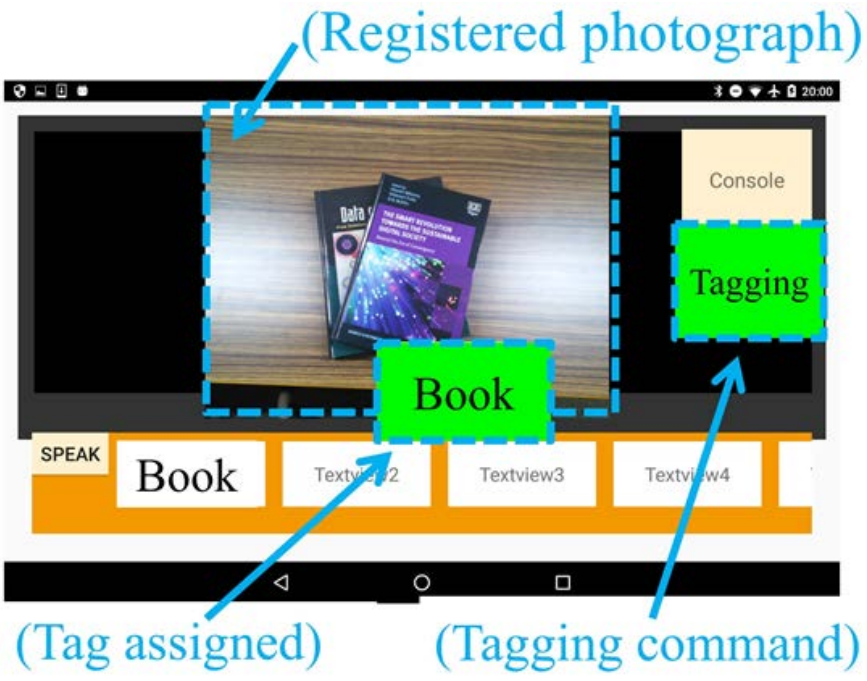


Fig. 2. Picture Registration

PICTONGUE recognizes words spoken by communication partners and arranges the pictures corresponding to the recognized words in a sequence. The sequence showing the topics of a conversation helps children with hearing difficulties to understand the conversation, and the sequence showing a schedule assists children with developmental disorders in seeing the activities of the schedule clearly. When using schedule mode, users specify the date when a schedule is conducted before arranging the pictures. Fig. 3 shows the user interface used to make a sequence. The area used to show speech-recognized words consists of text-views where the words are set. When there is no picture corresponding to a speech-recognized word, PICTONGUE converts the characters of the word to an image to show it in the area. Users can edit the word set in the text-view to search for a picture as there may be speech recognition errors. They can also change the picture to another one with the same tag. Fig. 3 shows that they can search the text-view where the word “study” has been set. By speaking the time, such as “9 o'clock,” users can set the time of a sequence, and the image of an analog clock indicating the time is shown. The console menu is used to save a sequence.

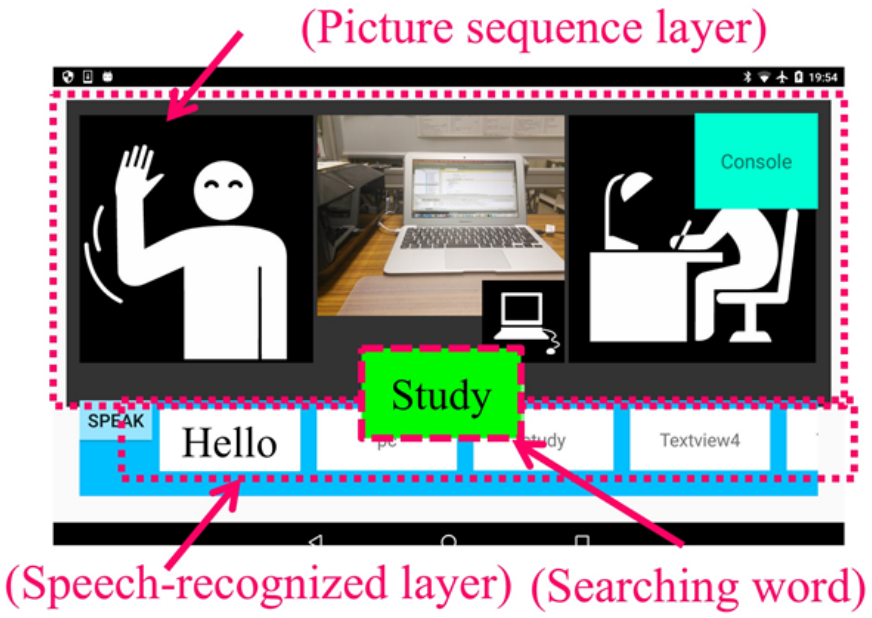


Fig. 3. User Interface to Create a Sequence.

*Browsing a Sequence*

Users can browse a sequence through a calendar interface. By tapping a date that they want to browse, a list of sequences with that date is shown. By selecting one sequence from the list, the sequence is shown. That is, the pictures contained in the sequence are displayed in order, together with the speech-recognized words. Fig. 4 shows an example of a sequence by converting the characters of a speech-recognized word to an image.


Fig. 4. Example of a Sequence.

*Assessing the User's Achievement*

The function to assess users' achievements was designed to give children with developmental disorders a sense of accomplishment. In PICTONGE, users can input whether they performed the activities of a schedule by tapping a dedicated button when they browse the sequence. This enables them to distinguish the completed schedule from others on the calendar.

## Demonstration Experiment

### *Outline of Test 1*

We conducted two tests to determine problems and potential improvements. The first test was performed with a small group (Test 1). The study was conducted between July 22nd and September 7th, 2015 in Sendai City, Miyagi Prefecture. We collaborated with a non-profit organization to sample 6 children with developmental disorders (6-15 years old). They were given tablets with the application preinstalled and asked to use it in their daily lives as much as possible. 5 of the children had difficulty communicating due to their developmental disorders, and 1 suffered from hearing loss. We let them practice with it before the test began.

### *Results of Test 1*

The test was conducted in the following manner: we allowed the participants and their parents to write open-ended questions and interviewed them further when appropriate. We also gave them a questionnaire that we would collect after the test was concluded. The children were asked to rate the application's usability in questions one through five and were asked to respond freely to questions one, two, and four. They were also interviewed in person. Comments regarding the application's effectiveness and utility:

- This application PICTONGUE helped us with conversations on a daily basis.
- I often said "let's enjoy this application".
- This application was useful when I told her/him what to do next.
- The combination of the speech-recognized word and the corresponding picture was interesting.

*Outline of Test 2*

The second test was performed based on the results of Test 1. The study was conducted between April 18th and May 9th, 2018 and took place at Tsuda University in places where students usually are (Fig. 5). We chose 15 participants for the study. They used new version of PICTONGUE (fixed bugs etc.) and verified what was working and what needed improvement.

They were given tablets and asked to use PICTONGUE on a daily basis. Subsequently, they assessed its usability and functionality. They were shown how to use the application and given a manual. They were also given a questionnaire, and we collected their answers via the internet after the test concluded. We asked the monitor students to evaluate the functions that were not present in the version of PICTONGUE used in Test 1. We also received comments concerning pictograms that they thought should have been included, as well as bug reports.


Fig. 5. Scene of Test 2.

In Test 2, the participants were provided with a semi-structured questionnaire to obtain a more detailed evaluation.

We wanted to determine whether PICTONGUE was useful in the following situations:

A: When spending time at home with family or alone.

B: When spending time as part of school setting, such as a classroom.

C: When participating in social activities, such as hobbies or volunteer work.

The participants were asked the above questions in relation to the following:

1. Could they communicate smoothly?
2. Could they successfully achieve mutual understanding?

The aforementioned variables and results will be combined and explained. For example, "A1" will be used to explain the efficacy of communicating at home or in a family setting, and "C2" will be used to show if a participant has experienced better understanding in their social life.

**Results of Test 2**

The average score that participants gave our application regarding usability was 52.3 out of 100. Although this is not a high score, it is reasonable given that PICTONGUE is still in development. Second, they rated PICTONGUE based on its functionality. The average score of was 58.3 and close to 60% out of 100 (see Fig. 6). There were comments such as:

“The application is useful for people who have difficulty hearing because it shows the entire sentence if I say the word and postpositional particle properly.”

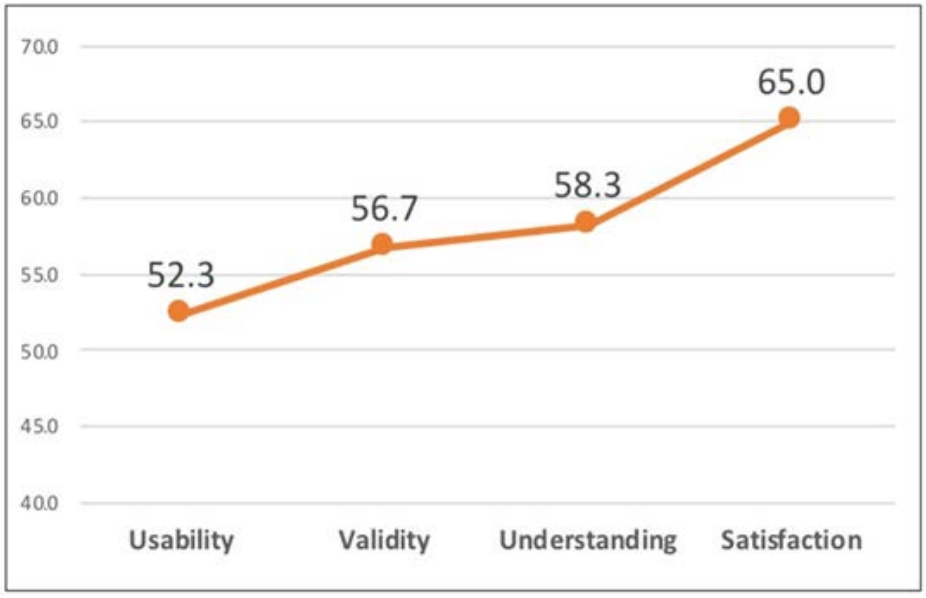


Fig. 6. Results of Test 2.

We found that the App. is helpful for people who have disabilities, based on a detailed analysis of the comments. The participants evaluated how this application operated to promote mutual understanding in communication. The average score was 56.7 out of 100. Hence, it can be inferred that PICTONGUE was useful in helping the participants understand one another.

**A: Daily Life.**

The following score is based on the different variables explained above. We asked the participants to give PICTONGUE a rating from one to five with regard to A1 communication in their daily lives and whether the application is helpful for expressing themselves (see Fig. 7 for results, five variates merge to three). The most frequent value was 4, and the average value was 3.27. One participant commented that “it was nice to communicate through PICTONGUE because photographs can express information that we do not normally perceive when we talk. I enjoyed the atmosphere and talking with the help of the application”. It can be inferred that this application is not bad for daily communication, although its score is not high. On the other hand, when we asked A2 “is this application helpful in promoting mutual understanding?” the most

frequent score was 3 and the average was 3.33. Participants also commented that this application was useful for people with color blindness (not only for those who were hard of hearing or had other hearing disorders) because it showed pictograms of basic words such as “today” and “tasty.” It can be inferred that the application is useful in multiple situations.

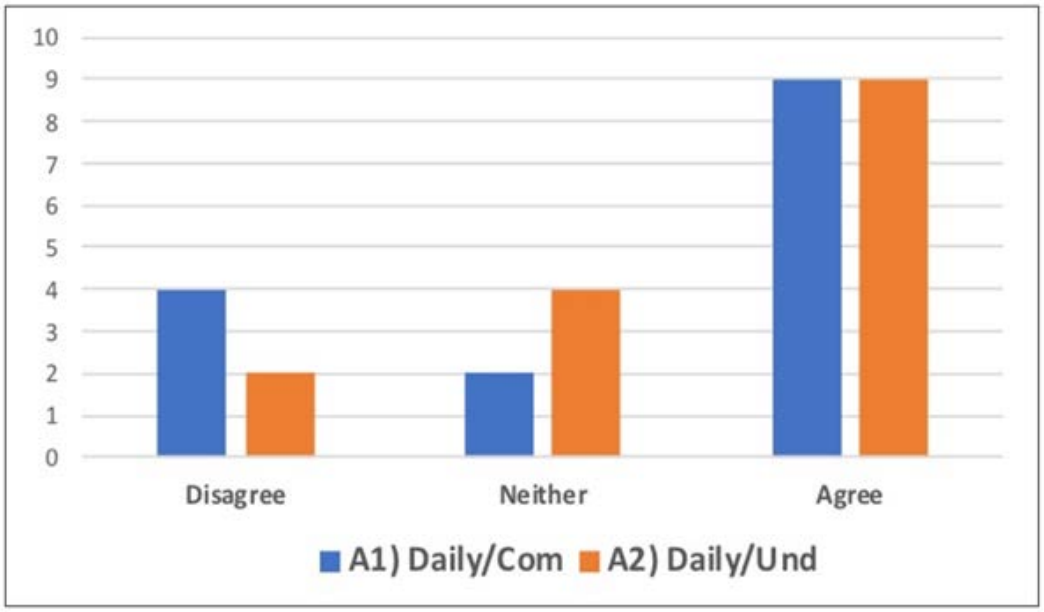


Fig. 7. Daily Life and Communication Understanding.

**B: School Life.**

The most frequent value was 4 and the average score was 3.47 for our application in school life (Fig. 8). There were comments such as “you can understand how the class was by taking photographs of the notes that you take in class.” This comment indicates how PICTONGUE was useful for taking photographs of the notes and of what teachers wrote on the blackboard. With regard to B2, “promoting mutual understanding,” the most frequent value was 4 and the average score was 3.53. This proves that PICTONGUE was effective in promoting mutual understanding using pictures. However, we received one comment stating “I was somewhat disappointed with the limited number of pictograms that expressed words outside of

daily life, such as ‘lecture’ or emotions and people’s names.” This indicates that abstract content, such as in the subject of a lecture, is not expressed in the pictograms.

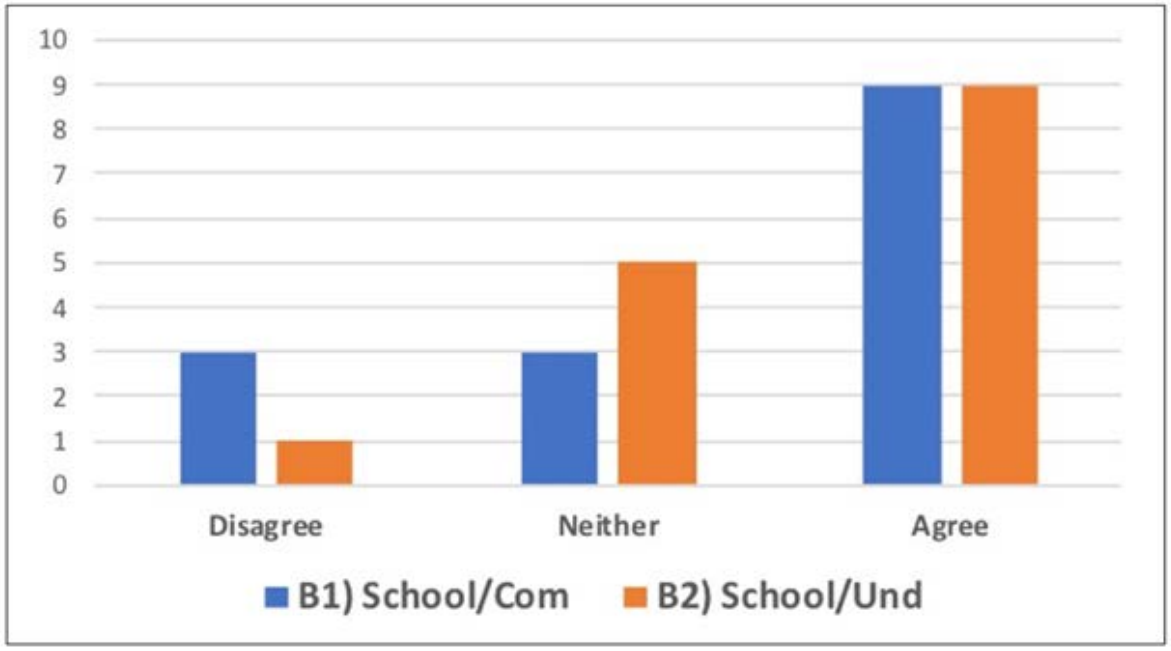


Fig. 8. School Lives and Communication Understanding.

**C: Social Life.**

Participants unexpectedly rated C, social life, very well. For C1, “communication and self-expression,” the most frequent value was 4 and the average score was 3.73 (Fig. 9). We received positive comments about the application’s picture-saving function, which displays the name via voice commands. For C2, “promotion of mutual understanding,” the most frequent value was 4, but the average score was 3.67, slightly below the previous score. There were some comments that indicated the application’s usefulness in showing pictures as pictograms. They noted that if they had known multiple people named Yamada, they could save pictures of each Yamada. This helped them to determine which person named Yamada they were talking to. On the other hand, we also received comments such as “I thought that I could talk to people entirely by showing pictures, but it took time to get used to doing it because you had to add tags to the

pictures." This comment suggests that the participants felt a burden because they had to save many pictures before PICTONGUE became useful. Because of the lack of pre-installed pictograms, they had to save pictograms after each use.

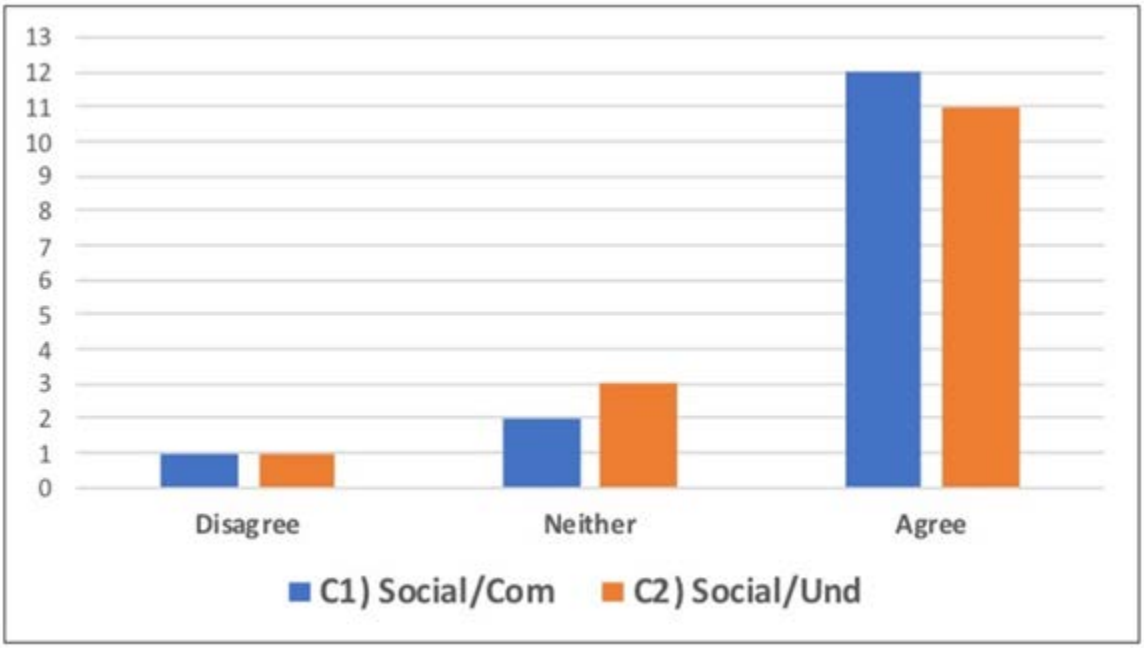


Fig. 9. Social Lives and Communication Understanding.

## Conclusion

Both Test 1 and Test 2 show that PICTONGUE can be useful in daily life and for keeping track of one's schedule at school. In short, the application is helpful for people who have difficulty with direct communication owing to hearing loss and developmental disorders. PICTONGUE has several merits; for example, it helps people with these types of disabilities to concentrate. Below, we discuss necessary improvements to be made at a later date.

### *Discussion and Contribution of Results*

The functionality of PICTONGUE improved greatly from Test 1 to Test 2. This is particularly evident in the results of 4; overall, "improvements in the functionality of pictures in the application" were highly praised. There were positive comments regarding the application's

function. Some appreciated that PICTONGUE not only shows a picture of location, but also maps for the surrounding areas (for example, when you say “Tsuda University,” it shows a photograph of Tsuda University and a map of the general area). This function is very helpful for children and students with hearing difficulties because they tend to mishear place names.

PICTONGUE was well received by people with disabilities because the application displays images directly related to whatever is being discussed. One person commented that “you can show others the core idea of what you want to say by just showing the screen. This application is useful for everyone, not just children who suffer from hearing difficulties.” The average score of the participants’ expectations for PICTONGUE in the future was 65 out of 100. We expect more people to be able to use the application after improvements.

*Further Challenges*

There were negative comments regarding PICTONGUE’s usability in both Tests 1 and 2. As detailed above, it was not easy to add tags to photographs, and it was difficult to delete photographs that were not used. There were several complaints regarding the application’s speech recognition system, and the monitors wished that they could change incorrect pictures with greater ease. It might be better to try the current version alongside another version of the application with a separate reset button that the user can select.

It was also clear that PICTONGUE had few pictograms and photographs that could clearly express what users wanted to say, according to participants’ comments. We still need to make improvements to make registering photos and pictograms easier and also to increase the number of pre-installed pictograms and photographs on the application. There is a lack of photographs and pictograms that pertain to social life and school/office situations. The reviewers suggested it would be important to gather date from the perspective of both conversation

participants. We think PICTONGUE will be used for sharing the basic situation of their real conversation. Although, this point is still most important further challenges of us.

This application was developed to promote mutual understanding between people who face hearing difficulties and have developmental disorders by utilizing pictograms and photographs in combination with speech. Although PICTONGUE is just “basic line” and still has problems as platform for advanced learning, the study suggests that it is clearly useful and that present issues could be improved. We suggest that the application could be used as a new way of communication to support people who suffer from disabilities such as hearing difficulties and developmental disorders. Further study of digital AAC applications like PICTONGUE would be of value to the field of learning technologies for children and students with disabilities, especially those with hearing difficulties and developmental disorders.

**Acknowledgement**

We would like to thank all members of the Beat-switch (Non-Profit Organization), Chikae Kaihara, Ichiko Yamasaki, and all participants of the experiments we conducted. We would like to thank Editage (www.editage.jp) for English language editing. This work was supported by JSPS KAKENHI Grant Number JP15K03959, JP15KK0132, JP26330388.

**Works Cited**

Dolic J. et al. “Evaluation of Mainstream Tablet Devices for Symbol Based AAC Communication.” Agent and Multi-Agent Systems. Technologies and Applications: 6th KES International Conference, Dubrovnik, Croatia, 2012, pp. 251-260. doi: 10.1007/978-3-642-30947-2_29.

Flores M. et al. “A Comparison of Communication Using the Apple iPad and a Picture-based System.” Augmentative and Alternative Communication, Vol. 28, No. 2, 2012, pp. 74-84. doi: 10.3109/07434618.2011.644579.

Pat M. “Values, Practice, Science, and AAC.” Research and Practice for Persons with Severe Disabilities, Vol. 42, No. 1, 2017, pp. 33-41. doi: 10.1177/1540796916661163.

Patil Y. et al. “Android Application For Deaf People.” Imperial Journal of Interdisciplinary Research (IJIR) Vol. 2, Issue. 3, 2016, pp. 450-452. doi: 10.1016/j.procs.2016.08.044.

Sennott S. and Bowkertitle A. “Autism, AAC, and Proloquo2Go.” Perspectives on Augmentative and Alternative Communication, Vol.18, 2009, pp. 137-145. doi: 10.1044/aac18.4.137.

Sorgini F. et al. “Haptic-assistive technologies for audition and vision sensory disabilities.” Disability and Rehabilitation: Assistive Technology, Vol. 134, Vol. 4, 2018, pp. 394-421. doi: 10.1080/17483107.2017.1385100.