A Communication Requirements Research of Children with Severe Cerebral Palsy

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Abstract
This study looks into the communication needs of a young cerebral palsy (CP) patient with severe physical disability and speech impairment. This individual case study involves interviews with the caretaker, observation of the patient's living habits, and development of customized assistive technology. A vocabulary database of the patient is made for the development of an augmentative and alternative communication (AAC) system. This research looks into previous research and literature for a general understanding of the potential difficulties of a CP patient, and then gathers individual data through interviews and observations. A foot-controlled computer cursor device is then developed to enhance the abilities of the patient's foot, enabling him to use a computer. Finally, data of the communication needs of the patient is collected and a set of scenario emoticon are designed.

Keywords: picture exchange communication system (PECS), scenario emoticon, cerebral palsy, foot-controlled assistive technology

Introduction

Communication disorders can be divided into two categories: organic disorders and functional disorders. Cerebral Palsy (CP) is a type of organic disorder cause by neurological damage. Since surgery cannot restore their damaged brain cells, CP patients may have problems with the muscles in their mouths, tongues, and throats. They may also experience communication difficulty due to slower mental development or intellectual disability (Liu, 1994; Lin, 2004).

Although 100% of CP patients have speech disorder, only 75% have intellectual disability. The remaining 25% have cognitive abilities like the average population but experience difficulties in communicating with others. Moreover, it may be hard to evaluate the intellectual level of these patients due to their communication disorders (Lin & Lin, 1994; Lin, 2004). Augmentative and alternative communication (AAC) system designed for these patients should use innovative ideas and designs in its communication functions in order to help patients of various intellectual and physical abilities (Lin & Yang, 2004; Potter, Korte & Nielsen, 2014).

The subject in this study with multiple severe physical disabilities, speech impairment, and illiteracy is a 15-years-old boy named Eli (an alias). The muscles in his entire body experience great hypertonicity, only his left foot have less tonicity and allow some controlled movements. Although Eli can follow directions to move his left foot, and vocally imitate someone talking about the flags colours and the relevant countries, his echolalia (imitation speech) is very unclear and requires a longer time to process. Due to his multiple disorders and a lack of stimulation and learning experience, it is hard to determine his cognitive abilities. Eli is able to use monosyllabic echolalia to answer questions from others. Based on the compliments or scolding around him, his mood also varies. Based on the these observations of Eli's understanding of speech around him and logical thinking ability when following instructions, Eli's intellectual is most likely a mild disorder or even the same as the average person. However, Eli is unable to easily and swiftly communicate with other or express his own needs.

This study aims to improve Eli's communication methods using the "Picture Exchange Communication System (PECS) developed by Bondy and Frost (1994). PECS is a great assistive communication and learning system for many patients with communication disorders because it is relatively cheap and very easy to use. It is suitable for different communication disorder patients trying to learn (Teng, 2005; Bondy & Frost, 1994). A child with intellectual disability or development delay can use PECS to improve speech capability. It may even greatly improve the speech capability of children with intellectual disability, who previous could only do monosyllabic echolalia. PECS also provides continuity and generalization, helping users to apply the communication skills they learned in the system to other situations (Teng, 2007).

Every CP patient has different physical disabilities, physiological condition, and other characteristic. In order to develop customized assistive device for these patients with

multiple disorders, each individual case must be researched and investigated to induce an appropriate design. Thus, in order to resolve Eli's problem of "having cognitive abilities but unable to communicate," this study must first understand "how to help Eli communicate with limited physical abilities" and "how to help Eli, an illiterate, use pictures to communicate with others." In order to resolve these three questions, this study conducts long-term discussions with Eli's mother and observes Eli to understand his physical communication habits and personal interests. The teaching and operational modes of PECS are used to design a "Scenario Emoticon AAC System." This study plans to use the concept of "emoticon" from messaging software programs in the system design. The emoticon are drawn based on Eli's reinforcement objects. A combination of an assistive technology and a tablet computer is used to help Eli communicate.

Literature Review

Eli learns slower than children of the same age do, mainly due to his multiple severe physical disabilities and communication difficulty. An easy-to-use AAC system can improve the flow and efficiency of the patient's learning process, as well as lighten the burden of the caretaker (Cheng & Tang, 2013; Lin, 2004). In order to help Eli, who is unable to express his own needs and opinion in learning, a communication channel with others must be developed. Suitable assistive device can improve communication so Eli can smoothly interact with others.

In the first section of literature review, we look into some potential physical disabilities and consequent communication difficulty of CP patients. The second section considers some assistive methods for Eli's physical disabilities. Finally, a solution using PECS is discussed, including some reasons for using PECS and the application of PECS.

1. Communication Difficulty of CP Patients

Among CP children, 75% of the patients have moderate intellectual disabilities, including lower understanding of contexts in communication, speech perception, and oral memory. Repeated practice and teaching is needed for them to learn (Li, 1991). CP children develop reading and writing abilities slower than children of the same age even before formal education (Peeters, Verhoevan, de Moor & van Balkom, 2009). According to Lin (2004), about one-fourth of CP patients have average intellectual abilities or even higher. For patients with speech impairment, but otherwise normal physical and intellectual abilities, they can communicate with others through writing or sign language. These patients generally experience a certain level of abnormal tonicity in their muscles, resulting in imprecise control of their mouths, tongues, and throats, or possibly epilepsy, partial or complete paralysis, hearing or vision impairment, emotional disturbance, and other growth disorders. Their speech impairments are often due to brain or neurological damage, causing patients to lose control of the muscles of their vocal organs. However, some patients' articulation and comprehension impairment is actually caused by their caretakers' education method (Pirila et al., 2007).

For autistic children with communication disorders, digital PECS are more effective than traditional paper PECS in encouraging oral expression. The cards are unable to

attract autistic children's attention because they are inconsistent with the unique learning habits of autism. On the other hand, digital PECS allows easy addition of new cards and convenience in searching for a card, thus decreasing the burden on the family and teachers of autistic children. PECS is applicable to many other communication disorders as well, not just autism (Cheng & Tang, 2013). Digitalized PECS and simplified card-making process are important elements for the patients and their caretakers. This study will also take these key points into account in design.

2. Assistive Method with PECS

For autistic children with communication disorders, digital PECS are more effective than traditional paper PECS in encouraging oral expression. Digital PECS allows easy addition of new cards and convenience in searching for a card, thus decreasing the burden on the family and teachers of autistic children (Cheng & Tang, 2013). Digitalized PECS and simplified card-making process are important elements for the patients and their caretakers. This study will also take these key points into account in design.

The PECS system developed by Bondy and Frost in 1994 included six (6) steps to promote spontaneous communication and help children initiate communication with others. The steps are as follows: How to Communicate, Distance and Persistence, Picture Discrimination, Sentence Structure, Answering Questions, Commenting. An example of the implementation of PECS research on the usage of PECS system with students of moderate intellectual disability (Teng, 2007). After conducting these six steps, the students in the research learned to use pictures or sentences to communicate with others, to accomplish spontaneous communications, to change their habits of taking others' possessions, to express their needs using cards or speech, and improve their speech capability. Most importantly, the skills they learned through PECS are maintained and generalized, able to be applied to other situations or communication with non-teaching persons.

In regards to selecting an AAC system, those with audio feedback can improve the sense of hearing of CP patients without speech capability, thereby enhancing their oral memory. Early intervention of AAC systems can help CP children with speech perception, oral memory, and prevent low memory retention, which may have ultimately led to reading disorder (Peeters, Verhoeven, de Moor & van Balkom, 2009).

After literature review and study on CP children and AAC system, this study decides investigate the communication requirements of Eli, and uses the six steps in PECS to improve communication of CP patients with "limited verbal understanding" in future.

Study Methods

This study fist carried out an interview with Eli's mother and observed Eli's physical and verbal abilities to understand and analyse the difficulties that Eli currently faces. With the help of industrial design experts and investigations of literature on CP and the AAC system, we firstly proposed a left-foot-controlled device to assist Eli in building a communication channel, and then delivered a communication framework for Eli's daily usage. This was followed by 10 months of assistance to Eli in using assistive technology

to operate a computer. At the same time, the establishment and design of scenario emoticon and vocabulary database were implemented.

1. Conceptual Framework

We conducted practical observation of Eli, and interviewed and discussed with his caregiver, which is his mother. Try to identify potential issues that CP patients may face when communicating with others and how these issues may be resolved. At the end, this study assisted Eli in operating a tablet computer through foot-controlled assistive technology, helping Eli to establish a communication channel with others.
As shown in Figure 1, the development of scenario emoticon AAC system involves the designing of a software operation procedure based on teaching and operational modes of PECS. In this study, PECS was digitalized and the paper picture cards were replaced by scenario emoticon. As for the vocabulary database of scenario emoticon, it was planned based on experiences of Eli's mother as a caretaker and Eli's daily demands observed in the study. After potential scenarios and essential vocabulary were listed, Eli's mother was involved in the discussion of finalizing the emoticon vocabulary database that is appropriate for Eli to use at present for learning and living. The finalized emoticon vocabulary database was applied in the design.

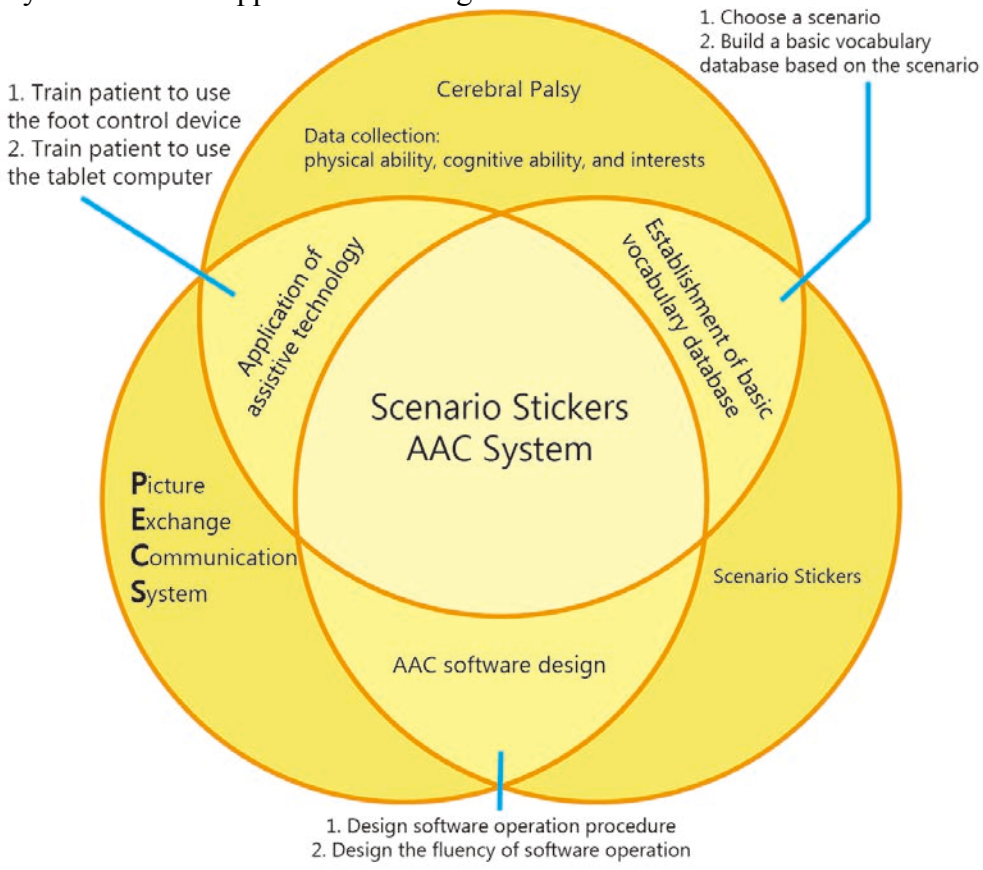


Figure 1. Diagram of study architecture

2. Study Process

In order to understand Eli's needs in tears of physical and cognitive abilities, interviews with Eli's mother and long-term observation were carried out, and methods to improve Eli's communication skills were investigated. The research involved four stages of designing, testing, and evaluation of assistive technology. Data collection and the respective executing design tasks of each stage are shown in Figure 2.

1. Interviews with Eli's mother and teachers from Eli's special needs school were carried out. The information obtained from the interviews was compared with that of observation and records of Eli's daily life. Eli's current difficulties and existing abilities were understood. The usage of assistive technology was proposed to improve Eli's physical limitations, so that Eli may operate a computer with assistive technology after training.
2. Through investigation of literature and cases of AAC software applications, the preliminary design of an AAC software was made. A basic vocabulary database that may potentially be used in the AAC software was made based on interviews and observation of Eli's life. After the design approach was determined, the practical production stage commenced.
3. In order to help Eli easily use the future scenario AAC software, a computer application that had similar operation methods to that of the study's software was chosen as training software. At the same time, discussions with Eli's mother were carried out to identify vocabulary that Eli uses daily and at school. A vocabulary database was consolidated and used as a reference for the designing of emoticon and software applicability. Thus, the first version of scenario emoticon AAC system was produced and tested.
4. A practical test of application and usage was carried out to evaluate software efficiency. People's understanding of Eli's expressions before and after implementing the system was compared, and the comparative results were used to improve software operation fluency or adjustments to emoticon contents.

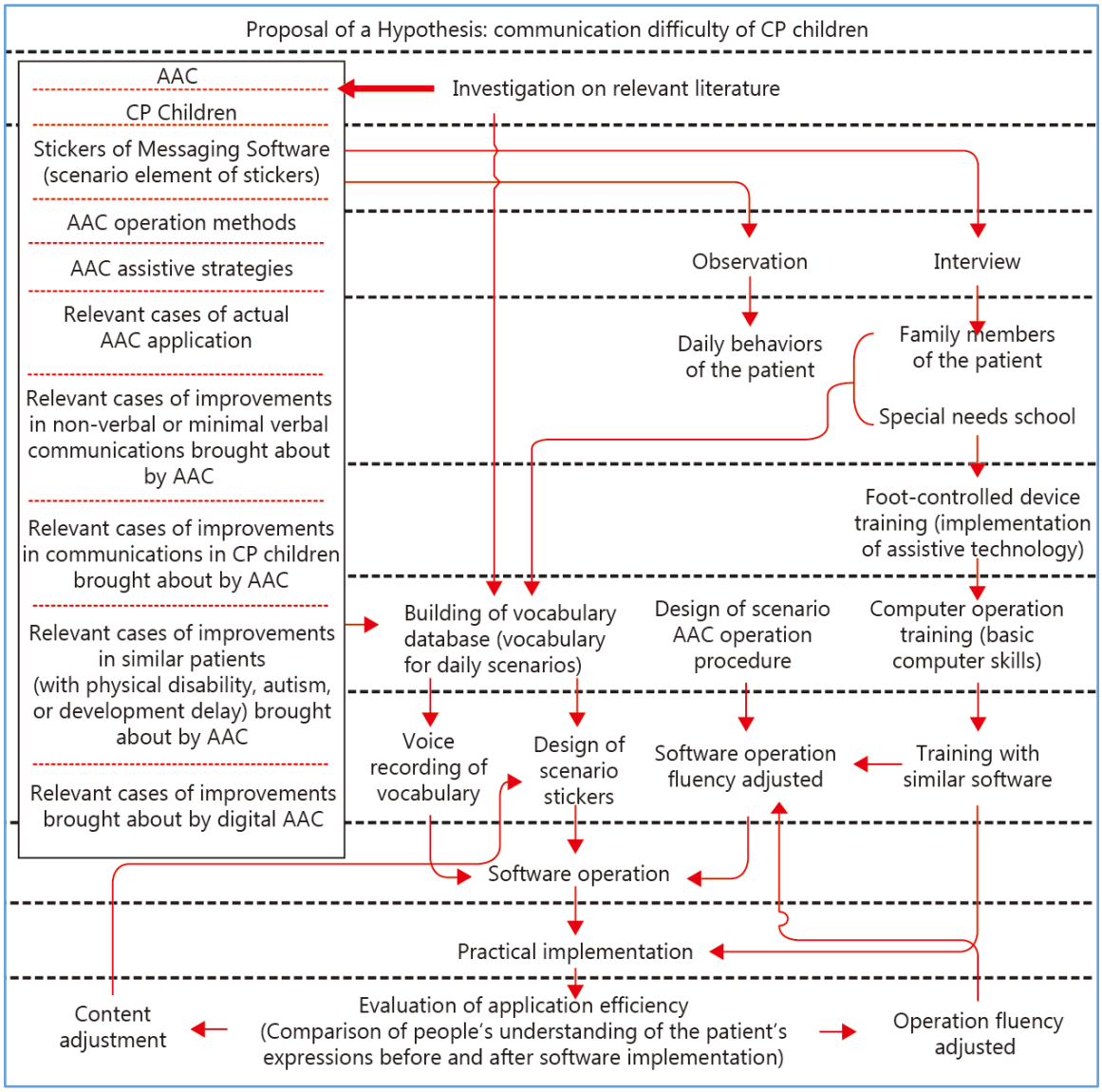


Figure 2. Flowchart of study process

3. Interviews and the Establishment of a Communication Channel

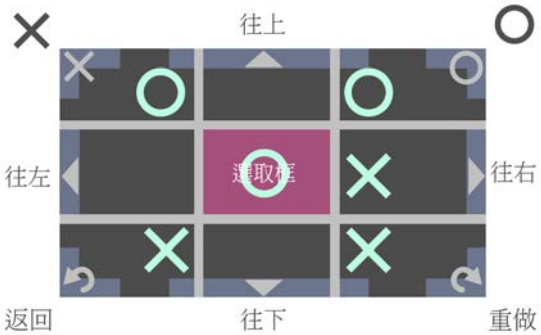
In order to assist Eli in solving communication difficulties in living and learning, the study conducted thorough discussions with Eli's mother to understand Eli's learning conditions at his special needs school and the assistance provided by the school, and proposed potential assistive strategies. Details of the first interview are shown in Table 1. So far, the study has conducted 12 interviews, with each being 2 hours long. The discussion on assistive technology implementation began in the second interview, involving selection of assistive technology, training for technology operation, selection of tablet computer stand, and etc. These discussions were thoroughly carried out in subsequent interviews, aiming to prepare Eli with the ability to use AAC system. The objective, process, and results of the 12 interviews are shown in Table 2.

Table 1. Topics and details discussed in the first interview.

Items	Details obtained from the interview
Eli's daily activities	● Eli enjoys watching TV and videos of Michael Jackson. ● Eli possesses better controlling skills with her left lower limb. When Eli lies in bed, he uses his left lower limb to shift his body so that he could face the television. ● Eli watches videos on Youtube by attaching a tablet computer to the bedside.
Existing assistive devices	● Wheelchair with posture support is used to avoid spinal deformity. ● Eli wears supportive shoes to avoid continuing deformity of his feet.  
Physical functions and features	● Due to the tonicity of his muscles, Eli would sometimes involuntarily turn his head when he is nervous. If this occurs when Eli is watching TV and he is unable to turn his head back to face the TV, he would use his left lower limb to shift himself until he could face the TV again. 
Cognitive ability	● Eli is capable of monosyllabic echolalia. ● Eli is able to match country names and their respective national flags through echolalia. ● When learning a new name, Eli would need something he is familiar with to help himself remember the name, such as, Mr. or Ms. Computer. Once Eli has remembered the person's face, Eli's

	mother would then begin to address the person by his/her real name to help Eli learn.
Assistance provided by the school	● The special needs school provides Eli with a bike that allows him to practice movements of his lower limbs. However, Eli dislikes using the bike. ● Teachers at the school sometimes assist in massage and stretching. ● There are many students. The teachers are not able to spend too much time in caring for one particular student.
Expectation of the study	● Eli does not like to be fixed in a wheelchair. However, if Eli is not in a fixed posture, his organs will suffer from pressures of physical deformities. If Eli's attention is less focused on his posture, he might be more willing to use the wheelchair. It would be ideal if Eli approaches others and initiate conversations with others. This would reduce the stress the teachers have. 
Additional notes	● Eli's left big toe is the best for pressing a targeted object. Eli has sufficient understanding of language. However, illiteracy in addition to inability to communicate with others normally has result in significant learning difficulties.

Table 2. Purposes, processes, and results of the 12 interviews

<table>
<tr><td rowspan="3">1st Interview
October 29, 2014</td><td>Purpose: The purpose was to understand, together with an industrial design expert, Eli’s physical abilities, habits, and cognitive abilities, and discuss possible assistive methods with Eli’s mother and the expert.
  </td></tr>
<tr><td>Process: The researcher and the industrial design expert discussed with Eli’s mother the difficulties Eli faces in daily life and learning, and proposed assistive methods. They also found out about Eli’s learning situation in school and the kind of assistances the school provides. Finally, a discussion was held with Eli’s mother regarding her expectations and views for this study.</td></tr>
<tr><td>Results:
● The muscles in Eli’s entire body experience great hypertonicity, only the muscles in his left knee, left lower leg, and left ankle have less tonicity.
● After discussion with the industrial design expert, it was concluded that although Eli’s left foot can function, it would be difficult for him to turn his head to face his foot and view a tablet computer, and therefore an eye-controlled assistive technology might be required to assist Eli to operate computers.
● An eye tracking device—The Eye Tribe—was used.
● The O And X game was developed; the computer game allows cursor control with eye movement data.
 

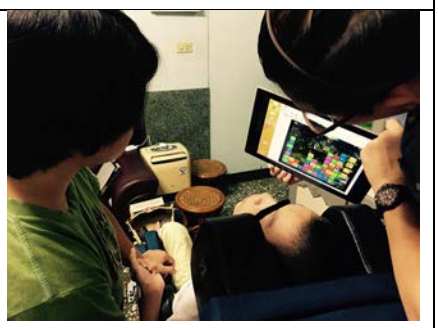
● Eli was trained to operate a computer with an eye-controlled device; the caretaker joined Eli to play the computer game in</td></tr>
</table>

	order to increase Eli's willingness to use such devices.
2nd Interview January 21, 2015	Purpose: The purpose was to introduce an eye-controlled device and the operation method for Eli to practice a one-hour exercise every day with the help of Eli' mother.
	Process: A learning session of device operation was given to Eli's mother for her to assist Eli in practicing computer cursor control with eye movement for one hour every day.
	Results: ● Eli's mother informed by phone that Eli could not maintain a straight-ahead eye position facing the device, possibility due to muscle tonicity problems. ● Even with Eli's head fixed in one position, eye misalignment problems were still not resolved.
3rd Interview January 31, 2015	Purpose: The purposes were to confirm whether the eye-controlled device is usable, discuss Eli's left foot control with Eli' mother, and test his control abilities.
	Process: It was confirmed that the eye-controlled device was not usable. Instead, a simple physical ability test was conducted by gently patting Eli's left foot and guiding him to move his foot in the instructed directions. Thus, a foot-controlled assistive technology was chosen for assisting Eli to operate computers.
	Results: ● The researcher developed a foot-controlled assistive device suitable for Eli's left foot. This assistive device is connected to a tablet computer and can move the computer cursor without requiring any toe movement. Instead, the cursor direction is controlled by having the heel as the support point and then turning left, turning right, front-kicking, and pressing backwards. The right-click function of the mouse can be enabled by pointing to the front with the tip of foot.
4th Interview March 21, 2015	● Purpose: The purpose was to have Eli carry out a simple trial on the foot-controlled assistive device.
	● Process: As the front-kicking and front-pointing control methods of this foot-controlled assistive device are similar, Eli sometimes confuses these two functions. However, after half an hour of training and cursor sensitivity adjustments, Eli was able to move the cursor. This was Eli's first time using a computer and a foot-controlled device. He was very happy at first, but became angry due to unsuccessful operations. Therefore, the researcher left the assistive device to allow Eli to get familiar with the computer user interface and foot control, and asked Eli's mother to note down problems encounter during operations.

	Results: ● Eli's mother informed by phone that Eli's mood swings while operating the assistive device caused muscle hypertonicity and subsequently damaged the device. ● Eli's mother sent a picture of the damages by mobile phone. After initial assessments, it was concluded that the rotation function and the key spring-back function were damaged. ● Eli's mother fixed the assistive device following the instructions of the researcher over the phone.
5th Interview March 27, 2015	Purpose: The purpose was to retrieve the first version of the foot-controlled assistive device and discuss the problems encountered and ways of improvement.
	Process: Though the problem was solved through phone conversations, the researcher still visited to thoroughly examined the foot-controlled assistive device and discussed the problems encountered in the past week while operating the device, in order to understand the possible reasons behind these problems
	Results: ● The researcher collected and compiled the problems encountered during operation and discussed with an industrial design expert experienced in making assistive devices. ● A new foot-controlled assistive device suitable for Eli's foot was made. The support point will still be the heel, and cursor's left and right movements will still be done by turning the fool left and right. However, the ways to move the cursor up and down will be changed to turning the tip of foot in the up-right and up-left direction, and the right-click method will be replaced by front-kicking instead.
6th Interview April 19, 2015	Purpose: The purpose of this interview was to have Eli carry out a simple trial on a sample-version of the new foot-controlled assistive device, and confirm whether the operation fluency problems were resolved. 
	Process: Eli was trained to operate the new version of the foot-controlled assistive device. It was confirmed that the operation problems were resolved and the assistive device was left for Eli's daily practice.

	Results: ● The size of the assistive device was too large and required modification. ● Ease of operation of the foot-controlled assistive device was confirmed. ● A moderate-sized and strong model was made. 
7th Interview May 23, 2015	Purpose: The purpose was to have Eli carry out a simple trial on the modified foot-controlled device, and train Eli to open a video file in a computer (a Michael Jackson's music video that Eli likes).
	Process: The researcher first guided Eli to control cursor direction, and then conducted a test to ensure that the device was strong enough for his muscle hypertonicity. After confirming that the devices can be smoothly operated, Eli was trained to open music video files in the video and music viewing page of the Microsoft Windows 8 operating system.
	Results: ● Eli began practicing one-hour computer operation exercise. ● With some assistance, Eli was able to open different music video files in the video and music viewing page of the Microsoft Windows 8 operating system. ● The assistive device did not suffer damage or become loose during the operation. ● However, two days later, one of Eli's family members bumped into the device and damaged it. ● Eli's mother informed the researcher of the control malfunctions. 
8th Interview May 27, 2015	Purpose: The purposes were to repair the foot-controlled assistive device and track Eli's progress in device operation.
	Process: An examination of the operating procedure of the assistive device software was conducted, the software

	configuration file was rebuilt, and the damaged parts of the hardware were replaced by stronger materials.
	Results: ● After examination, it was concluded that the configuration file was lost due to wrong procedures when opening the software. ● The operating procedure was explained again. ● The software configuration file was rebuilt ● Eli operated the device more smoothly than before.
9th Interview July 18, 2015	Purpose: The purposes were to track the results of the exercise for foot-controlled assistive device and to discuss the selection of a tablet computer stand.
	Process: Tablet computer stands suitable for Eli to use with the foot-controlled assistive device were shortlisted by the researcher, who then discussed with Eli's mother for final selection. The results of the exercise for the foot-controlled assistive device were tracked.
	Results: ● A discussion was carried out with Eli's mother, and a robust tablet computer stand was selected. The stand can prevent the system from becoming loose when accidentally bumped into. ● Eli sometimes directed his foot in the opposite direction, but with some quick guidance and practice, he was able to quickly click and open the desired music and videos.
10th Interview August 2, 2015	Purpose: The purposes were to assist Eli to apply for an account on the messaging software WeChat and try to send emoticon using the built-in emoticon functions, and discussed emoticon design and vocabulary.
	Process: The researcher discussed with Eli's mother the vocabulary that Eli uses daily, assisted her in helping Eli to apply for a WeChat account, logged in the researcher's WeChat account, and conducted an exercise of sending emoticon with Eli.
	Results: ● The icon of WeChat's emoticon library was too small for Eli to click on and open. ● The researcher opened the library and Eli was able to click on and send emoticon. ● Discussions with Eli's mother were carried out to determine 68 words or phrases that Eli might use in daily life and at school, which will be used to consolidate a basic emoticon database.
11th Interview August 25, 2015	Purpose: The purpose was to train Eli to open webpages.
	Process: The researcher assisted Eli to adjust the computer desktop background and icon sizes for ease of selecting and

	clicking.
	Results: ● Eli began practicing one-hour exercises of opening webpages. ● Eli was able to open web browsers and the Quick Launch bar. ● Operation was smoother than before.
12th Interview September 13, 2015	Purpose: The purpose was to train Eli to open games on the browser. 
	Process: The researcher bookmarked the webpage of a predetermined game page for Eli to open with the skills he previously practiced and conduct simple exercises of game operation.
	Results: ● Eli was able to open the webpage of the game bookmarked in the browsers more quickly than before. ● With some guidance, Eli was able to complete the first two challenges of the small game. 

Scenario Emoticon AAC System Design

With these 12 interviews and a newly developed and improved assistive technology, this study has now successfully improved Eli's physical abilities. He can now open a browser on the computer, click on a link, and play games. After a year of interviewing and customizing assistive device, this study has also gained a better understanding of Eli's echolalia. This process shows just how long and difficult the process is to help a patient with communication disorder to communicate. The assistive technology customized in this study is developed through many testing and adjustments. Especially designed according to Eli's left foot mobility, this assistive technology connects with a tablet computer to help Eli to communicate with others. However, the assistive technology, the computer, and even the various icons on the computer are all very unfamiliar to Eli.

Continuous practice is needed for Eli get used to the assistive technology and computer operation. In order to help Eli adapt to this type of operation, this study helped Eli's mother use the assistive technology so she can help Eli practice using it in daily life.
Based on interviews with Eli's mother, this study made a database of vocabularies Eli may use in life. These vocabularies are then divided into different scenarios to meet the needs of Eli in daily life. The three scenarios are dinning, living, and social. The dinning scenario is further divided into "feeling" and "choosing." The living scenario is divided into "wants," "unwell," and "entertainment." The social scenario is then divided into "greetings" and "emotions." Moreover, "greetings" is again separated into "general" and "family" to include all the needed phrases for various greeting situations and the names of each family member. Finally, in consideration of general application of the words "yes" and "no," a "general vocabulary" category is added. After the vocabularies and scenarios are selected, this study designed and drew the equivalent emoticon. At the same time, this study also discussed with Eli's mother to decide the sound recording of each word to decide on a tone that is more acceptable to Eli. For example, for the "punk" emoticon under family greetings, the sound recording is in Taiwanese, the same language Eli's family use when calling him a "punk." When Eli's family calls him "punk," Eli will also respond with the "punk" emoticon.

Table 3. Classification of Scenario Emoticon and Vocabulary

<table>
<tr><th colspan="8">Scenarios</th></tr>
<tr><th colspan="2">Dinning</th><th colspan="3">Living</th><th colspan="2">Social</th></tr>
<tr><th>Feeling</th><th>Choosing</th><th>Wants</th><th>Unwell</th><th>Entertainment</th><th colspan="2">Greetings</th><th>Emotions</th></tr>
<tr><td rowspan="2">Nasty
Delicious
Thirsty
Full
Hungry</td><td rowspan="2">Want to drink
Want to eat</td><td rowspan="2">Sleep
Outdoor
Downstairs
Upstairs
Bathroom</td><td rowspan="2">Head
Stomach
Back
Hands
Feet
Bottom</td><td rowspan="2">Music
TV
Watch Michael
See Pretty Girls</td><td>General</td><td>Home</td><td rowspan="2">Satisfied
Whatever
Helpless
Happy
Sad
Angry</td></tr>
<tr><td>How are you?
Bye-Bye
Goodbye
Miss
Sir
Hi~</td><td>Sister
Brother
Dad
Grandma
Grandpa
Mom
Punk</td></tr>
<tr><th colspan="8">General Vocabulary</th></tr>
<tr><td colspan="4">Yes</td><td colspan="4">No</td></tr>
</table>

The scenario emoticon AAC system developed in this study mainly helps Eli to use a foot-controlled assistive technology to control a computer. The computer then produces a sound recording and picture to help Eli interact with others. When Eli has a need, he can also use the monitor of the scenario emoticon AAC system to decide which emoticon to use to express his needs. He can then use his left foot to control the foot-controlled

assistive technology and choose the correct emoticon. The computer then plays a sound recording for Eli while displaying the relevant emoticon. Thus, the person communicating with Eli can understand Eli's needs using the sound and picture, thereby providing the right assistance. A detailed flow diagram of system operation is shown in Figure 4.

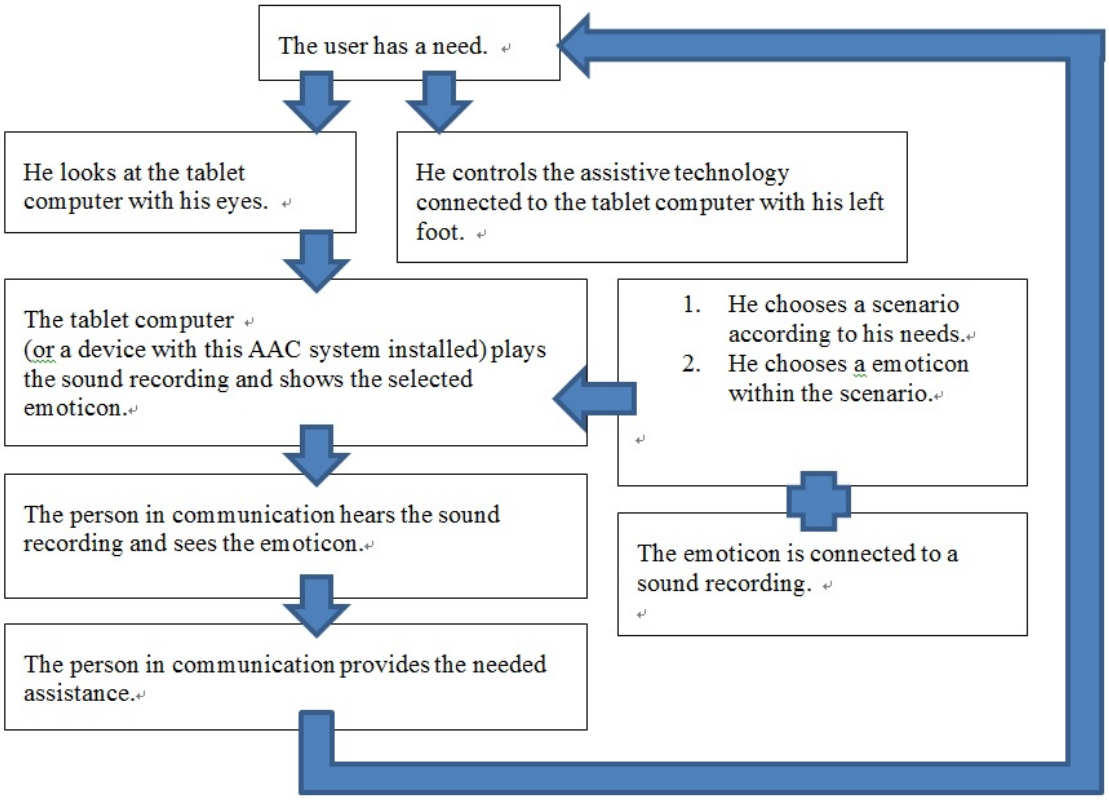


Figure 4. Scenario Stick AAC System Flow Diagram

Conclusion

This study successfully uses foot-controlled assistive device and tablet computer to help a CP patient with multiple physical disabilities and speech impairment to use a tablet computer. Vocabularies that Eli might use in daily life and at school are also collected through interviews and observations.

In terms of technology use, Eli is still unable to use the on-screen keyboard to type at this stage due to illiteracy and inability to control his toes for fine motor movements. He is also unable to click the left button of a computer cursor. However, with the help of a foot-controlled assistive device and some training with a computer, Eli is able to perform simple task on the computer with the help of a guide on the side. Eli can click on the desktop icon, open a browser, open an internet gaming website, play games, and even complete a game level. With the same actions, Eli will be able to select and open a music video, browse news websites, and play games on the internet. Most importantly, teachers at school will be able to design learning activities that utilize Eli's skills.

The vocabulary database can be used in the future to develop scenario emoticon AAC system. Moreover, researchers or teachers can also use them to understand Eli's living habits and develop assistive software for Eli or other individual cases.

References

Bondy, A. S., & Frost, L. A. (1994). *The picture exchange communication system*. Focus on Autism and Other Developmental Disabilities, 9(3), 1-19.

Cheng, Chun-Meng & Tang, Hsuan-Hui.(2013). *User experience and aids iCan APP : A case study of improve autism caregiver teaching burden*. Industrial Design, 128, 43-48.
Liu, Li-rong (1994). *Overcoming communication barriers (Vol. 60)*. Taipei :Yuan-Liou.

Lin, Bao-Guey, & Lin,Mei-Hsiu (1994). *Speech and language disorders of school-age children with cerebral palsy*. The Journal of Speech-languagehearing Association, 10, 30-52.
Lin, Hsin-yi,& Yang, Tsung-Ren. (2004). *The Effect of Picture Exchange Communication System on the Spontaneously Generalized Communication Behaviors for Low-Functioning Children with Autism.* (Doctoral dissertation or master's thesis).Retrieved from http://ndltd.ncl.edu.tw/

Pirila, S., van der Meere, J., Pentikainen, T., Ruusu-Niemi, P., Korpela, R., Kilpinen, J., & Nieminen, P. (2007). *Language and motor speech skills in children with cerebral palsy*. Journal of communication disorders, 40(2), 116-128.

Peeters, M., Verhoeven, L., de Moor, J., & Van Balkom, H. (2009). *Importance of speech production for phonological awareness and word decoding: The case of children with cerebral palsy*. Research in developmental disabilities, 30(4), 712-726.

Peeters, M., Verhoeven, L., & de Moor, J. (2009). *Predictors of verbal working memory in children with cerebral palsy*. Research in developmental disabilities,30(6), 1502-1511.

Potter, L. E., Korte, J., & Nielsen, S. (2014, June). *Design with the deaf: do deaf children need their own approach when designing technology?*. InProceedings of the 2014 conference on Interaction design and children (pp.249-252). ACM.

Teng, Yu-Hsin (2005). *Teaching Effective Communication Introduction : Picturing Exchange Communication System*. Special Eucation of Taitung, 22, 10-15.

Teng, Yu-Hsin (2007). *The Effects of the Picture Exchange Communication System in Communication Behaviors for an Elementary School Student with Mental Retardation*. (Doctoral dissertation or master's thesis).Retrieved from http://ndltd.ncl.edu.tw/

Zhang, Qiong-yi. (2014). *Behavioral Intention to Using Stickers on Instant Messaging App*. (Doctoral dissertation or master's thesis).Retrieved from http://ndltd.ncl.edu.tw/

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