Comparison of the Picture Exchange Communication System and a Speech Generating Device (iPad) to Improve Requesting Skills of Children with Autism

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The purpose of this study was to compare the relative efficacy of the Picture Exchange Communication System (PECS) and an Apple iPad to promote requesting behavior and speech in children with autism spectrum disorder (ASD) and limited functional speech. The two participants underwent training, which helped them to make requests with the PECS or an iPad. The results revealed that both the PECS and iPad were effective in promoting speech. While the acquisition of skills was fast with the PECS, vocal imitation was noted when learning with the iPad. However, no significant differences were observed in the acquisition of requesting skills between the two systems. These findings may be beneficial when considering the choice of augmentative and alternative communication for teachers and therapists who teach functional communication to children with ASD and limited functional speech. It is suggested that they try multiple systems and make a decision based on the results. Regardless of the system used, a certain level of voice imitation ability in the child may have a positive effect on the promotion of speech. Further studies are recommended to devise an iPad training program and manual and modify the used application. Furthermore, it is recommended studies be conducted with more participants to verify the effectiveness of imitative speech and speech promotion using a speech-generating device.

Key Words: augmentative and alternative communication (AAC), autism spectrum disorder (ASD), iPad, picture exchange communication system (PECS), requesting skills

Introduction

DSM-5 lists the core symptoms of autism spectrum disorder (ASD) as “persistent deficits in social communication and social interaction across multiple contexts” and “restricted, repetitive patterns of behavior, interests, or activities” (American Psychiatric Association, 2013, p. 50). In particular, the social communication and interpersonal exchanges of children with ASD and limited functional speech are limited to nonverbal communication such as pointing, gesturing, signing, and presenting pictures. Augmentative and alternative communication (AAC) is a useful strategy for these children (Mirenda, 1997). Among the AAC systems, the PECS® and speech-generating device (SGD), have been found to be effective in promoting functional communication in children with ASD (Flores, Musgrove, Renner, Hinton, Strozier, Franklin, & Hil, 2012; Lorah, Tincani, Dodge, Gilroy, Hickey, & Hantula, 2013).

The PECS is a communication system that employs picture cards to enable voluntary functional communication in children with ASD (Bondy & Frost, 2001). It has six distinct training phases: physical exchange, expansion of distance, picture discrimination, sentence structuring, answering what do you want? questions, and commenting. The first three phases of the PECS involve making requests through a simple exchange. Most studies on the effectiveness
of the PECS in children with ASD have demonstrated positive results in a relatively short time with children who are acquiring communication skills through the exchange picture cards as a means of functional communication (e.g., Ganz, Simpson, & Corbin-Newsome, 2008). The PECS has also been revealed to be effective in expanding vocabulary (Ganz et al., 2008), enhancing speech (Tincani, Crozier, & Alazetta, 2006), and increasing the frequency of voice imitation for children with voice imitation skills (Charlop-Christy, Carpenter, LeBlanc, & Kellet, 2002).

An SGD is an electronic communication aid device that enhances the communication skills of individuals with limited functional speech (Lloyd, Fuller, & Arvidson, 1997). Unlike sign language and the PECS, electronic devices such as a SGD can produce voice output and hence, facilitate communication partners to understand the speech (Sigafoos & Drasgow, 2001). A number of studies have revealed the effectiveness of a SGD in the acquisition and promotion of communication skills in children with ASD such as making positive requests (e.g., Thunberg, Ahlsen, & Sandberg, 2009). The use of a SGD has been found to be as effective as the PECS in expanding vocabulary and enhancing speech (Schlosser & Wendt, 2008). Furthermore, the utilization of an iPad to teach requesting skills to children with ASD through PECS procedures has the effect of promoting speech (King, Takeguchi, Barry, Rehfeldt, Boyer, & Mathews, 2014).

Mirenda (1997) noted four conditions that have to be fulfilled for AAC to enhance communication: response success, response efficiency, response acceptability, and response recognizability. Currently, the PECS and SGD are considered the most suitable methods to satisfy these conditions. Recently, some AAC systems were compared and examined so as to improve the communication skills of children with ASD (e.g., Agius & Vance, 2016). However, only a few comparisons in the same studies on the effectiveness of multiple AAC systems, including the PECS or a SGD, to promote and acquire the required skills have been made.

Boesch, Wendt, Subramanian, and Hsu (2013) examined the effects of the PECS and a SGD (ProxTalker®) on the promotion of the required skills in three participants with ASD. They revealed that two of the participants had difficulty using ProxTalker with a communication partner in Phase 2. Furthermore, independent requesting behavior using the PECS was more successful than employing a SGD. Lorah et al. (2013) found that where participants with ASD were taught communication skills using an iPad® as a SGD in conjunction with the PECS, more independent requests made with a SGD as a percentage of all the requests was higher than with the PECS. However, only a single picture card was employed to give the instruction.

As previously noted, studies that have compared the effects of the PECS and a SGD to promote requesting skills in participants with ASD have been limited by several factors, including the form and weight of the training material such as machines and equipment, the length of the training period, and the training process. These factors may have an impact on the results of the intervention. Furthermore, while both systems are effective in promoting speech, not enough research has been conducted on the effects of both. Accordingly, in this study, the relationship between the teaching procedures used for each phase of the PECS and an iPad as well as the enhancements involved in requesting behavior and speech were examined and compared.

### Method

#### Participants

The participants included two children diagnosed with ASD who had visited the educational counsel-
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ing room at a university. The characteristics of the
participants are presented in Table 1. This study was
approved by the appropriate university ethics com-
mitttees. As the participants were young children
with limited language skills, their parents provided
informed consent for their participation.

Ichiro (pseudonym). Ichiro who was seven years
of age at the start of the study was Japanese and in
the first grade at a special educational needs (SEN)
school that provided educational opportunities for
children with intellectual disabilities in East Japan.
The school comprised an elementary, junior high,
and high school. Ichiro's score for the Childhood
Autism Rating Scale (CARS) at the age of seven
years, six months was 42, suggesting severe autism.
Furthermore, Ichiro's total adaptive behavior com-
prehensive score was 34 for the Vineland Adaptive
Scales (second edition) at the age of seven years, one
month, thus demonstrating a low adaptation level. At
the age of six years, Ichiro completed the Kyoto Scale
of Psychological Development 2001, which revealed
he had severely delayed development, with a develop-
mental age in all areas of one year, one month. Direct
observation revealed that Ichiro had no speech and
made requests through vocalization behavior or voic-
ing sounds such as /a/. He found it difficult to express
his needs and feelings. In addition to training items
on requesting skills, he was given items on matching
samples and motor imitation. He had mastered a cer-
tain degree of picture discrimination and motor imi-
tation. Although his vocal imitation ability was low,
his understanding of visual objects, fine motor skills,
and motor imitation abilities were high.

Ming (pseudonym). At the start of the study,
Ming who was Chinese and enrolled in a normal
nursery school was three years, 11 months old. He
had come to Japan with his parents at the age of
three years, five months. At the age of four years,
three months, Ming’s score of 40.5 for the CARS
suggested severe autism. At the age of four years
and one month, Ming completed the Kyoto Scale
of Psychological Development 2001. The results
revealed his developmental age in all areas was
one year, six months, indicating he had moder-
ately delayed development. At the age of four years,
one month, Ming completed the Vineland Adaptive
Behavior Scales (second edition). His total adaptive
behavior comprehensive score was 47, thus suggest-
ing his adaptation level was low. His parents who
spoke Chinese at home related he had a vocabulary of
approximately 10 Chinese words. They added that his
spontaneous speech had almost disappeared at the
age of two years, eight months. In addition to train-
ing items on requesting skills, he was given items on
picture naming and motor imitation. He mastered a
certain degree of voice imitation skills, picture dis-
crimination, and motor imitation skills. At the begin-
ning of the study, he had little spontaneous speech.
Although he could use the word open as a request,
this did not occur often.

Setting

In the educational consultation playroom at the
university, the participants received approximately
one hour of therapy per week that comprised indi-
vidual training. Furthermore, approximately 30 min-
utes were assigned to the research. During all the ses-
sions, the participants were taught to make requests
by using the PECS and an iPad. All the sessions were
recorded using a digital video camera. The research
periods for Ichiro and Ming were approximately 17
months and 14 months, respectively.

Materials

PECS. Photo cards and/or photographs of food,
toys, and activities (photo cards: 70 mm × 70 mm;
photographs: 50 mm × 50 mm) were laminated, with
the name of the object in hiragana (the Japanese
cursive syllabary) written under each. A PECS
Communication Book (W 265 mm × L 235 mm ×
H 40 mm) was used.

iPad. The digital photographs of food, toys, and
activities were similar to those on the photo cards.
An iPad on which the vocaco® free version was
installed was employed. The name displayed on the
screen was the same as that on the photo card. The
sound after the participant touched the icon was a
recording of the voice of the communication partner.
Examples of the materials used with the PECS and
iPad are depicted in Fig. 1.

Design

An AB design across participants was combined
with an adapted alternating treatment design. It was
chosen because it allowed for a comparison of inter-
vention performances between the PECS and iPad
conditions and their effects on requesting skills. The
study phases were implemented in the following
order: baseline and intervention. The PECS and iPad training were implemented in the first 15 and last 15 minutes of the one hour of therapy. Initially, the order effects were controlled randomly and subsequently, in that order of each session of PECS and iPad conditions. Only the PECS and iPad were employed during the 15 minutes of the PECS and iPad training, respectively. The other training, for example, motor imitation and matching to sample was conducted during the mid-30 minutes of therapy. The participants only had access to the AAC systems during the experimental sessions.

Response Definitions and Measurement

The main dependent variable was requesting. A request was considered to have occurred whenever a participant exchanged a photo card from the PECS book during the PECS conditions independently or activated the iPad to obtain a preferred object under the iPad conditions independently. Data on the four dependent measures were collected in all phases of the study: rate of voluntary requesting behavior when using PECS, number of times speech was used at the time of requesting behavior when employing the PECS, rate of voluntary requesting behavior when utilizing the iPad, and number of times speech was used at the time of requesting behavior when employing the iPad. The PECS and iPad conditions were divided into three intervention phases in accordance with the PECS protocol (Frost & Bondy, 2002), with the mastery criteria set for each phase. To move from one phase to the next, the mastery criterion was set at 80% of the independent requests in two consecutive sessions.

Procedures

Assessment of Stimulus Preferences. A stimulus preference assessment was conducted to identify potential reinforcers before the intervention (Frost & Bondy, 2002). Before the assessment, interviews were conducted with the participants’ parents to identify their object preferences. Subsequently, each participant was observed in an unstructured free-play setting, with access to additional toys, to determine whether further preferences could be identified. A multiple-stimulus procedure without replacement and a paired-stimulus procedure were compared to assess the participants’ stimulus preferences. The top three snacks and toys with high selection and engagement in each category were selected. Ichiro’s favorite treats were fluffy chocolate bar rice cake, Meiji Takenoko No Sato Chocolate® (5), and Marie™ biscuits. His favorite toys were a towel swing, trampoline, and balance ball. Ming’s favorite treats were Toppo® (7), potato chips, and Marie biscuits, and his favorite toys included a marble run, Train Bank® (8), and towel swing.

Baseline. Each participant and his communication partner were seated face-to-face across a desk on which one photo card and an iPad displaying one icon were placed. The participants were allowed to pick up the photo card and touch the icon on the iPad. However, it was impossible for them to pick up the actual objects, which were managed by their
communication partner. When the participants either picked up the photo card and handed it to the communication partner or touched the icon spontaneously, the object was presented immediately. Regardless of whether they picked up the photo card and handed it to the communication partner voluntarily or touched the icon spontaneously, they were given the object on the photo card or the iPad screen within 10 seconds (Agius & Vance, 2016). When the participants ate the treat or played with the toy for at least 15 seconds, the engaged activity was considered completed and the trial ended. They each completed a total of 20 trials on each day of the PECS and iPad baseline, with two blocks per session (food block and toy block), and 10 trials per block.

**Intervention.** The procedures that were followed in all the phases of the PECS training and iPad training during the intervention are as follows. When the communication partner presented an object or when spontaneous use of the PECS or iPad occurred, each trial was considered to have started. When the participant ate the treat or played with the toy for 15 seconds, the engaged activity was regarded as having been completed once and the trial ended. The communication partner provided feedback immediately after a positive reaction: “Please give me … (the name of the object or activity).” If no response was made within 10 seconds after the start of the trial or a false reaction occurred, prompts were minimized as much as possible while observing the state of the participant on each occasion. First, their communication partners opened their hand or pointed at the correct icon and said, “Give it to me” while touching it. If the participant did not respond within five seconds, the prompter, seated behind the participant, held the participant’s hand to enable him to pick up the photo card and hand it to the communication partner or touch the icon together. The participant moved from one phase to the next when the mastery criterion, namely, 80% of independent requests in two consecutive sessions was achieved.

**PECS Training.** Phase 1: Phase 1 allowed the participant to look at, reach for, pick up, and hand the photo card, which are basic skills for communicating effectively when using the PECS, to his communication partner (Frost & Bondy, 2002). In this phase, the participants and their communication partners faced each other across a desk, on which a PECS book with one photo card on the cover was placed. The object was presented if the participants picked up the photo card and gave it to their communication partners spontaneously when asked to do so. If the participants did not hand the object to their communication partners as requested, but played with the photo card or threw it on the ground, the prompter, seated behind the participant, prompted them. If in two consecutive sessions, the participants displayed a low preference for an object by not playing with their toys or playing with the food, the object and photo card were changed in the next session.

Phase 2: The purpose of this phase was to increase the participants’ spontaneity and generalization of the picture exchange. In Phase 2, a PECS book with one photo card on the cover was placed on the desk in front of the participants. However, when the participants picked up the photo card and gave it to their communication partners when requested to do so, the object was presented. They were prompted if they did not respond correctly. The distance between the participants and their communication partners was extended to one meter. When the mastery criterion was realized, the distance was increased to two meters, and subsequently three meters. Apart from this, the procedures were the same as those in Phase 1.

Phase 3: The purpose of this phase was to enable the participants to discriminate between two photo cards. In Phase 3-A, the participants and their communication partners were seated face-to-face across a desk on which a PECS book with two photo cards on the front cover was placed. One photo card of the participants’ favorite object and one blank white dummy card were pasted on the cover of the PECS book. If the participants did not do what was requested, they were given a prompt. When the mastery criterion was reached, the participants were presented with one photo card of a favorite object and one dummy card unrelated to the favorite object. When the mastery criterion was reached, one photo card of the favorite object and another dummy card were presented. In Phase 3-B, two photo cards of favorite objects were presented. The participants were prompted if they did not do what they were required to do. After the communication partners had received the card from the participants and after verbal feedback was given, the communication partners placed the objects shown in the two photo cards on the tray and showed them to the participants. The communication partners then proffered the tray
and said, “Good! Take it!” If the participants took an object that matched the photo card that they had picked up, they were praised and given it. However, if their choice did not match the card, they were not allowed to take the object and a four-step error correction method was implemented. First, they were shown the correct photo card, which was labelled verbally. Second, when the participants looked at the photo card, the communication partners prompted the participant to give the correct photo card by holding out their hand near the photo card and physically prompting if necessary. When the participants made the correct choice, this was acknowledged verbally. Third, the communication partners gave a non-related directive such as asking them to touch their shoulder. Finally, when the participants followed the directive, their communication partners enticed them by interacting with the desired object. When the participants touched the correct photo card, their communication partners praised them verbally. However, when the participants gave them the correct photo card, their communication partners handed them the desired object.

iPad Training. Phase 1: In Phase 1, the participants were allowed to touch an iPad icon with their finger. This is a basic skill required to communicate effectively when using an iPad. In this phase, the participants and their communication partners faced each other across a desk and an iPad was placed between them. When the participants touched an iPad icon spontaneously with their finger, the iPad spoke the name. Subsequently, their partner asked them for the object. After verbal feedback, the object was presented. The other procedures were same as those followed in the PECS training.

Phase 2: The purpose of this phase was to increase the participants’ spontaneity and generalization of the requests by using an iPad. In Phase 2, an iPad was placed on the desk in front of the participant. When the participants picked up the iPad and walked to the communication partners and touched the iPad icon with their finger when asked, the name of the object was spoken by the iPad. Their communication partners subsequently requested the object or activity. After speech feedback, the object was presented. The other procedures were same as those followed in the PECS training.

Phase 3: The purpose of this phase to make the participants discriminate between two iPad icons. In Phase 3-A, the participants and their communication partners were seated face-to-face across a desk on which an iPad with two icons on the screen was placed. One of the icons was of the participants’ favorite object and the other a blank white dummy icon. The remaining procedures were the same as those followed in the PECS training. However, rather than exchanging the photo card for an object, the participants touched the iPad icon with their finger.

Treatment Integrity

Treatment integrity data were collected by two observers who were graduate students trained in behavioral observation and had been briefed on the study procedures. They watched a video of the instructional scene independently and made notes on checklists that were designed for each phase and intervention condition. They were required to document the implementation or non-implementation of the procedures under each condition. Checklists were used during 50% of the intervention sessions. The overall treatment integrity between the two observers was 94.2% (range: 92.4% to 95.9%).

Inter-Observer Agreement

The observers used digital video camera records of all training sessions to make independent observation records. The first observer (the first author) observed the training scene in the video recording and took notes. The second observer, a graduate student trained in behavioral observation, who had been provided with an explanation of the definition of a positive reaction previously observed the training scene independently and took notes. During each intervention session, both observers collected data on the frequency of independent requests and number of prompted trials. For each session, inter-observer agreement was calculated by dividing the number of trials with agreements by the total number of trials with agreements plus disagreements and multiplying this by 100. The mean total agreement was 99.59% (range: 90% to 100%) for Ichiro and 98.89% (range: 90% to 100%) for Ming.

Social Validity

Both sets of parents and the five therapists (graduate students) who participated in the research completed a questionnaire. The questionnaire assessed the validity of the target behavior and adequacy of
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The participants rated the statements on a 7-point Likert-type scale, ranging from 1 (completely unacceptable) to 7 (perfectly acceptable) (See Appendix).

Data Analysis
The percentage of independent, that is, unprompted requests as a percentage of all trials made in each session of the study was calculated by using the following formula: independent requests/(independent requests+prompted requests)×100. The results were analyzed for level, trend, and variability across each study phase by employing visual comparison.

Results

Ichiro
Ichiro’s results are displayed in Fig. 2. No independent requests were made using the PECS or iPad during the two baseline sessions. There were four sessions in PECS Phase 1, 17 in Phase 2, eight in Phase 3-A, and 10 in Phase 3-B. There were five sessions in iPad Phase 1, 15 in Phase 2, and 19 in Phase 3-A. In iPad Phase 3, Ichiro was observed touching other objects frequently but not the top and bottom icons. Within the limitations of the research period, data collection was completed by Session 41. However, Ichiro had not yet reached iPad Phase 3-B.

The number of times Ichiro used speech when displaying requesting behavior using the PECS or iPad is presented in Table 2 and Fig. 4. In the PECS training, he used speech eight times; specifically, he did not speak spontaneously once but rather by imitation eight times. Ichiro used speech seven times during the iPad training; once again, he did not speak spontaneously but by imitation seven times. Furthermore, before Ichiro made a request using the iPad while
moving from a sitting position toward the communication partner, it was noted that he touched an icon many times, brought the iPad close to his ear, and listened to the reproduced voice.

**Ming**

Ming’s results are displayed in Fig. 3. He made no independent requests when using the PECS or iPad during the two baseline sessions. Seven sessions were conducted in PECS Phase 1, 23 in Phase 2, nine in Phase 3-A, and 14 in Phase 3-B. In many instances, Ming took objects from the tray that differed from those on the photo card he had picked up. There were nine sessions in iPad Phase 1, 23 in Phase 2, 19 in Phase 3-A, and two in Phase 3-B. The number of times Ming used speech while displaying requesting behavior using the PECS or iPad are presented in Table 2 and Fig. 4. Ming used speech during the PECS training 13 times; specifically, he spoke spontaneously three times and by imitation 10 times. Furthermore, he used speech in the iPad training 29 times: he spoke spontaneously seven times and by imitation 22 times. Moreover, before Ming made a request using the iPad while moving from his sitting position toward the communication partner, it was noted that he pressed the icon many times, brought the iPad close to his ear, and listened to the reproduced sound.

**Social Validity**

Both Ichiro and Ming’s parents related that they understood the interventions clearly. In relation to the validity of the target behavior and adequacy of the training, the researchers and parents evaluated both the PECS and iPad positively. While the researchers and parents rated the PECS as perfectly acceptable, moderately acceptable, and neutral, they rated the iPad as perfectly acceptable and moderately acceptable. There was no difference in their evaluation of the two systems with regard to its future use in supporting other communication skills (Questions 5 and 11 of Appendix) and introduction in daily living situations (Questions 6 and 12 of Appendix). However, there was a difference between researchers and parents’ perceptions. While the researchers perceived the two systems as perfectly acceptable, moderately acceptable, and slightly acceptable, the parents viewed them as neutral and slightly unacceptable.

| Participant | Requested items | Speech while using PECS | Speech while using iPad |
|-------------|-----------------|-------------------------|-------------------------|
|             |                 | Spontaneous  | Imitation  | Spontaneous  | Imitation  |
| Ichiro      | Balm*a          | /bam/4       | /ba/2      | /du/1        |             |
|             | Towel swing     | /sw/n/1      | /s/3       | /du/2        | /d/2       |
| Ming        | Biscuit         | /tkɔ/2       | /tkɔ/4     | /kwə:nt ɔ:ɾ/' (in Chinese) 1 | /tkɔ/7 |
|             | Toppo           | /tkɔ/1       | /kwə/ (in Chinese) 1 | /tkɔ/1 | /kwə/1 |
|             |                 |             |             | /kwə/1 | /kwə/1 |
|             | Towel swing     | /du/1        | /du/1      | /sw/n/1      | /s/1       |
|             |                 | /d/2         |            | /sw/n/1      |            |
|             | Marble run      | /rʊo ln/1   | /kwə/1     | /rʊo ln/4    | /rʊo ln/2  |
|             | The othersd     | /kwə/1       |            | /kwə/4       | /kwə/2     |

**Note.** aRequested items are added only when speech occurred. bSpoken speech (in Japanese). cThe numbers of times speech was used while using the PECS or an iPad. dUsing an iPad for requests.
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Discussion

The intervention helped the two participants make requests by exchanging a photo card or touching the iPad icon to receive an object. This concurs with the results of previous studies on the effects of the PECS and iPad (e.g., Charlop-Christy, Carpenter, LeBlanc & Kellet, 2002; Lorah et al., 2013).

Acquisition of Requesting Skills

The number of sessions Ichiro needed to learn the two systems was similar. While he required four and 17 sessions to learn Phases 1 and 2 of PECS, respectively, he needed five and 15 sessions for Phases 1 and 2 of the iPad, respectively. Although he learned Phase 3-A of the PECS in eight sessions, he failed to learn Phase 3-A of the iPad in 19 sessions.

Similarly, while Ming learned Phases 1 and 2 of the PECS in seven and 22 sessions, respectively, he learned Phases 1 and 2 of the iPad in nine and 22 sessions, respectively. However, he learned Phase 3-A of the PECS in nine sessions and Phase 3-A of the iPad in 17 sessions. Although there were individual differences between the two participants, they both required slightly less time for the PECS before learning Phase 3. In essence, there were no significant differences in learning the two systems.

Previous studies on the effects of the iPad have shown that mastery of Phase 2 is achieved after 10 to 15 sessions. The results of King et al. (2014) revealed that it took 18 sessions, six sessions, and 14 sessions to teach children with ASD requesting skills with an iPad in Phase 2. In this study, Ichiro and Ming completed Phase 2 in 15 and 23 sessions, respectively. This may have been due to Ming’s shorter attention-span.

While the target behavior of the PECS was to exchange the photo cards, that of the iPad was to touch a photo icon. The learning speeds were almost the same for both systems in Phase 2. Both systems were straightforward, with only one photo card or one icon. However, in Phase 3, there were two
photo cards or two icons. The cover of the PECS Communication Book was large and the positions of the photo cards could be changed easily. In contrast, the iPad application use was limited as the cards appeared smaller on the screen and the placement of the icons on the screen could not be changed easily. This limitation may have affected the participants’ learning speed. Neither of them had been trained before the intervention to touch an iPad screen. Furthermore, a number of factors may have affected their attention, including the changeability of the screen and malfunctioning of the application because of operator errors. These factors may have also affected their ability to make independent requests.

**Impact on Speech**

As noted previously, Ichiro used speech in the PECS training and iPad training on eight and seven occasions, respectively through imitation, but never spontaneously. Although Ichiro had not learned vocal imitation skills, he imitated the names of the requested objects. Ming used speech in the PECS and iPad training on 13 and 29 occasions, respectively. Furthermore, his speech was spontaneous three and seven times in the PECS and iPad training, respectively. Because Ming learned vocal imitation skills, vocal imitation and spontaneous speech behaviors were observed.

Thus, there was no difference in the number of times Ichiro used speech with the PECS and iPad because he had not mastered vocal imitation. On the
contrary, Ming, who had mastered vocal imitation, used speech slightly more often with the iPad than with PECS. However, there was no significant difference between the two systems when it came to the overall acquisition of requesting skills. Furthermore, because Ming had little speech in other tasks that were performed within one hour of the individual training, the use of the iPad may have promoted his speech. This is consistent with Agius and Vance (2016) who revealed that iPad training promoted speech spontaneously in one of their three participants.

After the intervention, while Ichiro had an increased vocal imitation ability but no speech, Ming had increased both his speech and vocal imitation abilities. This difference in performance suggests that prior to the intervention, Ichiro had no voice imitation skills and Ming had voice imitation skills. This validated Schlosser and Wendt’s (2008) conclusion that pre-treatment vocal imitation skills are a very strong predictor of subsequent speech production, regardless of the treatment conditions, namely, sign alone, speech alone, simultaneous, or alternating.

In addition, during training for both systems, when the participants displayed the target behavior, namely, handing over a photo card or touching an icon, their communication partners asked them for the name of the food or toy or to complete the activity as feedback. Unlike PECS, with the iPad, a sound, specifically the name of the object, was played each time the icon was touched. Before the two participants made requests using the iPad while they were moving toward the communication partner or sitting down, it was noted that they touched the icon several times, put the iPad near their ear, and listened to the reproduced voice. These behaviors may be considered to be self-feedback for the participants who were interested in the sound or reproducing it. Reproduction of the sound several times provided the participants with many opportunities to hear it and may have led to the large number of vocal imitations associated with the use of the iPad.

These findings may be useful when considering the choice of augmentative and alternative communication for teachers and therapists teaching functional communication to children with ASD and limited functional speech. When teachers and therapists want to teach a child using the PECS or an iPad, it is best to base the choice on the skills the child has already acquired and personal preferences. In this study, learning speed was higher when using the PECS for Ichiro. However, the promotional effects on speech were almost the same for both systems. Therefore, the PECS was more appropriate for Ichiro. On the contrary, although the learning speeds were almost the same when either system was employed for Ming, he used speech more frequently while using the iPad than the PECS. Therefore, using the iPad may be more appropriate for Ming.

**Social Validity**

In relation to the validity of the target behavior and adequacy of the training, the researchers and parents evaluated both systems positively. Thus, the validity of the target behavior and training was demonstrated. Although both the researchers and parents acknowledged the use of the systems in their daily life, the parents were concerned that they would not be able to use the PECS or iPad properly by themselves. Therefore, it may be necessary to train parents and relevant teachers to use these devices at home and school.

**Limitations and Future Research**

This study has several limitations. First, the time constraints of the research period led to the discontinuation of the study after Phase 3. Second, the data on maintenance or any generalizations could not be collected. It is recommended that besides reproducing the study, the participants should be enabled to acquire the required skills post-Phase 3 and compare maintenance/generalizations in terms of speech. Third, the limitations of the iPad application used in this study may have affected the results and thus, it is recommended that future research employ a modified application or other apps with fewer restrictions. Finally, there were only two participants who had different profiles of the acquisition of vocal imitation skills, which affect communication skills. It is recommended that future studies identify participants’ degree of autism. Furthermore, it is crucial that the presence or absence of vocal imitation skills be identified before studying participants’ expression of speech and how learning of both systems is acquired. Finally, it is imperative to verify the effectiveness of devices with voice output functions in the participants’ vocal imitation and speech promotion.
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Endnotes

1) PECS (Picture Exchange Communication System) is a registered trademark of Pyramid Educational Consultants, Inc. (www.pecs.com).
2) ProxTalker is a registered trademark of ProxTalker.com, LLC., Connecticut, USA (www.logantech.com).
3) iPad is a registered trademark of Apple Inc., Cupertino, CA, USA (www.apple.com).
4) Vocaco (Version 1.4.1) is an application of Dreamonline Co. Ltd., Tottori, Japan (www.dreamonline.jp).
5) Meiji Takenoko No Sato Chocolate® is a product of Meiji Seika Kaisha, Ltd., Tokyo, Japan.
6) Marie biscuit is a product of Morinaga & Company, Ltd., Tokyo, Japan (www.morinaga.co.jp/products) (www.meiji.co.jp/sweets/chocolate/kinotake/products).
7) Toppo is a registered trademark of Lotte Co. Ltd., Tokyo, Japan (www.lotte.co.jp/products/catalogue/choco).
8) Train Bank is a registered trademark of Shine Co. Ltd., Tokyo, Japan (www.shine-jp.com).

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### Appendix

#### Table A1 Social Validity Questionnaire

| Questions                                                                 | Answers |
|---------------------------------------------------------------------------|---------|
| 1. Do you think that support for communication skills by using the PECS was effective for the child? | 1 2 3 4 5 6 7 |
| 2. Do you think that the targeted behavior (requesting goods through exchange of picture cards) was appropriate for the child? | 1 2 3 4 5 6 7 |
| 3. Do you think that the PECS training method was appropriate for the child? | 1 2 3 4 5 6 7 |
| 4. Do you think that it is a good idea to continue teaching the PECS in the future? | 1 2 3 4 5 6 7 |
| 5. Do you think it would be a good idea to apply the PECS to support other communication skills? | 1 2 3 4 5 6 7 |
| 6. Do you think that it is a good idea to introduce the PECS in daily life situations? | 1 2 3 4 5 6 7 |
| 7. Do you think that support for communication skills by using an iPad was effective for the child? | 1 2 3 4 5 6 7 |
| 8. Do you think the targeted behavior (requesting goods through touching the icon of the iPad) was appropriate for you? | 1 2 3 4 5 6 7 |
| 9. Do you think that the method of training on an iPad was appropriate for the child? | 1 2 3 4 5 6 7 |
| 10. Do you think that it is a good idea to continue teaching iPad use in the future? | 1 2 3 4 5 6 7 |
| 11. Do you think it would be a good idea to apply an iPad to support other communication skills? | 1 2 3 4 5 6 7 |
| 12. Do you think that it is a good idea to introduce iPad use in daily life situations? | 1 2 3 4 5 6 7 |

*Note.* 1=completely unacceptable, 2=moderately unacceptable, 3=slightly unacceptable, 4=neutral, 5=slightly acceptable, 6=moderately acceptable, 7=perfectly acceptable.