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A novel communication application to encourage social interaction by children with autism spectrum disorder

Hannah Graham* *BPhy*
School of Physiotherapy, University of Otago, New Zealand

Alice Bond* *BPhy*
School of Physiotherapy, University of Otago, New Zealand

Mariette McCormick* *BPhy*
School of Physiotherapy, University of Otago, New Zealand

Ollie Hobbs* *BPhy*
School of Physiotherapy, University of Otago, New Zealand

Chris Yoo* *BPhy*
School of Physiotherapy, University of Otago, New Zealand

Swati Gupta *PhD*
Senior Research Scientist, Callaghan Innovation

Hilda Mulligan *PhD*
Senior Lecturer, School of Physiotherapy, University of Otago, New Zealand

Marcus King *BEng*
Principal Engineer & Team Lead, Callaghan Innovation

*At the time of this study, were undergraduate students at the School of Physiotherapy, University of Otago.

ABSTRACT

Difficulty with social interactions is a feature of Autistic Spectrum Disorder (ASD) and can be present in children who have other developmental disorders. A novel application using computer technology was designed by Callaghan Innovation to improve social interaction in this population by assisting casual conversation between two people with minimal external facilitation. We compared the application with the children's existing Augmentative and Alternative Communication (AAC) devices and Picture Communication Symbols (PCS™). A sample of three pairs ($n = 6$) of adolescents, who have a diagnosis of ASD or another developmental condition affecting their social interaction and communication, were videotaped and analysed using all three modes. The new application provided better social interaction, attention, independence and enjoyment than the existing systems.

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Key Words: Social interaction, Autistic Spectrum Disorder (ASD), Special needs population, Augmented and Alternative Communication (AAC), Computer technology

INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental syndrome which may result in differences in cognitive processing, reduction in social interaction, and stereotypical behaviour and fixated interests (American Psychiatric Association 2013). The prevalence of ASD in the US is 1 in 68 (Centres of Disease Control and Prevention 2010), with approximately 40,000 individuals with ASD in New Zealand (Ministries of Health and Education 2008). As it is a spectrum disorder, there

is a large variation in severity and no individuals with ASD will have the exact same symptoms. Impaired social interactions seen in ASD include lack of social or emotional reciprocity including a lack of eye contact and hand gestures, resulting in difficulty in developing and maintaining relationships with others (Lord et al 2000).

It is estimated that about 50% of children with ASD do not develop functional speech, therefore requiring an alternative way to communicate (Ganz et al 2012). Augmentative and

Alternative Communication (AAC) systems are commonly utilised to aid people with complex communication needs. AAC systems constitute an array of communication aids, such as sign language, gestures, symbols, pictures and speech generating devices. One of the modes for aided communication is the Picture Exchange Communication System (PECS®) (Pyramid Group Management Services, Inc., Syracuse, New York, USA) which is a low tech system that is well established for use in the speech-affected population. It was designed specifically to aid social interactions in children with communication problems (Bondy and Frost 2001). The use of touch pad-based AAC systems has recently become popular because of the medium's ability to create low-cost applications.

AAC systems are typically used by a single individual rather than in a collaborative conversation, possibly due to a lack of systems available that support interactive conversation, or to the wide variety of vocabulary and symbols used, making it difficult to integrate conversations across such devices (Gonzales et al 2009). Also, for those with severe communicative disabilities, even communication with electronic AAC systems can be limited, through difficulty in comprehension by peers due to abnormal sentence structure (Soto and Hartmann 2006).

Callaghan Innovation, a New Zealand government agency, developed a novel communication application to encourage social interaction and casual conversation between people who use AAC devices. The aim of this study was to investigate the feasibility of this application for adolescents by asking whether the novel application enabled better social interaction, joint attention and independence as compared to Picture Communication Symbols (PCS™) and each adolescent's usual AAC system.

METHOD

This feasibility study was approved by the University of Otago Human Ethics Committee (ref 11/195) and comprises of a comparative case series.

Participants

Recruitment took place at a special needs centre situated within a state high school in Christchurch, New Zealand. This facility caters for around 40 adolescents with ASD, Down's syndrome or other developmental disorders and who have high or very high needs. The study and its inclusion criteria were described by members of the research team to the teaching staff at the facility, who then identified potential participants for the study. The inclusion criteria included i) a diagnosis or impairment which affects social interaction and communication, ii) the ability to follow very simple instructions and demonstrations, iii) adequate motor control to manipulate a touch screen and picture cards, iv) regular use of an electronic AAC tool, and v) familiarity with PCS™ cards.

Written informed consent for each participant to take part in the study was obtained from the parent/s or caregiver/s. Teaching staff paired participants so that individuals in each pair were familiar with each other (for example, were in the same school classroom), were of similar age, and had similar communicative ability.

Six participants (3 females, 3 males, mean age 16.2 years, age range 12-19 years) were recruited to form three pairs. Each pair had one participant with ASD and one participant with a different neuro-developmental condition. Each participant was assigned a code from P1 to P6. The pairs were as follows; P1 and P2, P3 and P4, and P5 and P6.

Materials

This study compared the novel application with two AAC systems: the PCS™ cards and the participant's usual electronic AAC device or application. The novel application used symbols that participants were already familiar with through their usual use in the school setting. We orchestrated a turn based conversation in each mode (see Table 1).

Table 1: Type of conversation used in the study

Participant A	Participant B
Hello	Hello
How are you	I feel... (good, tired, sick, sad)
What are you doing today?	I am going to... (swimming, smartboard, music and movement, walk, exercise, Special Olympics, computer, cooking, reading, sports)
Who with?	With... (photos of school staff and students)

We used a set of PCS™ cards (relevant to the conversation in Table 1) that attached temporarily to fabric mats to facilitate the conversation using this method. Each participant was given one mat with cards relevant to their turn and a larger third mat was used as the shared mat which participants conversed on with the cards. VELCRO® was placed on the PCS™ cards so they could be attached to the mats.

For the electronic AAC system, each participant used their own device or application that included speech generation, icons and written words or phrases. The personal AAC systems used were DynaVox (Tobii Dynavox, Pittsburgh, USA) (two participants), Proloquo2go (AssistiveWare, Amsterdam, the Netherlands) (one participant) and TouchChat (TouchChat Apps, Apple Inc., Cupertino, California, USA) (three participants).

The novel application was designed in such a way that the features to facilitate a conversation such as in Table 1 were built into it and did not require any special setup.

Procedure

Before data were collected, the three pairs of participants received two training sessions of 10-15 minutes for each mode: PCS™, their electronic AAC devices/applications, and the novel application. These sessions were facilitated by two members of the research team in collaboration with one of two Speech and Language Therapy (SLT) students interning at the school. As the SLT students were to act as the facilitators during data collection, this training allowed them to practise instructing the participants and understand how to use all of the AAC systems used in the study.

Data collection took place in a quiet room at the school. One of the two trained facilitators was present in the room at all times during data collection. A teacher-aide was also present in the room for two participants who required supervision at all times. The teacher-aides were instructed not to speak to the participants or intervene unless the facilitator was unable to manage a participant's behaviour.

The room had one table in the middle with two chairs side by side in front of it, although a chair was removed for two participants who used wheelchairs. Three digital video cameras ensured all behaviours of the participants and facilitator were recorded: one from behind the participants to capture the screens/picture boards, and the other two in symmetrical positions on the front left and right sides. Data were collected over five school days with each pair of participants completing one mode (PCSTTM, electronic AAC and novel application) each day, in a randomised order, until the three modes were completed. If a pair was unable to complete a mode due to other school commitments or illness on the scheduled day, they completed that mode on the next available day. All data were collected between the hours of 9 am and 10.30am. The order of the pairs each day was subject to their availability as the research team did not want to disrupt normal school routines.

The type of conversation in Table 1 was attempted for all three modes of communication. The facilitator was in charge of ensuring each pair was seated appropriately for data collection. For each mode the facilitator gave the same appropriate instructions before starting the timer, and indicated which participant would begin the conversation. Each pair was then first given 30 seconds to begin conversing with their partner without any prompting or instruction from the facilitator to measure whether or not, and after how long do, participants initiate conversation without being prompted by the facilitator. After these 30 seconds, the facilitator was allowed to intervene or prompt participants as necessary and allowed to select the appropriate picture card or icon in order to facilitate the conversation. Total time of the conversation was recorded. One conversation included participants switching roles i.e. Participant

A used Participant B's utterances in Table 1 and B used A's. Conversations were terminated if they exceeded 10 minutes.

For the PCSTTM cards setup, participants were given one felt mat each; mat 1 had Participant A's words and mat 2 held Participant B's words. A larger shared mat was used to display the cards participants selected to use in the conversation. After A had placed their words on the shared mat, B would reply in the same manner. This continued until either the conversation or the time finished; if there was still time left, the facilitator would re-organise the mats and swap the conversation. For the Personal AAC tool, participants were asked to greet the other participant and then to tell each other what they were going to do that day and select appropriate symbols to create their utterances and form a conversation. The novel application had the conversation in Table 1 embedded in it.

Data Analysis

A data analysis sheet which listed behaviours that could potentially be demonstrated by participants was compiled. The chosen behaviours were identified in existing assessment measures of social and communicative behaviours commonly exhibited by adolescents with ASD or communicative impairments. These assessment measures included the TRIAD Social Skills Assessment (Stone et al 2010), the Autism Social Skills Profile (Bellini and Hopf 2007), the goals utilised in SCERTS (Prizant et al 2003) and the behaviours observed by Jordan et al (2013) in a small study that used a fine grain analysis to analyse behaviours in adolescents with ASD and other cognitive impairment.

To ensure the behaviours in the data analysis scoring sheet were relevant, we performed two trial data analyses (not included in the final analysis) using a short video of two individuals with ASD which was collected when the novel application was first introduced to staff and students at the centre. Based on this, modifications to the chosen behaviours were made and the final list of target behaviours was agreed upon. The chosen behaviours were divided into positive and negative behaviours (which could be measured either by frequency or length of time) and are described in Tables 2 and 3.

Table 2: Positive Behaviours

Behaviour	Description
Looks at facilitator	Participant looks at facilitator. This includes looking spontaneously or in response to prompting or intervention.
Looks at partner	Participant looks at partner. Includes spontaneous looks or looks in response to speech or elements in the mode.
Communicates with facilitator via gestures	Use of a gesture to communicate with facilitator in isolation, to support speech, or attempts to verbalise.
Communicates with facilitator via speech	Recognisable utterances spoken to facilitator. This included using facilitator's name, repeating words, reading from the two AAC systems and the novel application, greetings, questions and comments.
Communicates with partner via gestures	Use of a gesture to communicate with partner in isolation or to support speech or attempts to verbalise.

Communicates with partner via speech	Recognisable utterances spoken to partner. Includes using partner's name, repeating words, reading from the two AAC systems and the novel application, greetings, questions and comments.
Expression of joy	Any indication of joy through speech, noise, actions or facial/body expression.
Attempts to verbalise	Any noise that is an attempt to communicate but is not recognisable as a word. Laughing or yawning are not counted in this category.
Positive touch	Touching partner to communicate or enhance social interaction in a positive manner, commonly, touching to return focus, remind partner of a turn or to display excitement. Touch was deemed inappropriate if forceful or unwanted.
Joint attention	Total time both participants were simultaneously attending to the same elements of the mode, including eye contact.

Table 3: Negative Behaviours

Behaviour	Description
Repetitive behaviour	For example, rocking or continuous hand movements.
Turn taking error	Participant incorrectly took their turn including attempt to take turn before partner had completed their turn, or continuing to ask or answer questions without allowing partner to reply.
Focus away from the game	Total time participant not visually attending to the activity.
Inappropriate action	Behaviours deemed inappropriate such as refusal to participate and aggression.
Facilitator intervenes or prompts	Facilitator prompts or intervenes to assist activity, including behaviour management, reminding participants to take turn or return attention to activity, or physical assistance.

Five researchers analysed the video data, two or three target behaviours each. Each video was watched three times, with a fourth viewing from an additional angle if behaviours were obscured. The analysis of the video data commenced once the facilitator had finished speaking the initial instruction and was ended either on completion of the conversation or at the 10 minute mark. If there was ambiguity or question about any behaviour, the research team held a collaborative discussion until agreement was reached.

RESULTS

To allow equitable comparison between the modes, we recorded the length of time of each conversation and extrapolated the data to equal 10 minutes. The novel application performed noticeably better than the other two AAC modes for all metrics. It facilitated better social interaction, more joint attention, required less facilitator intervention, took less time, and participants seemed to enjoy using it more than the other two modes.

Positive and negative behaviours: The novel application resulted in the greatest frequency of positive behaviours (479.7) and the lowest frequency of negative behaviours (106.2) across the three modes (Figure 1). This was followed by PCSTTM cards and the personal AAC device, which performed the worst of all, with lowest frequency of positive behaviours (334.7) and highest frequency of negative behaviours (274.6).

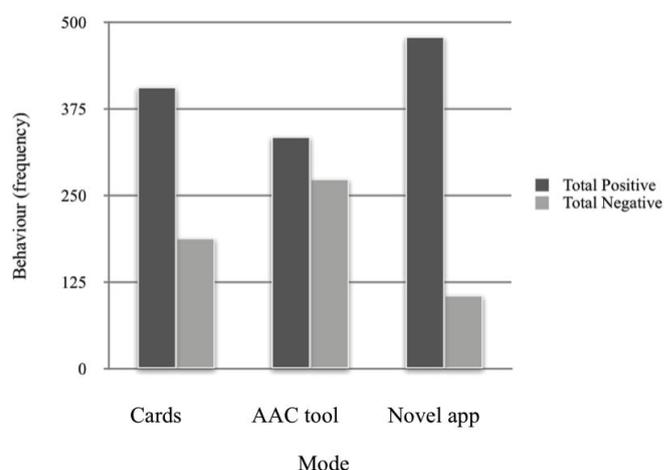


Figure 1: Total positive and negative behaviours

Time taken: The novel application allowed participants to finish their conversations fastest of all, followed by PCSTTM cards (Figure 2). When using their personal electronic AAC tools, only pair 1 completed the conversation in the allocated 10 minute time slot. Three trials were terminated by the facilitator because the planned time limit of 10 minutes was reached, one when using the PCSTTM cards (pair 3), and two while using their personal AAC tool (pairs 2 and 3). All trials with the novel application were completed well under the 10 minute time limit.

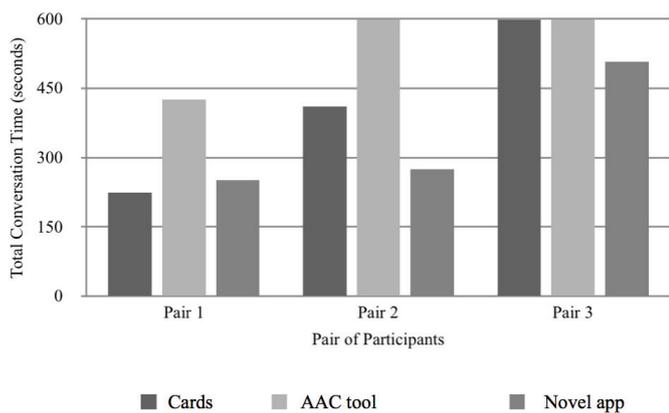


Figure 2: Time taken by each participant for each model

Attention: Participant's attention and level of engagement were measured via joint attention and amount of focus away from the game. The total time that each pair showed 'joint attention' was greatest for all pairs when using the novel application, followed by personal AAC tool, and lowest for all pairs when using the PCS™ cards (Figure 3). A significant decrease in 'focus away from the activity' was also noted for each participant while using the novel application (Figure 4).

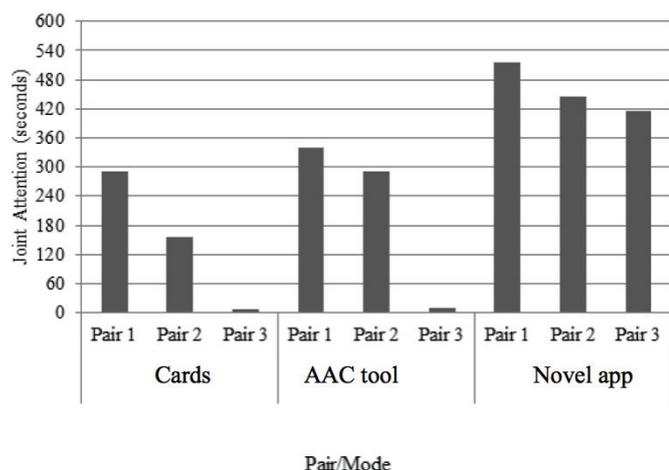


Figure 3: Joint attention of each participant pair

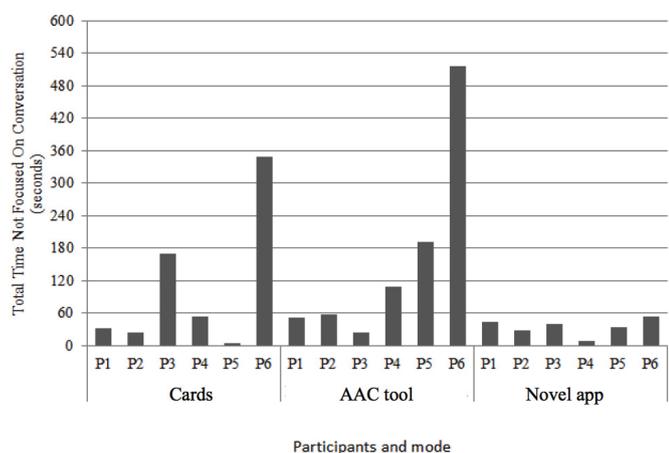


Figure 4: Focus away from the activity

Enjoyment: Participants appeared to enjoy using the novel application more than the other modes. The greatest frequency of expressions of joy for all participants occurred while using the novel application (Figure 5). Four of the six participants (P1, P3, P4 and P6) expressed joy at least twice as often while using the novel application compared to the other two modes.

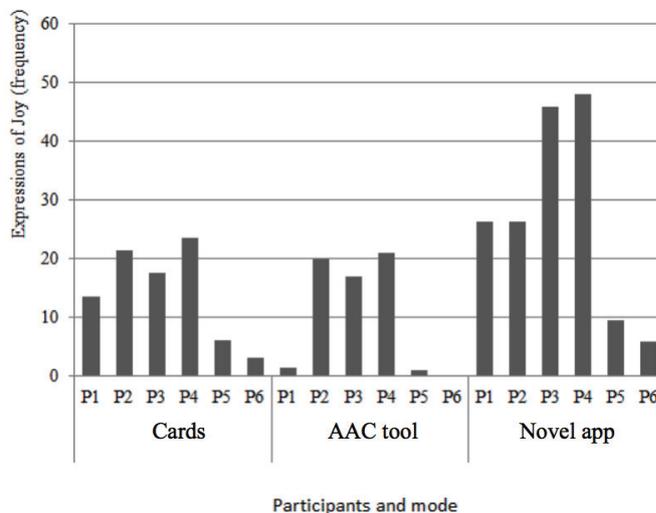


Figure 5: Expressions of joy by each participant

Facilitator intervention: Participants demonstrated greater independence when using the novel application. After just two training sessions, participants required considerably less assistance using the novel application than with either the PCS™ cards or their personal AAC tool, even though they were already familiar with these and used them in everyday life. Participants 1 and 2 required no prompts or intervention from the facilitator to complete both parts of the conversation when using the novel application but required 5 - 10 prompts each for PCS™ cards and 31 - 39 prompts each when using their personal AAC tool. Participant 5, however, who also had an upper limb motor impairment, required more facilitator intervention while using the novel application (49.7) as opposed to 39 for PCS™ cards, but required 70 for the personal AAC device (Figure 6).

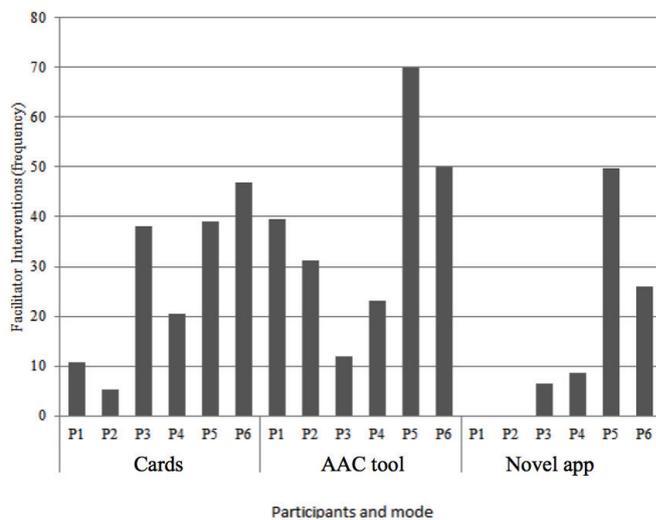


Figure 6: Facilitator interventions for each participant

Attempts to verbalise: The highest frequency of attempts to verbalise by participants was observed while using the novel application. For PCS™ cards and their personal AAC tool, numbers of attempts were somewhat similar (Figure 7). Participant 1 and Participant 2 made no attempts to verbalise in any mode.

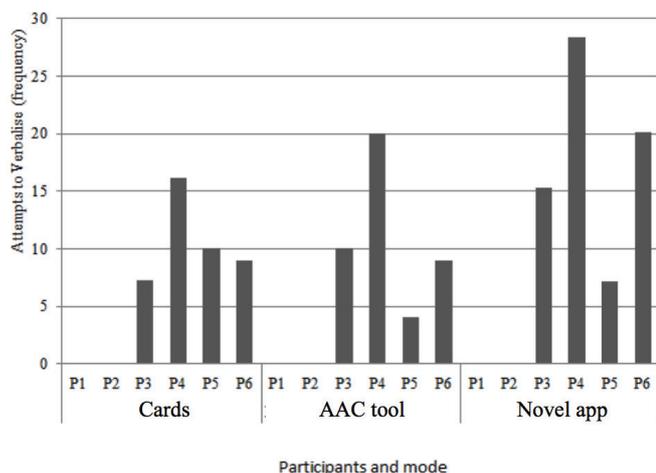


Figure 7: Attempts to verbalise by each participant

DISCUSSION

The findings of this study support the use of the novel application as an encouraging application for improving social interactions by adolescents with special needs. It required considerably less facilitation than the two modes of PCS™ cards and personal electronic AAC devices/applications, thereby providing increased independence for its users. The novel application also showed superior ability to the other forms of AAC systems with which it was compared in increasing positive social interactions, such as expressions of joy and attempts to verbalise, and also in improving the participant’s simultaneous attention to the task and eye contact with their communicative partner.

Reciprocity: To compare the three modes of communication, the way the picture cards were normally used had to be altered. The cards had been previously used by participants in communication to others when they wished to express wants and feelings, but not to converse back and forth with another person. Therefore, communicative reciprocity through typical ‘turn taking’ interaction was withheld. As explained in the method, a new style of picture card interaction was taught to the participants in order to facilitate reciprocity and allow comparison to the novel application. However, the physical task of having to locate, identify, and pull off each picture card and then place it on the ‘shared conversation mat’ in appropriate order appeared more cognitively and physically demanding for our participants than the demands of the novel application. This may have slowed down the interaction with the partner, thereby explaining why our results demonstrated the least amount of joint attention across all three pairs when they used the picture cards for interaction. On the other hand, the features of the novel application appeared to positively influence dual engagement and thus promote communicative reciprocity.

Attention: Joint attention is a behaviour that is often decreased in ASD and other developmental disorders (American Psychiatric Association 2013). It describes a lack of simultaneous attention to objects, and an inability to attend to objects of another person’s interest by following eye-gaze or gestures (Dawson and Sterling 2008). Therefore, the increase in joint attention of participants when using the novel application was a very positive result.

Facial expressions: Whilst using the novel application, each participant expressed joy at a considerably higher frequency in comparison to the other two modes. Although ‘expression of joy’ was counted as “any indication of joy through speech, noise, actions or facial/body language”, video-analysis proved this was most often displayed by the participants through facial expression. Considering both children and adults with ASD commonly have reduced outward facial expression (Gordon et al 2014), these results suggest the novel application has a positive socio-communicative influence. It is known that facial expression can aid in initiation, modification and regulation of social interaction (Gordon et al 2014). Therefore increases in non-verbal elements of communication (such as expression of joy) may facilitate social interaction and understanding between children with ASD when using the novel application.

Verbalisation: Each participant in this study had a different level of communication skill. Facilitation and the use of an AAC device is required to enable four of our six participants to communicate in their everyday life. For these four participants, the effectiveness of the different modes to facilitate any form of verbal communication was measured by counting any noise that was an attempt to communicate but was not recognisable as a word. The other two participants also used an AAC device even though they are able to verbalise intelligibly, albeit only sometimes; these two participants (P1 and P2) therefore did not have any counts recorded under ‘attempts to verbalise’ and instead were recorded under ‘speaks to partner’. Our results supported the use of the novel application as the most effective mode for facilitating ‘attempts to verbalise’ (for P3, P4 and P6) and for ‘speaks to partner’ (for P1 and P2) over the other two modes used in this study. Improved initiation of sound or words due to the use of the novel application is an extremely positive outcome for our study as the lack of social and communication skills often hampers learning (Ennis-Cole 2015).

Timespan: The time slot allocation of 10 minutes was decided by the research team together with school staff, after the practice trials, as being an adequate amount of time for a simple two way conversation to be completed. Of the nine sessions of data collection, three took the total 10 minutes, while the other six sessions were under the 10 minute cap. We therefore extrapolated the data out to give a fair representation of the interactions recorded across the different modes, for example, three minutes is not a long time to hold concentration compared to 10 minutes. It would have been interesting to examine attention span against time, to see whether, if a participant was given the freedom to use the application for as long as they wished to, how long this would be and at what rate the behaviours would occur.

Measures: Although the measures of behaviours used in this study were based on validated assessment tools, modifications were required to remove components irrelevant to our study. For example, the item “interacts with peers during unstructured activities” on the Autism Social Skills Profile (Bellini and Hopf 2007) was unable to be assessed, as the nature of our study required pairs of participants to communicate within an orchestrated and structured environment. Of the three participants diagnosed with ASD involved in our study, only one was known to commonly display repetitive behaviours. This is somewhat unusual as repetitive behaviours are a common characteristic displayed by people with ASD (American Psychiatric Association 2013). Therefore, while a change in data about repetitive behaviour may indicate the potential influence of each mode, it was not an important factor in our study, due to only one participant exhibiting this behaviour.

Discrepancies: As shown in our results, the category “Looks at Facilitator” was analysed as a positive behaviour. However, during data analysis, researchers noticed this target behaviour was more often displayed in a negative manner. Often this occurred when the facilitator was intervening due to difficulty in game-play. This possible mixture of positive and negative interactions may explain why our findings for the novel application were low, as it also required less facilitator intervention than the other two modes.

Interestingly, teaching staff reported anecdotally that after regular use of the novel application (the application was left at the school for use by its students after the study was completed), two students were seen conversing via the novel application for approximately 20 minutes, something highly unusual at the facility. Also, some of the participants had begun greeting each other spontaneously and one pair developed an enduring friendship. This had not been observed prior to exposure to the novel application, despite the adolescents having attended school together for a number of years. It appears, therefore, that the novel application has the potential for transfer of its skills to real life.

CONCLUSION

This study tested the feasibility of a novel application to engage adolescents with ASD or another developmental condition, in interactive social communication. The novel application facilitated an improvement in positive behaviours of joint attention, expressions of joy and attempts to verbalise. When compared with picture cards and the participants’ personal AAC applications, the novel application resulted in a decrease in frequency of negative behaviours, such as loss of focus and intervention by the facilitator. Further research with a larger cohort and with a wider range of children with communication disorders would help determine how the use of this application can be optimised for developing social interaction skills.

KEY POINTS

1. A novel application enabled better and more enjoyable social interaction among adolescents with communication impairment than when they used their usual methods of PCS™ cards or personal electronic AAC device.

2. The novel application required much less facilitator intervention than the user’s usual methods of interaction, thus enabling the users to be more independent.

DISCLOSURES

This study was unfunded.

Two authors are affiliated to Callaghan Innovation, the organisation that designed the novel application. However, neither of these authors were involved in data collection for this study. The other authors report no conflicts of interest. The study was unfunded.

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ADDRESS FOR CORRESPONDENCE

Dr Hilda Mulligan, School of Physiotherapy, University of Otago, PO Box 56, Dunedin, Telephone 03 3643657.
Email: hilda.mulligan@otago.ac.nz

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