

“Black white zebra orange orange”: How children with autism make use of computer-based voice output communication aids in their language and communication at school.

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[Article title] “Black white zebra orange orange”: How children with autism make use of computer-based voice output communication aids in their language and communication at school.

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Structured Abstract:

Purpose

This naturalistic study adapted exploratory school practice in order to support empirically-informed decision making in the provision of augmentative and alternative communication (AAC) technologies for children with autism.

Design

Research was conducted with three boys with autism and little speech, as part of a curricular literacy lesson. A mixed method approach, involving observational coding and staff diaries, identified how the boys used computer-based voice output communication aids (VOCAs), also called speech generating devices (SGDs) and how the technology impacted on their communication and language.

The boys were observed in initial lessons ('baseline' sessions), without the VOCA present and in sessions in which the VOCA was available ('intervention' sessions).

Findings

VOCAs were used for two main communicative purposes; naming and giving information; with aids being used primarily to support curricular, task-related communication. Existing modes of communication continued to be used when access to the VOCA was available. In addition, all three boys showed an increase in Mean Length of Utterance (MLU) after the VOCA was introduced. The findings suggest that computer-based VOCA technology can augment children's communicative participation in lesson activities. Specific patterns of change were also recorded in the boys' communication, suggesting individualised responses to this technology.

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This paper extends the empirical base for clinical decision making by reporting the use of high tech VOCAs by school age children with autism for additional forms of communication, beyond those described elsewhere. It adds to the evidence that interventions which include access to a computer VOCA can have a positive impact on the language complexity of children with autism. It describes the potential of VOCAs to provide an enabling and inclusive technology in a classroom setting.

Keywords:

autism, VOCA, communication, language, intervention

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A diagnosis of Autism Spectrum Disorder (ASD) includes impairments in social interaction and communication, with communication impairment often comprising a delay or complete absence of spoken language (DSM-IV, American Psychiatric Association, 1994). Approximately 30-50% of individuals with ASD fail to develop any speech (National Research Council, 2001). Given these communication difficulties, a wide range of intervention methods have focused on providing augmentative and alternative communication systems (AAC) to support the expression of individuals with ASD. One of the most commonly used interventions is the Picture Exchange Communication System (PECS; Bondy & Frost, 1994) which involves the manual exchange of pictorial symbols for preferred items. An analysis of data from 34 published studies on PECS suggests that this low-tech system is effective in promoting functional communication among individuals with little/no speech, including those with an autism diagnosis (Sulzer-Azaroff, Hoffman, Horton, Bondy & Frost, 2009).

Voice output communication aids (VOCAs), also called speech generating devices (SGDs), represent another commonly used communication intervention for ASD. These devices involve the activation of graphic/pictorial symbols in order to generate the corresponding verbal label, in the form of a digitised/synthesised voice, and have the advantage over picture exchange systems in being readily perceived and understood by communication partners (Lancioni, O’Reilly, Cuvo, Singh, Sigafoos & Didden, 2007). As with PECS, there is emerging evidence of the efficacy of VOCA/SGDs in facilitating communication for those with ASD (Schlosser, Sigafoos & Koul, 2009). In a recent systematic review of the literature on the use of SGDs with individuals with ASD, 78% of

studies were judged to show conclusive evidence of communication intervention effects (van der Meer & Rispoli, 2010).

Most VOCA based research interventions in ASD have involved “medium tech” digitised speech output aids with a limited message capacity (e.g. Schlosser *et al*, 2009), and have predominantly focused on the teaching of requesting, usually for food or drink items (van der Meer & Rispoli, 2010). Undoubtedly, the ability to make successful requests is of critical developmental and psychological importance for non-verbal children (Lancioni *et al*, 2007). Such a strong focus on requesting may however mask the potential of voice output systems to facilitate wider forms of communication in children with ASD (Mirenda, 2008). The recurrent use of meal times further restricts the communicative possibilities of the contexts in which VOCA use is explored (Thunberg, Ahlsten & Sandberg, 2007). Although limited, the evidence is encouraging to suggest that VOCAs may be used by children with autism for broader communicative functions than requesting (Drager, Light & Finke, 2009; Ronski, Sevcik, Smith, Barker, Folan, Barton-Hulsy, 2009). For example, Thunberg *et al* (2007) recorded children with ASD using SGDs to comment and answer questions within their family based activities of book reading and sharing experiences of the pre- school day.

When compared with more limited, medium-tech devices, high-tech VOCAs offer greater scope for researching the broader communicative potential of individuals with ASD. High tech aids run generative language and communication software which provides the user with access to multiple messages, a large spoken vocabulary stored in linked dynamic screens, and the potential for complex expression through sentence assembly (ACE Centre, 2011). Thunberg *et al* (2007), for example, recorded children with ASD using portable touch screen computers which gave access to 279 messages. Indeed, recent technological advances, particularly in the field of mobile computing, are transforming AAC intervention options. For example, functions once confined to dedicated, purpose-built and relatively expensive

communication aids are now accessible on PC and standard operating systems through the use of communication software. The use of high-tech AAC for individuals with ASD would seem particularly apt, given that computer technology appears to facilitate the engagement and learning of people with autism (Bölte, Golan, Goodwin & Zwaigenbaum, 2010). Thus, establishing an evidence base for the efficacy of high-tech communication interventions, which explore forms of communication beyond requesting, is clearly a research and practice priority.

In addition to augmenting communication, complex VOCAs potentially enhance children's language through the opportunities for word combination. Both Thunberg *et al* (2007) and Drager *et al* (2009) report spontaneous symbol combination by participant children who accessed computer-based VOCAs, with more complex expression achieved than typically generated through speech alone. Jamie, age 7.6 years, produced two word utterances with his dynamic screen SGD during the study, which he rarely did unaided (Thunberg *et al*, 2007), and the 3 year old participant in Drager *et al*'s (2009) case study combined concepts to create novel utterances. Further research into the impact of access to high tech VOCAs on the language of children with ASD appears merited by these encouraging reports.

The present study explored how three children with autism and little expressive language used high-tech VOCAs in a classroom context. The research derived from existing practice in a specialist school for children with autism, in which school laptop computers running generative language and communication software were used to create low cost, complex communication aids. A naturalistic intervention approach was adopted; the aids were used in a school curricular context and the children worked with familiar school staff as communication partners. The use of a naturalistic approach, characterised by the functional application of the aid and a transactional understanding of the communication process, is

consistent with other high-tech VOCA interventions to develop complex communication (Drager, 2009; Thunberg *et al*, 2007).

In contrast with many VOCA/SGD intervention studies (van der Meer & Rispoli, 2010), the present study did not examine training the children to use their communication aids. Rather, the research focus was on how the children were able to use their already familiar communication devices in a novel classroom context and thus generalise their VOCA skills to a new setting. This was explored with a mixed methods approach; quantitative data was gathered from classroom observations of the children and qualitative data was collected from staff diaries and parental interviews. Parental data informing on the children's experience of computer-based AAC is reported elsewhere (Checkley, Hodge, Chandler, Reidy & Holmes, 2010).

The present study assessed changes in a range of communicative forms beyond requesting, including giving information and naming behaviours; forms of communication that would be appropriate and relevant to lesson participation. Language complexity was also assessed by examining vocabulary range and mean length of utterance. The children's communication and language was compared across initial sessions in which the high-tech VOCA was not available to subsequent sessions in which access to VOCAs was provided.

The key research questions were as follows: (1) for what communicative purposes do the children use their VOCA in a lesson setting; (2) to what extent do the children use their VOCA, relative to other modes of communication, such as speech; (3) how does access to a high-tech VOCA impact on the children's communication and language? Through these lines of enquiry the research sought to present ecologically valid data on the value of computer communication aids for children with autism and draw conclusions which would remain relevant in the context of rapidly changing and increasingly accessible communication technology.

Method

Participants

Three boys took part in the study, Cameron aged 12; 3, Daniel aged 11;10 and Simon aged 11;6 (years; months). These names are pseudonyms. Each boy had a diagnosis of autism and had severe communication difficulties affecting their receptive and expressive language. All the boys attended different classes. The three boys were selected on the basis of their positive engagement with high tech AAC in individual activities, their level of attention control and their capacity to use a visual vocabulary that exceeded their spoken vocabulary. All the boys had prior experience of using low and high tech AAC including picture exchange and dynamic display software. All the boys used touch pad computer access.

Cameron had an early history of moderate hearing loss and had poor speech intelligibility. Cameron's spontaneous speech was typically single words but he could be cued to say familiar request sentences and produced a series of words when highly motivated. Cameron could give sustained attention to his own and adult led tasks, he enjoyed the challenge of structured work activities. Cameron was generally solitary, but would initiate to make requests and to start playground games with familiar adults. He showed a gradually increasing interest in technological AAC after being introduced to this at age 8.00. Early on for example, Cameron would choose to read a favourite book alone, using a Techspeak & Techtalk 32™ by AMDi to "say" words.

Daniel had severe word finding difficulties, he made semantic substitutions and had no independent word recall strategies. Daniel used drawing as a route for more complex expression including reporting some experiences, thoughts & feelings, such as anger. Daniel was playful with familiar adults and used comic mime in interaction and for some self expression, e.g. pretending to faint when he did not like something. Although his attention

was often affected by video recall, Daniel was considered by staff to be a strong visual learner who could sustain attention to his own and adult led tasks, Daniel showed gradually increasing interest in technological AAC after being introduced to this at age 8.00.

Simon had a diagnosis of obsessive compulsive disorder (OCD) in addition to autism. He needed familiarity and highly structured routines and became anxious without these. Of the three boys, Simon showed the greatest receptive difficulty; he had limited auditory memory, typically recalling only the final word. Simon developed a sudden interest in computers and in digital and computer AAC at age 10 having shown no previous interest.

Setting

The context for the research was a specialist school for children with autism. Data collection for the study took place in the boys' weekly literacy lessons. The VOCAs had not been used in these sessions prior to the research period. The literacy lessons followed a regular structure which included book reading, a whole class talking activity based on the book, and individual literacy tasks. The aim of the whole class talking activity was to provide the group with opportunities for communication and was jointly planned by the class teacher and speech and language therapist. During the planning, relevant vocabulary was identified and programmed on to the boy's VOCA in preparation for this part of the lesson. Talking activities included identifying story characters from images of their footprints in snow, describing the size and colour of exotic fruit and African animals, talking about a range of animals' habitats and describing the location of story objects in a game.

Components of Intervention

High tech VOCA. The children were provided with individual computer-based VOCAs, created using the school's laptop computers. These ran Grid 2™ (by Sensory Software International Ltd) dynamic display, voice output communication software and Ingfield Dynamic Vocabularies (IDV)™, by Connor and Larcher (1997). This gave the

students independent access to a large vocabulary bank and to a flexible sentence building facility with speech output. Students used a combination of single and linked pages created specifically for an activity, together with dynamic, categorical page sets provided by the vocabulary package.

Communication partner. Recognising the central role of communication partners in scaffolding the communication of children who use AAC (Blackstone, Williams & Wilkins, 2007; Von Tetzchner, Brekke, Bjorthun & Grindheim, 2005), each student had a communication partner, from their class staff team, who partnered them in the literacy lesson. Communication partners attended an initial training session which encouraged them to create symmetry and parity in their interaction around the VOCA with the child, using a facilitative and fun style. They used the computer VOCA alongside the student and modelled correct or more complex responses.

VOCA skill development group programme. Throughout the research period, the three students and their communication partners also attended a semi-structured weekly AAC skill development group together. The aim of the VOCA group was to enable students to communicate in motivating, fun, shared activities for a range of communicative purposes. VOCA use occurred alongside other modes of communication including signing and speech. Group activities were based on principles of good practice in AAC drawn from sources including Hazel & Larcher, 2005, Light *et al*, 2005 and Von Tezchner *et al*, 2005. The VOCA skill development group was led by a speech and language therapist; the principal investigator.

Design

A mixed methods approach was used with quantitative observational data collected through the analysis of video recordings and qualitative data derived from staff diaries. The study employed an AB design, according to the absence/presence of computer VOCAs. In the

baseline period of observation, comprising three sessions, participants accessed only their usual low tech paper-based forms of AAC. Cameron used single key word symbols to support his access to the lesson, Daniel had lesson-specific key word sheets arranged to allow sentence building and Simon used a single curricular word board of 40 key words for all 3 lessons. The VOCA was then provided for the children in nine further sessions. A staggered start was used; each participant became the focus of observation six weeks after the previous participant had begun their observation period. This helped to control for extraneous variables within the AB design and also aided project management in a busy school context.

Data Collection

Observational video data. The children's use of communication and language was coded directly from videotapes of eight of the literacy lessons, comprising the three initial sessions and five of the nine sessions in which the boys accessed VOCAs. The five sessions selected for coding included an initial, mid-point and final session with selection being comparable across participants. Videotaping focused specifically on the initial 10 minutes of the "talking activity" portion of the lesson, enabling comparison of the children's communication and language on the same activity across all of the literacy sessions.

The different forms of communication used by the children were scored within the following categories: attention-directing, requesting, rejection, greeting, self-expression, naming, giving information. Communicative acts for which the intention to communicate was unclear were also recorded. Categories were derived from the Pragmatics Profile of Everyday Communication in Children (Dewart & Summers, 1995); a clinical assessment framework for identifying how children communicate their different intentions in everyday contexts. Operational definitions for the different forms of communication were generated to assist coding (Table 1). Each instance of a communicative behaviour observed within the 10 minute talking activity was coded according to the category of communication and the time at which

the behaviour occurred. In addition, the mode of communication used by the boys for each communicative act was recorded. These categories included both single means of communication: voice (speech or vocalisation); manual (sign or gesture); AAC (symbol and text, VOCA); and combined means of communication (e.g. speech and gesture). For each of the 10 minute videotaped excerpts, total frequency counts were calculated for the observed communicative acts in terms of the form and mode of communication.

All videotaped excerpts were first coded by the lead researcher. To examine the reliability of coding the communicative acts, two further researchers were employed to view and code 25% of the videotaped sessions. The codes generated by the raters for these videotaped excerpts were compared using a percentage agreement calculation: $\text{total agreements} / (\text{total agreements} + \text{total disagreements}) \times 100$. Agreement between coders for the frequency of communicative behaviours ranged from 75.9% to 81.4%. For the frequency of specific forms of communication (e.g. attention, requesting), agreement ranged from 70.5% to 75.6%. When coding the mode of communication used (e.g. speech, VOCA), agreement spanned between 85.7% and 96.2%.

In order to examine the use of language, utterances were directly transcribed from the 10 minute video excerpts and examined to give vocabulary range and mean length of utterance (MLU). Vocabulary range was calculated by totalling the number of different words used by the student. MLU was calculated from the total number of intelligible words used in all utterances/total number of utterances which included intelligible words. Utterances classed as unclear or as using no vocabulary (such as musical vocalisation) were not included. Where an utterance used a single VOCA word cell containing more than one word, for example, "*Gruffalo's child*", the number of cells combined by the child rather than the number of words expressed was used to calculate MLU. Repeated words in a single communicative act using a VOCA were counted only once. Vocabulary range and MLU were

calculated based on the production of words through any mode of communication, not just speech.

Staff Diaries. Class teachers and the communication partners completed semi-structured records to evaluate the child's use of the VOCA in each session. Staff were asked to record instances of VOCA use by the child which they considered interesting or impressive during the session, and to record their general observations and comments on VOCA use. Diary summaries were prepared and returned to staff for their verification, to ensure that the researchers had interpreted their comments appropriately.

Results

Communication

Use of VOCA. Observational data were first examined to explore how the children were using their VOCAs during the sessions. In terms of frequency and form of communicative acts, video data showed that Daniel used the VOCA mostly to give information, whereas Cameron and Simon used the VOCA predominantly to name (see Figure 1). Further analysis was performed to explore the content of all communicative acts coded as giving information and naming. Judgements of relevance were made based on the video analysis notes, with each communicative act categorised as task related, non task related or ambiguous. At least 98.5% of each boy's communications were categorised as task related. An example of non task related "giving information" is Simon's use of *Owen toilet* (speech) to comment about another pupil.

[Insert Figure 1 about here]

Staff diaries also record participants giving information and naming as part of the class activity. All the diaries record that the boys answered questions with the VOCAs, using single words and word sequences; "Cameron confidently switched between 2 grids and answered all questions correctly." "Daniel had no problems using new grids to answer

questions”. “Simon combined speech and VOCA to give 2/3 keyword responses”. Daniel’s partner additionally records his use of the VOCA for a spontaneous request to be first in a game, and an incidence of self expression in which he used a word cell from the class rhyme activity screen, “boo”, to initiate a game with her. She comments; “In very playful mood – playing “boo” with me and enjoying my reaction”. This is the only description of a child using the VOCA for self expression in the diaries. Where self expression is recorded, other modes of communication are used. Cameron’s partner for example, describes how his self expression was supported instead with his familiar paper symbols when he was upset by noise. Our data thus records that in using the VOCAs for naming and giving information, the boys were generally using the aids to augment their task relevant communication. Other communicative intentions were rarely expressed through the VOCA.

Mode of communication. To consider the extent to which the children made use of their VOCA relative to their other modes of communication, an analysis was made of the total number of communicative acts performed using: (a) speech/vocalisation, (b) VOCA, (c) speech and VOCA combined, and (d) methods not involving speech or VOCA (e.g. gesture). Mean percentage scores for the different methods were then calculated across these five videoed sessions (see Figure 2). This revealed that, although use of the VOCA was made, speech and vocalisation remained the main mode of communication. For each child, there was variability in the use of VOCA across the five sessions; most strikingly for Cameron (VOCA use accounted for 0-54% of his communicative acts) but with more consistent VOCA use for Daniel (35-43%) and Simon (22-30%).

[Insert Figure 2 about here]

Staff diaries also indicate the differing extent to which each child selected to use the VOCA in the literacy lessons. Daniel always used the VOCA; “He definitely enjoys using the VOCA, he uses it with no hesitation or prompting.” Cameron made more variable use across

the sessions. In an early session his partner recorded, “Didn’t seem interested in using his laptop, he looked at the screen but answered verbally”, but this changed in the later sessions; “He wanted to use the VOCA as soon as I asked the first question.” Simon’s staff diaries record irregular use. For example, the first diary record notes. “Confident and calm use of VOCA”, for the following session the diary records his rejection of the VOCA.

Communication in baseline and intervention phases. To explore patterns of change in communication, mean scores were calculated for the three baseline sessions and five VOCA sessions, based on the total number of communicative acts used in each session and the forms of communication used (see Table 2). In addition, the percentage of non-overlapping data (PND) was calculated. PND provides a quantitative index of intervention effectiveness in single case designs by comparing the percentage of data points in an intervention phase which exceed the highest data point in the baseline phase. A PND score of 100% for example indicates that all of the data points in the intervention phase exceeded the highest baseline data point. A PND of at least 70% is taken to suggest effectiveness of intervention (Scruggs & Mastropieri, 1998). In the present study, PND was calculated to compare between baseline and intervention sessions and examine the consistency of any change observed.

[Insert Table 2 About Here]

The data displayed in Table 2 presents the individualised patterns of change recorded in the communication of each child after the VOCA was introduced. Daniel demonstrated a clear decrease in communication when he accessed the VOCA. Notably, Daniel’s level of requesting and naming behaviour declined when the VOCA was available to use, but an increase in giving information is recorded. By contrast, both Cameron and Simon showed an overall increase in communication when the VOCA was introduced. For Cameron, the suggested increase in communication when the VOCA was available appears to relate to an increase in self-expressive behaviours. For Simon, who uses a more varied range of

communicative acts than the other boys, an increase in giving information, naming and rejection are noted during the VOCA intervention. Our analysis thus records individual variability in children's communication, both before and after they accessed the VOCA. The only reliable pattern of change in the communication data was shown by Daniel, who showed a greater number of communicative acts during baseline sessions than in any of the intervention sessions (as indicated by a PND calculation of 0%).

Language

To consider how language use was influenced by access to a VOCA, vocabulary range and MLU were examined from the three baseline sessions in comparison to the subsequent sessions when the VOCA was present. In addition to inspecting mean scores, the percentage of non overlapping data points (PND) was calculated (see Table 2). The mean scores suggest that all three boys show increased vocabulary ranges when they accessed VOCAs. However, the PND figures indicate that this was not consistent across sessions for Cameron and Simon, only Daniel showed a reliable increase in vocabulary range.

A more stable pattern of findings was indicated in relation to MLU (see Table 2); all boys showed a consistent increase in the number of words combined, after the introduction of the VOCAs. This change was most marked for Daniel and least notable for Simon.

Staff diary records also indicate the language complexity achieved using the VOCA. Daniel and Cameron are described as readily building sentences, moving between the activity pages to assemble word sequences, which they edited and self corrected. Daniel and Cameron are also described as spontaneously adding information, providing more than the required response. "Cameron built sentences to match pictures". "He assembled his answer and added more to the sentence without being asked". "Daniel naturally builds sentences, swapping from different pages" "He was able to select the words he wanted to use, to add information". "Daniel wanted to add more information. For the picture of a zebra he built, "black white

zebra orange orange”, he’d remembered the zebra eating the orange”. Simon’s session diaries also record his use of linked words, but record that he was generally dependent on prompts to assemble words.

Discussion

The present study adapted existing practice within a specialist school to record how three boys with autism used their computer-based VOCA's in a novel classroom context. Both quantitative and qualitative data were collected to assess the boys' communicative acts and their language during sessions in which the VOCA was absent or available for use. The boys were found to use their VOCAs for two main communicative purposes; naming and giving information. A small number of examples of other forms of communicative acts are recorded for Daniel, including spontaneous requesting and the spontaneous self expression of a playful intent. However, analysis of the content of the communications, supported by the staff dairy records, led us to conclude that the aids were primarily used for curricular, task-related expression. In addition, the diaries suggest that for two of the boys this was achieved with notable independence. These findings therefore offer evidence that children with autism can use computer-based VOCA technology to support additional forms of communication beyond those reported elsewhere. Thunberg *et al*, (2007) characterised their SGD research environments in terms of the communicative “roles and goals” that each context provided for the child and their communication partner. They concluded that “the introduction of a SGD gave the children better possibilities to fulfil these roles and goals” and that the children “got credit for this” (p 471). Our data allows a similar interpretation; the VOCAs facilitated the children’s ability to meet the communicative expectations of their lessons and so supported their participation. Although the communication software offered wide expressive potential, this study thus recorded that the communication technology was used by the boys for specific

communicative purposes within their range of modes of expression. It functioned principally to support their curricular communication and participation.

The extent to which the children used the VOCA, in comparison to their other modes of communication was analysed, and individualised patterns were observed. For all the boys however, speech and vocalisation remained their preferred mode of communication after the VOCA was introduced, and all the boys continued to use their established modes of communication in addition to the VOCA. We concluded that the children used the complex VOCA technology to augment their communication; it did not replace their existing modes of communication in the lessons.

Monitoring the children's frequency and form of communication across baseline and VOCA sessions revealed highly individualised patterns of change. Simon had a strong need for consistency and high frequencies of rejection were associated with changes to Simon's lesson routine. In Cameron's case, a rise in communicative acts categorised as self-expression was recorded. These acts principally took the form of musical vocalisation and self talk which appeared to link to his cognitive processing while he used the VOCA. Daniel showed a clear decrease in the frequency of communication when the VOCA was provided, although the number of instances of giving information increased. This may be accounted for by the extended time taken by Daniel to assemble and edit the complex constructions so categorised. For example, in a story-based game, he searched through several pages to locate the words to describe the toy spider held by a staff member who was wearing a goat mask, *Spider goat (VOCA) Hannah (speech)*. It took a similar time to assemble and edit his description of a macaque monkey and its baby; *Big white black grey monkey small white pink monkey (VOCA)*. Thus within their individualised patterns of communication, changes were identified which were particular to each child. These changes are suggested to relate to the boys' tolerance of change, processing behaviours and the time taken for word location and

assembly with a VOCA. Individualised responses to computer-based VOCAs are also reported by Checkley et al (2010) who describe children's different levels of enthusiasm for this technology.

A consistent change, recorded in the language of all the boys, was an increase in their mean length of utterance. All three boys included more words in their communication when they had access to a high tech VOCA, although the number of words combined by the boys varied. Staff diaries record that for two of the boys this included spontaneous and independent language construction; they assembled words and added information beyond that expected in the activity. Our study thus suggests that all the boys were able to achieve greater language complexity in their task focused communication when the VOCA was available. Although some of the boy's complex expression was achieved directly through the use of the VOCA to assemble words, the staff diaries suggest the VOCA also had an impact on children's spoken language. For example staff recorded, "The VOCA helps Daniel recall words he would normally struggle with verbalising". "Simon appears to use it as a "word recall" device. He points to a symbol then repeats verbally (with or without activating the cell)." "Cameron seemed to use screen for visual clarification before verbalising answers". The implication of the diary records is that the aids facilitated the boys' language processing in various ways. The VOCAs may have impacted on memory, promoting word recall and the combination of words, and may have promoted meta-linguistic activity (i.e. thinking and talking about language) leading to conceptual refinement and sentence revision. The aid may also have clarified task expectations and so built the boys' expressive confidence. Our naturalistic study however, does not allow us to conclude that VOCA access alone facilitated this change in language. Checkley (2006) and Thunberg, Ahlsen & Sandberg (2009) report changes in adult expectations and adult-child interaction around VOCAs. Similarly in this study, changes in the adult-child relationship after the introduction of the aids may have

impacted on the children's language. Thus, although we cannot identify specific explanatory processes, our research adds to the observations of Drager *et al*, 2009 and Thunberg *et al*, (2009), by recording a positive impact on their complexity of the language when children with autism access a computer-based VOCA intervention.

Clinical Relevance

By recording the potential of high tech VOCAs to support the communication of students with autism in their school activities, this study offers parents and practitioners a basis for considering their value in promoting children's educational inclusion. In addition, this study suggests that by facilitating students' use of richer expression than may usually be achieved through low tech AAC and their existing modes of communication alone, VOCA interventions may empower students to express a more complex understanding of and response to an activity, and so enhance their participation.

The very specific communicative use which the students made of the dynamic screen vocabulary software has relevance for the resourcing of communication technology for students with autism. This outcome points to the value of context specific AAC solutions to support the communicative participation of young people with autism. It is recognised that no single device is able to meet all an individual's needs and that the price of comprehensive communication aids can be prohibitive (AAC-RERC, 2011). The implication of the study is that specific and limited sets of dynamic screen software (such as available through apps) may offer sufficient resources to enable students to meet the communicative expectations of particular educational contexts. Exploring specialised communication apps, such as the parent designed Grace App (2011), would appear to be merited. In addition recent research interest in the use of i-pod and i-pad technologies, to provide SGD's for young people with autism (Kagohara *et al* 2010; AAC- RERC, 2011) may identify valuable new options for increasing access to enabling communication technologies.

Limitations

In considering our findings, no attempt has been made to evaluate the relative impact of the different intervention components, such as the role of the communication partner, on the communication and language outcomes for the children, although this may form the basis for future research. Rather, our present focus was on the integrated impact of these components. Furthermore, it was not possible to attain full control of all variables which may have impacted on the students' communicative intent and communication opportunities. These include staff training, adult/child interaction patterns, consistency of staffing, and aspects of classroom environmental management. Ideally too, a greater number of baseline and intervention sessions would have been used which may have revealed more established trends in the data, given the variability in outcome measures across trials. However, the management of the research sessions and number of trials was constrained by practical and ethical considerations, given that the research was taking place within a naturalistic setting as part of the school timetable. Thus we recognise that whilst the setting of the study lends ecological validity to our findings, this was at the partial expense of methodological rigour and control.

Conclusion

This school based study reports that children with autism and significant communication difficulties can use computer-based VOCA technology to support additional forms of communication beyond those reported elsewhere. Specifically the findings suggest that VOCAs may be used by some children with autism to augment their existing modes of communication in their curricular, task focused communication and that access to this technology is associated with positive changes in children's language complexity. The study

therefore concludes that access to high tech VOCAs may aid the communicative participation of children with autism in their lesson activities by augmenting their ability to meet the communicative expectations of lessons and enabling them to express a more complex response to the activities. However, although the boys accessed generative software offering broad communicative potential, they used their VOCAs for specific and limited communicative purposes. Thus while providing evidence for the inclusive value of computer-based AAC for children with autism, the study can also lead us to reconceptualise expectations of communication technologies for such children. Access to limited and inexpensive technological AAC solutions such as apps, rather than comprehensive communication software, may be of appropriate functional value.

This study cautions us to anticipate children's individualised responses to access to communication technology. However the paper offers evidence of the enabling and inclusive potential of such technology for children with autism in their classroom settings. The study thus provides initial empirical and naturalistic evidence to inform decision making within the current AAC technology context of development and change, and points to the value of continued research in this area.

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Table 1

Operational definitions for the different forms of communication generated to assist coding

Form of communicative act	Operational definition with examples
Attention directing to self or to other people and objects.	Child communicates to get someone’s attention or to share their interest. Examples; moves partner’s face, communicates “look”.
Requesting: objects, actions, help, more and information.	Child asks for something or asks a question. Examples; uses related word to request. Makes a choice when given alternatives. Points to what is needed. Communicates “help”.
Rejection	Child communicates no, I don’t want it, finish or go away. Examples; says “finish”, pushes away.
Greeting	Child greets or says goodbye. Example, waves.
Self expression, self assertion of emotion, humour and independence.	Child expresses positive and negative feelings or asserts their independence. Examples, smiles and laughs, shows curiosity with new VOCA word page, Gets cross, taps face. Musical vocalisation, video talk and solitary play are included here.
Naming	Child names what they see or are thinking about. Echoing single words and phrases where the referent is present or meaningful to the student. Examples; Uses single words to respond to questions eliciting labelling, e.g. “what’s this?”
Giving information.	Student gives additional information, beyond naming what they can see. Examples; calls out additional relevant words. Adds sounds effects or gesture. Sentence builds to use 2 or more words, guesses what will come next.

Table 2

Mean scores for communication measures, vocabulary range and MLU for Daniel, Cameron and Simon in baseline and intervention phases.

Communication	Daniel	Cameron	Simon
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Total number of communicative acts			
Baseline Mean	63.00	29.33	106.33
Intervention Mean	36.60	39.60	135.00
PND	0%	60%	60%
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Self-Expression			
Baseline Mean	14.67	7.33	25.33
Intervention Mean	15.4	13.20	27.20
PND	0%	60%	0%
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Giving Information			
Baseline Mean	6.33	0.33	3.67
Intervention Mean	9.20	1.60	10.00
PND	60%	20%	60%
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Naming			
Baseline Mean	21.33	15.67	63.00
Intervention Mean	8.40	17.60	70.80
PND	0%	40%	60%
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Attention			
Baseline Mean	0.00	0.00	1.33
Intervention Mean	0.40	0.00	0.40

PND	20%	-	0%
<hr/>			
Requesting			
Baseline Mean	16.00	0.00	2.33
Intervention Mean	0.60	0.00	3.60
PND	0%	-	40%
<hr/>			
Rejection			
Baseline Mean	0.00	1.33	0.33
Intervention Mean	0.60	0.00	9.00
PND	20%	0%	60%
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Language	Daniel	Cameron	Simon
<hr/>			
Vocabulary Range			
Baseline Mean	15.67	8.00	32.33
Intervention Mean	20.60	12.60	39.20
PND	80%	60%	40%
<hr/>			
Mean Length of			
Utterance (MLU)			
Baseline Mean	1.36	1.03	1.04
Intervention Mean	2.75	1.60	1.20
PND	100%	100%	100%
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Figure Captions

Figure 1. Percentage of communicative acts using VOCA, categorised according to form of communication. Percentages are provided for 'giving information' and 'naming' categories only.

Figure 2. Mean percentage of communicative acts using the different modes of communication. Percentages are given for speech/vocalisation and VOCA only.

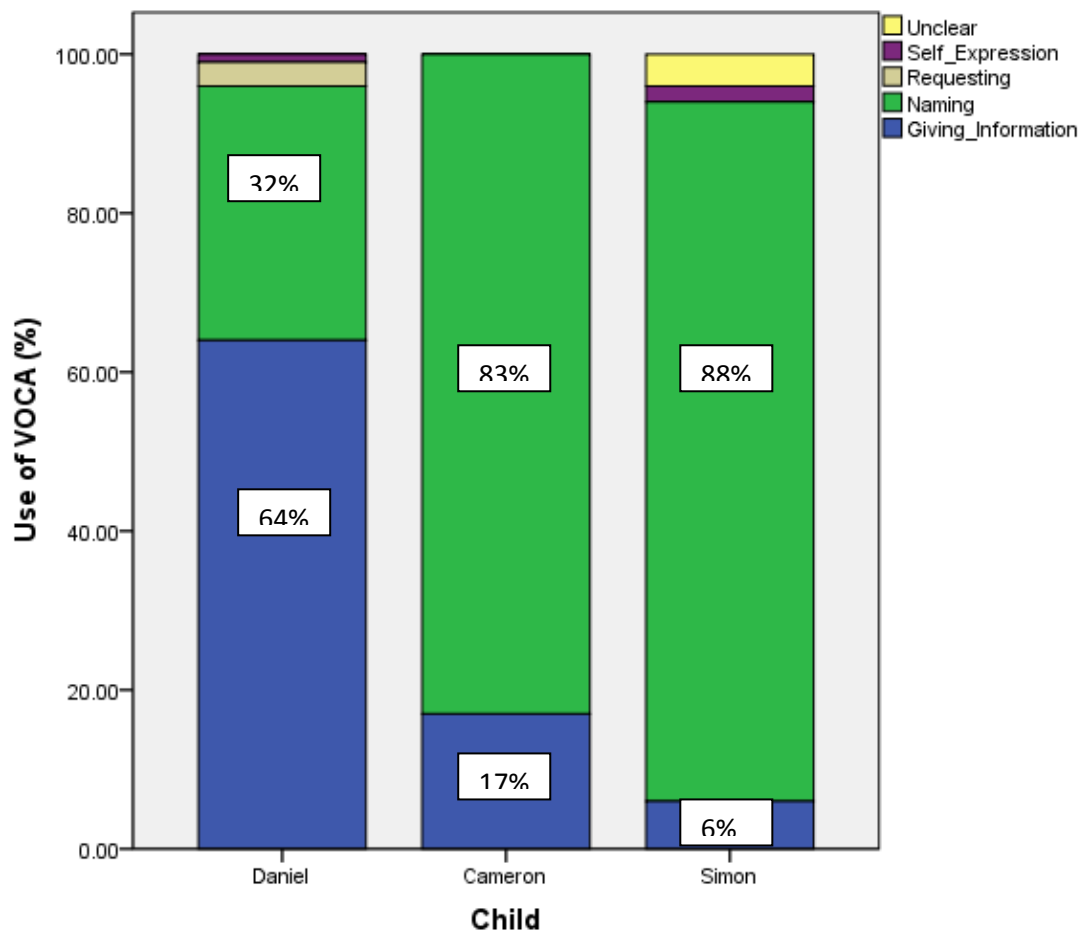


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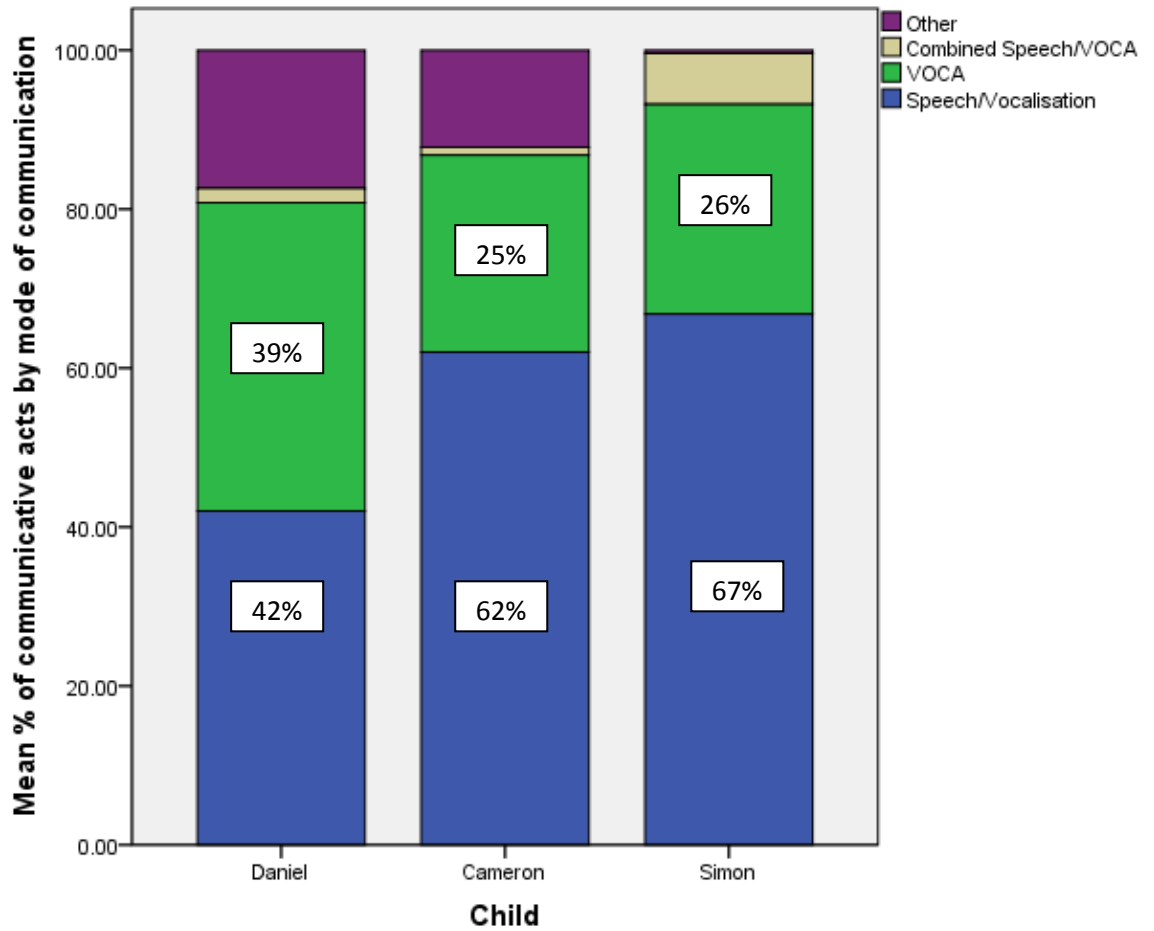


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