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Acquisition and Generalisation of Key Word Signing by Three Children with Autism

Xuet Ying Tan

Department of Human Communication Sciences, La Trobe University, Australia

David Trembath

Griffith Health Institute, Griffith University, Australia

Olga Tennison Autism Research Centre, La Trobe University, Australia

Karen Bloomberg

Department of Human Communication Sciences, La Trobe University, Australia

Teresa Iacono

La Trobe Rural Health School, La Trobe University, Australia

Teena Caithness

Department of Human Communication Sciences, La Trobe University, Australia

Correspondence:

David Trembath

Griffith Health Institute

Griffith University QLD 4222

E: D.Trembath@Griffith.edu.au

Abstract

Objective: The aim of this study was to examine the effect of Key Word Sign intervention on the acquisition and generalisation of manual signing among three children with ASD, and to measure any changes in their production of spoken words and gestures following intervention.

Methods: A multiple baseline single-case experimental design to measure changes for each of the three children.

Results: All three children began using signs following the introduction of the KWS intervention, and generalised their use of some signs across activities. The introduction of the intervention was associated with either neutral, or statistically significantly positive, changes in the children's production of spoken words and natural gestures.

Conclusion: The results provide preliminary evidence for the effectiveness of KWS for preschool children with ASD, which parents, therapists, and educators can use to inform clinical practice.

Introduction

Much research attention has focused on developing communication skills in children with Autism Spectrum Disorder (ASD) in light of evidence that up to 28% may not develop functional speech [1]. Given that language development is a key prognostic indicator for long term outcomes for children with ASD, establishing a means of functional communication has been recommended as the primary goal of intervention for these children [2]. In particular, Augmentative and Alternative Communication (AAC) in the form of graphic symbols on low or high technology communication aids, or manual signs or gestures, has been found to facilitate the development of symbolic communication in children with ASD [3]. AAC constitutes an intervention strategy that is most effective when used in conjunction with other evidence-based strategies that address an individual's learning needs and considers communication partners and social contexts [4].

Researchers have proposed two main reasons why AAC might benefit children with ASD. First, and most commonly, AAC is believed to harness relative strengths in visual processing of information reported in children and adults with ASD. Although evidence for this relative strength in visual processing is based primarily on anecdotal reports [e.g., 5], there is some evidence that children with ASD may perform better in instructional tasks when provided with visual (pictures or manual signs) than auditory (speech) instructions [6,7]. Lloyd and Fuller [8] suggested that information presented in the visual modality (in particular, pictures symbols) is less transient, thereby assisting retention, and provides additional cues to decipher abstract symbols in speech. Second, the use of recognisable and tangible communication symbols may also help the communication partner interpret children's communication attempts, thereby helping them respond to children's communication in a meaningful way [9]. Parents and professionals seeking to support children with ASD must choose from a range of aided and unaided AAC options.

With the advent of cheaper and more accessible technology in recent years, there has been growing interest in the use of aided forms of AAC (e.g., tablet PCs). However, researchers have also identified several drawbacks to aided AAC strategies, including problems with selecting symbols, issues with portability, and inadequate staff training leading to children being denied access to their communication aids [9,10]. Unaided strategies, including manual signs and gestures, overcome some of the disadvantages of aided systems, in particular, the need for ready access to a piece of equipment [9]. Manual signing also avoids the disruption in interaction that occurs when the person using AAC must return to his/her aid to formulate the next message [9]. However, the implementation of any AAC system still requires careful vocabulary selection [11] and communication partner training [12]. In addition, manual signing also presents disadvantages compared to aided systems, including the reliance on others in the environment to recognise signs and the reliance on recall rather than recognition memory [13]. Furthermore, there has also been concern expressed by families that use of manual signs and other forms of AAC may interfere with speech development [14,15]. However, this concern has been dispelled in terms of lack of evidence, with some studies demonstrating that AAC, in the form of manual signs or aided low tech system, being associated with gains in speech production [16].

Manual signing

Early AAC research involving children with ASD focused on measuring the acquisition of signing amongst children with little or no functional speech. Carr, Binkoff, Koliginsky, & Eddy [17], for example, taught four children with ASD who used little or no functional speech to use expressive sign labels for five common household objects. Subsequent studies compared the relative benefits of ‘sign-only,’ ‘speech-only,’ and ‘sign and speech’ interventions in supporting the expressive communication of children with ASD. The results indicated that simultaneous communication (sign and speech) was superior to

sign-alone or speech-alone conditions, resulting in (a) increased speed of acquisition of expressive signing [7,18]; (b) increased receptive comprehension [19] (c) better generalisation [7,20]; and (d) acquisition of speech in some participants [7,20]. There is also preliminary evidence [e.g., 19,21] to suggest that sign-based interventions may be effective in supporting the comprehension of children with ASD.

Wendt [3], in the most recent systematic review of research examining the use of sign-based interventions for children with ASD, identified preliminary evidence for their effectiveness in enhancing symbol acquisition and production; improvements in speech comprehension and production. However, he also noted that many studies failed to provide conclusive evidence as a result of problems with methodological rigour, including lack of treatment fidelity and poor inter-observer agreement. The relative lack of recent evidence into the use of manual signs with children with ASD may reflect simply a tendency for the research literature to focus on aided, and in particular, high technology AAC. Iacono et al. [22] argued that the focus on high-tech AAC is at odds with the approaches most commonly used by speech pathologists, parents, and teachers in everyday practice. Research into KWS is therefore needed to ensure that AAC intervention provides a more comprehensive multi-modal approach than is afforded by offering high and low-technology aided systems only. Such multi-modal approaches enable individuals to opt for preferred AAC modalities, which may vary across situations and has been argued to increase motivation and improve success [3].

Key Word Sign

Key Word Sign (KWS) is an unaided form of AAC commonly used in clinical practice to support the comprehension and expression of children with ASD [23], but for which few empirical data exist. Using KWS, the communication partner creates a signing environment in which signs adopted from the Deaf sign language for a country are used.

Manual signs for key words are used as normal grammatical sentences are spoken. The manual signs used incorporate features from sign language, including directionality and placement. These features increase intelligibility of the message as the signs provide visual cues (visual-spatial, visibility) to the spoken message [23].

The fundamental goal of KWS is to support the development and use of functional communication. Specifically, KWS is designed to support children and adults with complex communication needs to communicate their needs or wants, exchange information, establish social closeness, and practise social etiquette [24]. Consistent with other AAC interventions, KWS intervention must enable children and adults to communicate effectively with a range of communication partners across all social contexts. However, children with ASD are known to have difficulty generalising newly acquired skills to new environments [25]. Studies, such as those by Remington & Clarke, have examined maintenance but failed to directly address generalisation, and these highly didactic approaches have been criticised for failing to result in spontaneous and meaningful communication [13]. Therefore, there is a need to ensure that intervention approaches aimed at supporting the social-communication development of children with ASD include clear strategies for supporting generalisation [26].

Generalisation

A critical step towards supporting the generalised use of AAC strategies, such as KWS, is to ensure that children have access to appropriate vocabulary [11]. Studies involving typically developing children and adults [11,27], as well as studies involving children with disability [28], have indicated the need for access to both *core* and *fringe vocabulary*. Core vocabulary comprises words and messages that are frequently and commonly used by most people and across a range of situations [29]. Fringe vocabulary, on the other hand, contains highly individualised and context specific words and messages and is different for each person [29]. In recent years, it has been suggested that AAC interventions should focus on

teaching core vocabulary, due to the capacity of these words and messages to be used across a range of contexts, thus supporting generalisation [11]. However, no studies have been conducted to examine specifically the generalisation of core vocabulary for young children who use AAC. Therefore, there is a need for research into the effectiveness of AAC interventions to identify and address the issue of generalisation directly in order to ensure meaningful outcomes.

The aim of this study was to examine the effect of KWS intervention on the acquisition and generalised use of core signs, fringe signs, natural gestures, and spoken words among children with ASD. Our predictions were: (1) children would acquire both core signs and fringe signs as a result of the intervention; (2) due to the relevance of core vocabulary across activities, the children would generalise their use of core signs from play activities in which KWS had been modelled, to other play activities in which KWS modelling had not yet been provided; (3) due to the context specific nature of fringe vocabulary, children would produce fringe vocabulary only during play activities in which such vocabulary was modelled, and not generalise to other play activities; and (4) that the introduction of the KWS intervention would be associated with either a neutral effect or positive increase in the children's production of spoken words and gestures.

Methods

Ethics approval

Approval for the conduct of this study was obtained from the La Trobe University Human Ethics Committee.

Design

A multiple baseline across condition single-case experimental design with direct repetition across three participants was used to examine the acquisition and generalisation of targeted signs across three play activities. The independent variable was the Key Word Sign

(KWS) intervention delivered in accordance with the KWS methods outlined by Brownlie et al. [23], and introduced gradually into the three play activities. The primary dependent variables were the children's production of core signs and fringe signs. The children's production of natural gestures and spoken words were recorded during the sessions for the purpose of exploratory analysis.

It is important to note that we used the multiple baseline design for two separate purposes in this study. First, in order to examine intervention effects and demonstrate experimental control, we used the design to examine each child's acquisition and use of fringe signs across activities over time. These signs were specific to particular play activities, and so, should not have appeared until after they were taught. Second, we examined the children's acquisition and use of core vocabulary across activities over time, to determine whether or not the children generalised their use of core signs from activities in which teaching had been provided, to those in which no teaching had yet been provided.

Participants

The participants were three male children aged 3-4 years, with a formal clinical diagnosis of ASD confirmed by the research team using the Autism Diagnostic Observational Schedule [30]. The children were recruited through advertisements distributed through professional forums, early intervention services, and allied health professionals who provide support to children with ASD. The participants met the following inclusion criteria of (a) English being the primary language spoken at home; (b) demonstration of intentional communication based on parent report and observation during intake assessment; (c) assessed as having moderate-severe expressive language delay using the Mullen Scales of Early Learning [MSEL; 31]; (e) demonstrated adequate upper extremity gross motor skills and indications of potential to produce motor movements on the MSEL; and (f) no reported hearing or vision impairments. A summary of participant characteristics are provided in Table

I. Pseudonyms have been used.

Insert Table I about here

John was 3 years and 2 months old at the commencement of the study and communicated mostly using vocalizations, eye gaze, pointing, and actions. He made requests by taking an adult by the hand or pointing, and expressed objection using his vocalizations or by pushing, turning, or moving away. John occasionally waved goodbye but used few other gestures. He found it difficult to adjust to changes in his routine and often became anxious when transitioning between activities. At childcare, John appeared happy to play alongside other children, but he rarely initiated interactions or engaged in cooperative play.

Kenneth was 3 years 11 months old and also communicated mostly through his vocalizations, occasional pointing, and actions, including taking an adult by the hand. He occasionally said “no” to reject an object or another person’s approach, but usually communicated rejection by pushing the object or moving away. Kenneth was generally unresponsive to others’ initiations, and his interests were keenly focused around cars, trains, puzzles, and books. He tended to play alone and to avoid other children, but did tolerate the approaches of familiar adults. Kenneth found transitions very difficult and often became upset when preferred items were packed away or removed, as expressed through crying, screaming, and physical actions.

Liam was 4 years 1 month old and had the most advanced communication skills of the three children, as reflected in his scores on the receptive and expressive scales of the MSEL (see Table I). He used a combination of words, gestures, eye gaze, and actions to express his needs and wants, to greet, and to share information. However, his speech was comprised mostly of unintelligible jargon, meaning that while he displayed clear intentional communication, even his parents and familiar communication partners had difficulty understanding his communication. Liam appeared interested in interactions, but required his

communication partner to scaffold play and, like John and Kenneth, often became upset during the transition between activities.

Setting and materials

The study was conducted in a clinic room measuring approximately 4 x 4 metres in a University clinic. Three cupboards were used to house three separate sets of toys (6 in each). These 18 toys were chosen on the basis of being common in preschool settings and to encourage imaginative, constructive and sensory play. There was a child-sized table with two chairs in the room that were used for table-top play activities.

Session structure

The baseline and intervention sessions comprised three 10-minute segments during which the clinician and child played with the set of 18 toys. Prior to intervention, the toys were randomly assigned to three cupboards (A, B, and C) to allow for the staggered introduction of intervention over time and evaluation of generalization effects. During each session, the clinician engaged the child in play activities using only toys from one cupboard at a time for each 10-minute segment, in the order of Cupboards A, B and C. A timer rang at the end of each 10-minute segment and the clinician gave notice that it was the end of the activity and encouraged the child to help pack away the toys into the box and cupboard.

Intervention description

The treatment was delivered by a speech pathologist (5th author), blind to the children's pre-treatment assessment results, according to the procedures outlined by Brownlie et al. [23]: (a) signing using appropriate signs and natural gestures with corresponding spoken words, (b) incorporating signs in natural interactions, (c) providing opportunities for the child to communicate, and (d) responding to the child's communicative behaviours. In cases where children did not respond to the clinician she simply modelled the sign and continued the

activity. Note that treatment did not include any direct teaching of Key Word Sign (e.g., hand-over-hand guidance to produce signs).

To help ensure treatment fidelity, a set of play scripts relating to toys in the three cupboards were developed. The script contained examples of (a) key words signed in a sentence, (b) descriptions of directionality and placement used in signs, (c) interactive turn taking, and (d) ideas for creating communicative opportunities. However, in order to replicate clinical practice, the clinician was not restricted to a subset of signs or a specific number of sign productions. The limitations of this approach are discussed in the limitations section. Parents/caregivers attended their children's treatment sessions. However, in an attempt to maintain fidelity of treatment across participants, parents were not encouraged to participate or interact with the child during the sessions, and were instructed not to initiate use of KWS with their children at home during the course of the study. Parents were provided with the opportunity to complete a Key Word Sign training course at the completion of the study, and were given a copy of the Key Word Sign dictionary [32].

Baseline

During the baseline sessions, the clinician followed the children and responded to their communicative attempts, but did not model the use of KWS. The clinician also created natural opportunities for the children to communicate and responded to his potentially communicative acts in a meaningful way. The children were exposed to all 18 toys during baseline sessions to ensure that they had an opportunity to demonstrate any prior learning of signs associated with particular toys. Once a stable baseline was established for each child on the dependent variables related to sign production (core signs and fringe signs), the first intervention phase commenced.

Intervention

The KWS intervention was introduced in a staggered fashion in three phases. During *Phase I*, the structure of sessions was the same as for baseline, except that the clinician modeled the use of KWS during play with toys from Cupboard A during the first 10-minute segment. To illustrate, instead of the clinician saying “Do you want more?” using words alone, she said “Do you want *more*?” and signed MORE concurrently. During the remaining two 10-minute segments (playing with toys from Cupboards B and C), KWS was not used as per baseline conditions. During *Phase II*, the clinician modeled KWS during play with toys from Cupboards A and B. No modeling of KWS was provided during play with toys from Cupboard C, which was consistent with baseline conditions. During Phase III, the clinician modeled KWS during play with toys from all three cupboards.

Follow-up

At two weeks post-intervention, children attended a follow-up session which involved two 15-minute activities. During the first activity, the clinician instituted baseline conditions. During the second activity, she modeled KWS. This provided an opportunity to observe the children’s maintenance in sign-free environment followed by a signing environment, thus enabling us to consider the possibility that children may be more likely to sign in the presence of an adult using (and thus validating) the same communication mode. Consistent with baseline procedures, all 18 toys were randomly sorted into two cupboards in an attempt to control for stimulus saliency and the children were allowed to choose toys from one cupboard at the first 15-minute activity and then from the other cupboard at the second 15-minute activity.

Data coding

The first author, who was blind to the children’s pre-treatment assessment results, coded the baseline, treatment, and follow-up videos using the Noldus Observer XT 9.0 [33]. The target behaviours (children’s production of core signs, fringe signs, natural gestures, and

spoken words) were coded using continuous time-sampling with 10-second intervals. For each interval, the coder identified whether or not (yes/no) the child had produced each of the four predetermined target behaviours. The number of intervals in which the child produced each target behaviour was expressed as a proportion of all intervals for the purpose of analysis.

Data analysis

Visual analysis was completed for each graph in order to examine changes across, and trends within, phases. Tau-U analysis was then conducted using an online calculator to determine the effect size and statistical significance [34]. Tau-U provides a measure of data non-overlap between two phases, in this case, baseline and intervention. It is a distribution free, nonparametric technique suitable for small data sets that do not follow a normal distribution. Alpha was set at 0.5; a Bonferroni correction was not applied as the measures tested were dependent [35].

Reliability coding

A research assistant, blind to study aims, hypotheses, and the children's pre-treatment assessment results, completed reliability of 20% of sessions randomly selected across all baseline, intervention, and follow-up sessions. Reliability was calculated for each video by dividing the total number of intervals in which the coders agreed, by the total number of intervals in which they both agreed and disagreed, and then multiplying by 100 to yield a percentage [36]. The average reliability index for videos in baseline conditions was 93% (SD 3.9), with a range from 85% to 97%; and the average reliability index for videos in intervention conditions was 89% (SD 2.7), with a range from 84% to 93%.

Treatment fidelity

To measure the extent to which the KWS treatment was carried out as planned, the first author (primary coder) also coded each interval of each video according to whether or not (yes/no) the treating clinician modeled the use of KWS. During intervention, on average, the clinician modeled signs in 77% (SD 5.89, range = 58-90) of 10-second intervals with John, 66.89% (SD 12.84, range = 44-86) of intervals with Kenneth, and 77.44% (SD 8.67, range = 62-87) of intervals with Liam. The reliability coder also completed a 5-item fidelity rating scale for each of the 20% of videos she coded. For each item, she was required to respond to the question using a 5-point likert rating scale (1=strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The results were: (1) Mean=4 (Mode=4, SD=0) for “*only key words in speech are signed*”; (2) Mean=3.72 (Mode=4, SD= .47) for “*provided opportunities for child to communicate*”; (3) Mean=3.64 (Mode=4, SD= .50) for “*use of directionality*”; (4) Mean=3.18 (Mode=3, SD= .75) for “*use of placement*”; and (e) Mean=4 (Mode=4, SD=0) for “*responded to child’s signals in a communicative manner*”.

Results

Session details

Data were collected over a period of 12 weeks, comprised of a minimum of three baseline sessions, three sessions per intervention phase, and one follow-up session. For John, data from one intervention session were not used because of a failure of recording equipment. Also, despite strategies to restrict sessions to 10 minutes, they each continued longer in order to allow appropriate time to transition between cupboards. Baseline sessions were of an average duration of 36 minutes for each child and intervention of 34 minutes for John and 36 minutes for both Kenneth and Liam. All possible intervals were included in a segment (i.e., beyond the 10 minutes) to account for consistency in the communicative opportunities provided during the session, particularly at the start and end of activities (e.g., opportunities

to request preferred toy from those in cupboard, to signal a desire to pack away toys at the end of the activity).

Production of signs

The children's production of core and fringe signs over the course of the study is illustrated in Figures 1-3. The children produced no core or fringe signs during the first three baseline sessions, involving toys from Cupboards A, B, or C. Following the intervention, John began using core signs during the play activities, whereas Kenneth and Liam began using both core and fringe signs. John produced a total of 6 different signs, Kenneth produced 4 different signs, and Liam produced 34 different signs over the course of the study. As predicted, the children who learned to use fringe signs (Kenneth and Liam) only did so following the gradual introduction of intervention conditions to play with toys in each cupboard, thus demonstrating experimental control. However, the size of the intervention effects were modest (Kenneth Tau-U = 0.31-0.54, Liam Tau-U = 0.18-0.38) and not statistically significant.

Insert figures 1-3 about here

Generalisation

John and Liam demonstrated statistically significant increases from baseline to intervention in their use of core signs across the three play activities, whereas Kenneth's modest increases were not statistically significant. For John, intervention effects were large for all three cupboards (Tau-U = 1, $p = 0.010$). Effects for Liam were medium to large across Cupboard A (Tau-U = 0.9, $p = 0.036$), Cupboard B (Tau-U = 1, $p = 0.002$), and Cupboard C (Tau-U = 0.71, $p = 0.033$). As evident in Figures 1-3, all three children appeared to generalise their use of core signs from play activities involving toys in Cupboard A (for which KWS modeling had been provided) to toys in Cupboards B and C for which no modeling had yet

been provided. This effect was most pronounced for John, who used core signs during play with toys from Cupboard B and C in sessions 4 and 6, despite only having been taught these signs in session 3 during play with toys from Cupboard A. The results were less pronounced for Kenneth and Liam, who both produced a small number of core signs in Cupboards B and C in the sessions immediately prior to the introduction of intervention to play with toys in those cupboards.

Production of gestures and spoken words

Figure 4 illustrates changes in the children's production of signs (core and fringe combined), gestures, and spoken words over the course of the study. The values presented are the average percentage of 10-second intervals in which each of the target behaviours was produced, for each session over the course of the study. Overall, clear effects are difficult to discern through visual inspection. Statistical analysis of differences across conditions indicate a significant increase for Liam in gestures (Tau-U = 0.82, $p = 0.036$) and spoken words (Tau-U = 0.94, $p = 0.016$). John demonstrated a non-significant increase in his production of gestures and spoken words over the course of the study, while Kenneth demonstrated a non-significant decrease in gestures ($p = 0.53$) and increase in spoken words.

Insert figure 4 about here

Discussion

All three children with ASD acquired signs during the study and generalised the use of some core signs across play activities. In addition, the introduction of KWS intervention was associated with a neutral, or positive, change in the children's production of spoken words and gestures. However, the results should be viewed as offering preliminary evidence, due to the modest and varied outcomes for each of the three children and consistent with the scope of the study. The implications for future research directions, and potential implications for practice, are discussed.

Acquisition of signs

All three children began using signs following the introduction of intervention, with most increases accounted for by increased production of core vocabulary. In descriptive terms, the children acquired between 4 and 34 signs in total during the course of intervention. However, the strength of individual treatment effects varied across children, play activities, and vocabulary type (core versus fringe). This variability was best demonstrated by John, who produced statistically significant increases in core vocabulary across all three play activities following the introduction of intervention ($Tau-U = 1, p = 0.010$), but did not produce any fringe vocabulary over the course of the study. The fact that John did not produce any fringe vocabulary meant that we were unable to demonstrate experimental control over his acquisition of signing. However, experimental control was achieved for Kenneth and Liam whose fringe signs only appeared once intervention was provided, as hypothesized.

In considering the magnitude of treatment effect, care must be taken in attributing clinical significance to findings that met statistical significance, and vice versa. To illustrate, the magnitude of Kenneth's and Liam's increases in fringe vocabulary were not statistically significant (using Tau-U), and so it could be argued that intervention was not effective. However, in clinical terms, these two children with complex communication needs progressed from no use of signs during baseline, to use of a small repertoire to communicate their wants and needs in intervention, after only nine KWS sessions. Other approaches to quantifying experimental single case data include Percentage of Non-Overlapping Data and Percentage of All Non-Overlapping Data (e.g., Wendt, 2009): indeed, it is readily apparent in light of the zero to near-zero scores in baseline, these would have yielded scores of 100% each, suggesting large treatment effects. It was felt, however, that the method chosen was a more discerning measure of effect size. Clearly, clinicians and researchers need to consider

the findings with respect to the pre-treatment communication skills and age of each child in the study, as well as the potential for different methods of analyses (visual, different statistical methods) to lead to a conflicting interpretation of the findings. We suggest that for children with little or no functional speech, who are about to start school, the acquisition of even a small number of symbolic communicative acts represents a clinically significant outcome.

An important contribution of this study to the literature is the use of a simultaneous communication approach (i.e., sign+speech). This approach enabled the clinician to follow the child's lead, thereby using an incidental naturalistic strategy, but with the addition of providing a model in sign of the target vocabulary. In contrast, previous studies [e.g., 17,18,20] examining the acquisition of signs used either structured behavioural methods or direct teaching with multiple prompts. Our results showed small, yet in some cases significant gains, in terms of the children's spontaneous production of signs following modelling only of KWS in interactive play. However, the effect of behavioural approaches [e.g., 18] appear to be greater in terms of vocabulary production than obtained this study. Therefore, future research is warranted to determine if benefits may be gained from incorporating features of behavioural interventions, such as physical prompts, into KWS to further support the production of manual signs. Such more direct approaches may be particularly valuable for children like John, who did not acquire fringe signs following exposure to the naturalistic intervention.

Generalisation

Although there is widespread recognition of the need to document the extent to which intervention effects for children with ASD generalise to other contexts, few studies have dealt with the issue explicitly. Indeed, most reports have been based on loosely defined measures and informal parental report [e.g., 7]. Our aim was to make the issue of generalisation a key

focus of this study, through our use of a multiple baseline treatment design for each child. This approach enabled us to measure the children's generalisation of core vocabulary (which we expect children to use across multiple contexts) in a systematic way, while documenting the children's production of activity-specific fringe vocabulary as a demonstration of experimental control. Consistent with our hypotheses, all three children generalised their newly acquired core signs (e.g., 'finish,' 'help,' and 'stop') across activities. These findings appear to confirm the need for children with ASD, who use AAC strategies including KWS, to have access to both core and fringe vocabulary (in this case signs), in order to build their communicative competence [11]. The findings also indicate that although children may generalise their use of core signs from one activity to another, they are likely to require context-specific training to learn fringe signs.

Natural gestures and spoken words

Given the well-documented, but to date unfounded, concern that using signs may have a negative impact on the development of speech [37], we also collected information on the children's production of gestures and spoken words during baseline, intervention, and follow-up phases. By coding and analysing the children's use of speech and natural gestures, we were able to document changes in these skills over time. To this end, visual and statistical analysis revealed either neutral or statistically significant positive changes in the children's use of speech and natural gestures following the introduction of the KWS intervention. These findings are consistent with those of previous studies [e.g., 38], indicating the introduction of signs appears to be associated with a neutral or positive effect on speech and language development. Clearly, it is not possible to determine from our data if these neutral or positive effects were due to maturation, the introduction of KWS, or factors not controlled for in the study (e.g., early intervention targeting language development in other settings).

Limitations

As discussed, the findings must be considered with reference to the nature of the design, which allows for demonstration of effects, but not generalization to the population [32] and the fact that experimental control (acquisition of fringe signs) was demonstrated for two of the three children only. Furthermore, by staggering the introduction of intervention to allow for the measurement of generalisation, we inevitably reduced the intensity of the intervention provided. It is possible that providing more KWS intervention (i.e., across all activities immediately) over the same number of sessions may have yielded more definitive and consistent results.

In order to replicate clinical practice, the clinician responsible for delivering the intervention was free to model all signs in the KWS vocabulary rather than a restricted set. This meant that each child was invariably exposed to a different set of Key Word Signs and number of models of each sign used. However, fidelity data reflecting adherence to the principles of KWS intervention, as well as data reflecting the amount of modeling provided, indicate that while the specific signs may have varied, the amount of exposure was broadly equivalent across the three children.

Future research directions

Despite previous studies examining sign-based interventions for children with ASD, this is the first study to examine KWS specifically. The results are broadly consistent with previous literature, indicating that sign-based interventions may be appropriate for some children with ASD who use little or no functional speech. However, as with other studies, we found significant variability in the children's responses to treatment. Clearly, research is needed to better understand the causes of this variability, with the view to enabling parents, clinicians, and educators to make informed decisions about whether to implement KWS with a particular child with ASD. Such studies should examine not only the 'crude predictors' of intervention outcomes including cognitive ability and pre-treatment language level, but also

fine-grained measures of social-cognitive functioning and attention [39]. In the case of KWS, which relies on children looking as the clinician models the signs, there is a pressing need to examine the possible impact of reduced visual attention on intervention outcomes.

Furthermore, there is the potential for preferences and situational variable to impact on the use of KWS. Principles of multi-modality dictate that individuals be provided with options from which to choose those modalities they prefer, and these preferences may differ across situations or communication partners, and developmental stages [3,40].

Current best practice dictates that each child with ASD should have access to a comprehensive program of Early Intensive Behavioural Intervention. Yet most AAC interventions, including KWS, have been implemented and evaluated only as stand-alone treatments. It is implausible that a discrete, stand-alone intervention such as KWS could address the complex and pervasive symptomology seen in children with ASD who have little or no functional speech. Consequently, future research is needed to examine the potential benefit of applying KWS (and other AAC interventions) in a deliberate, targeted, and controlled manner to comprehensive Early Intensive Behavioural intervention programs. Such an approach may see KWS trialed for the subset of children who do not respond to speech-alone focused intervention and for whom additional support is required. Furthermore, such research could examine the impact of KWS on both receptive and expressive communication development.

Conclusion

Our study examined the effect of KWS intervention on the use of core and fringe signs, natural gestures, and spoken words for three preschool children with ASD. We found an experimental effect for the acquisition of fringe signs for two of the three children. We observed a non-experimental effect of acquisition and generalization of core signs across play activities following introduction of the KWS intervention. The results are consistent with

previous studies of signed-based interventions, suggesting the possible utility of KWS for a subset of children with ASD who use little or no functional speech. However, further research is needed to identify for whom KWS is most likely to be beneficial, whether it is more effective than other communication-focused intervention, and the possible role of KWS as part of comprehensive Early Intensive Behavioural Interventions.

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Declaration of Interests

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

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Table

Table I. Participant Demographics

Table I
Participant Characteristics

	John	Kenneth	Liam
Chronological Age (months)	38	45	49
MSEL*			
Early Learning Composite	49 (1)	49 (1)	84 (15)
Visual Reception	20 (1) **	20 (1)	51 (54)
Fine Motor	20 (1)	20 (1)	57 (76)
Receptive Language	20 (1)	20 (1)	35 (7)
Expressive Language	20 (1)	20 (1)	25 (1)
VABS***			
Adaptive Behaviour Composite	71 (3)	77 (6)	91 (27)
Communication	63 (1)	59 (1)	76 (5)
Daily Living Skills	83 (13)	75 (5)	100 (50)
Socialization	75 (3)	77 (6)	105 (63)
Motor Skills	78 (7)	91 (8)	91 (27)
Services Accessed			
Preschool/childcare	1 day/week	1 day/week	2 days p/week
Early intervention group (2-3 hours session)	1 day/week	1 day/fortnight	1 day/fortnight
Speech Pathology session		3 x p/month	

* Expressed as a *T-Score* (Mean=50, SD=10) and *percentile rank*. ** Lowest possible T-score

is 20. *** Expressed as a *standard score* (Mean=100, SD=15) and *percentile rank*.

Figures

Figure 1. John's production of core and fringe signs.

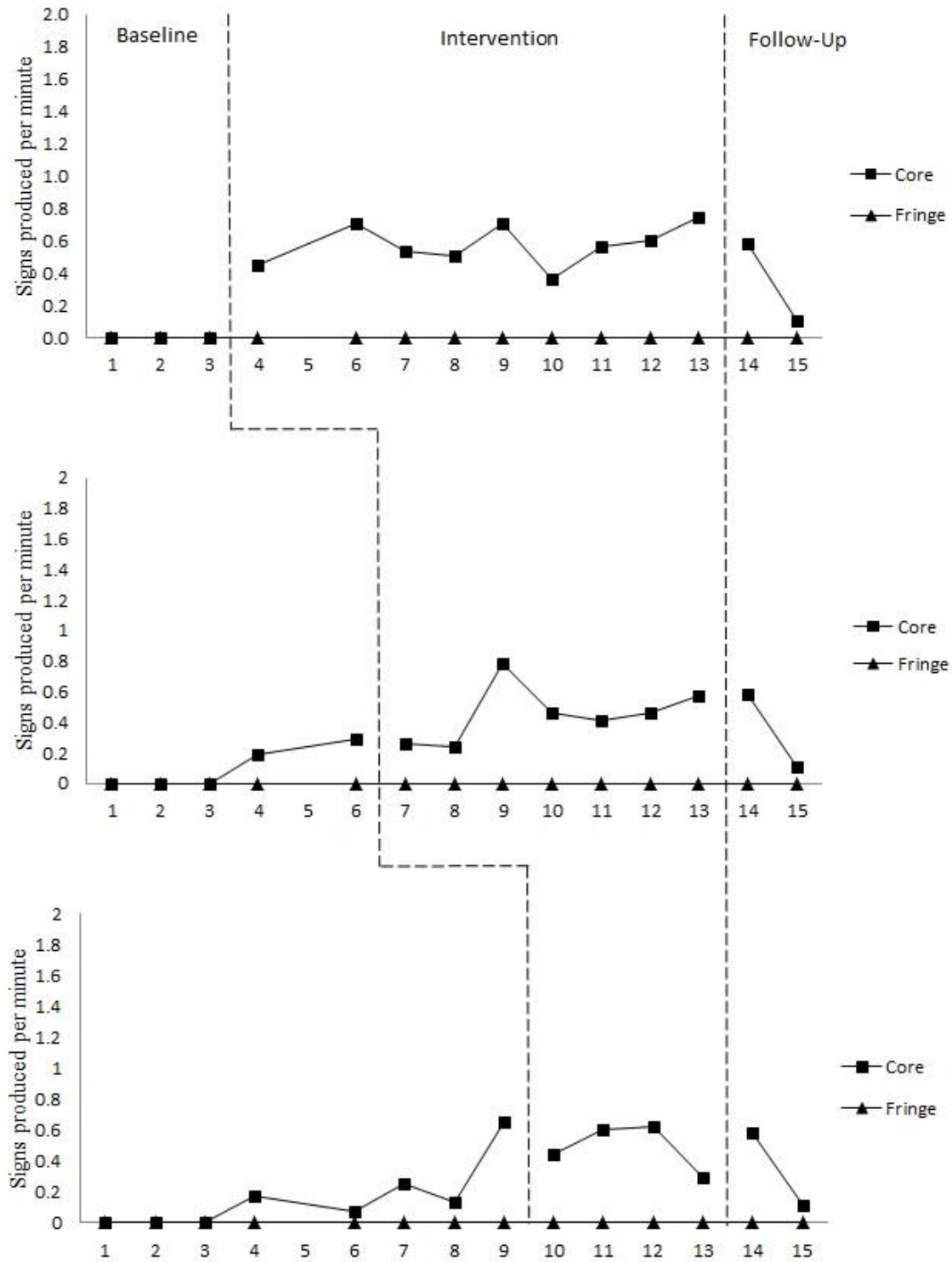


Figure 2. Kenneth's production of core and fringe signs.

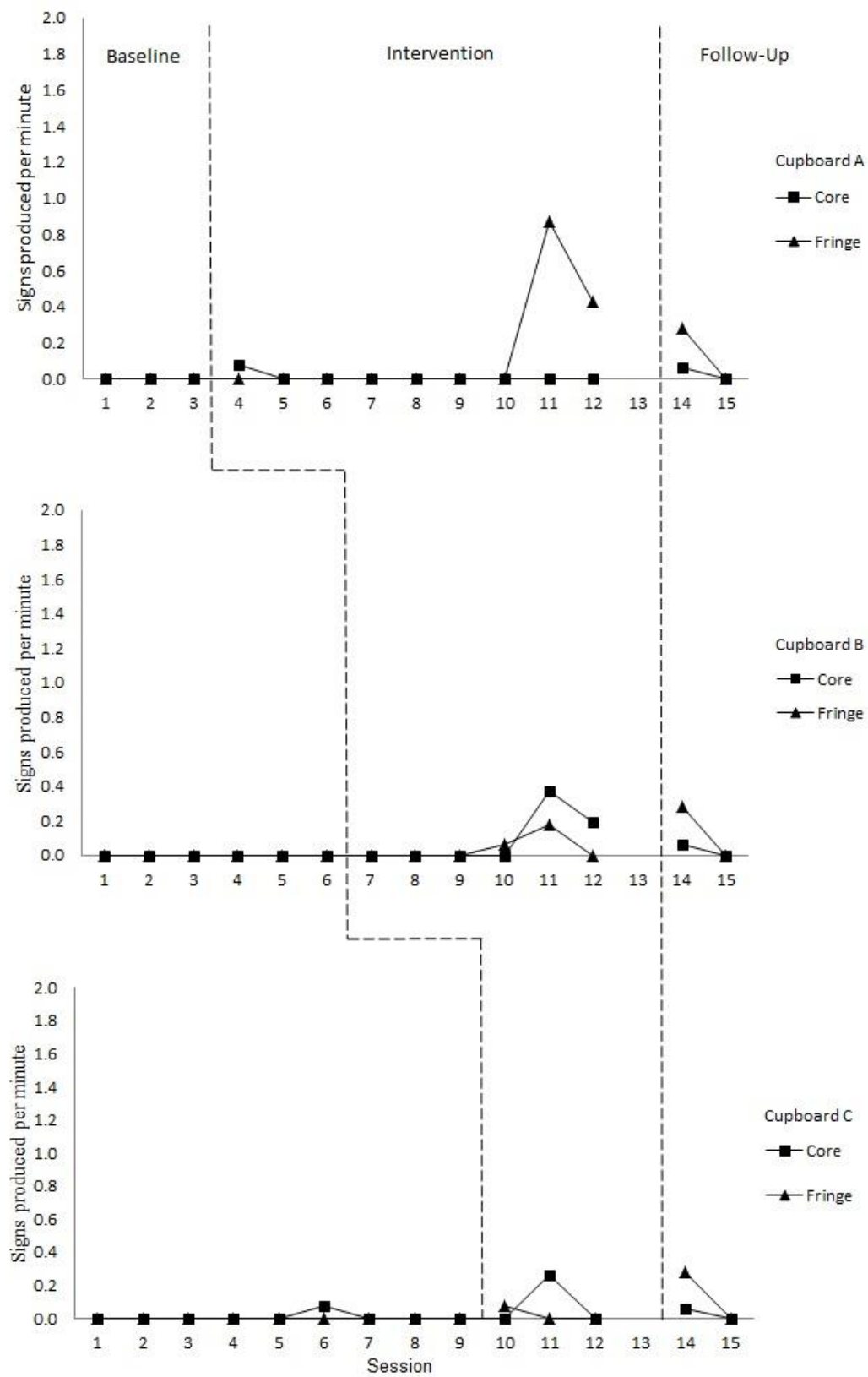


Figure 3. Liam's production of core and fringe signs.

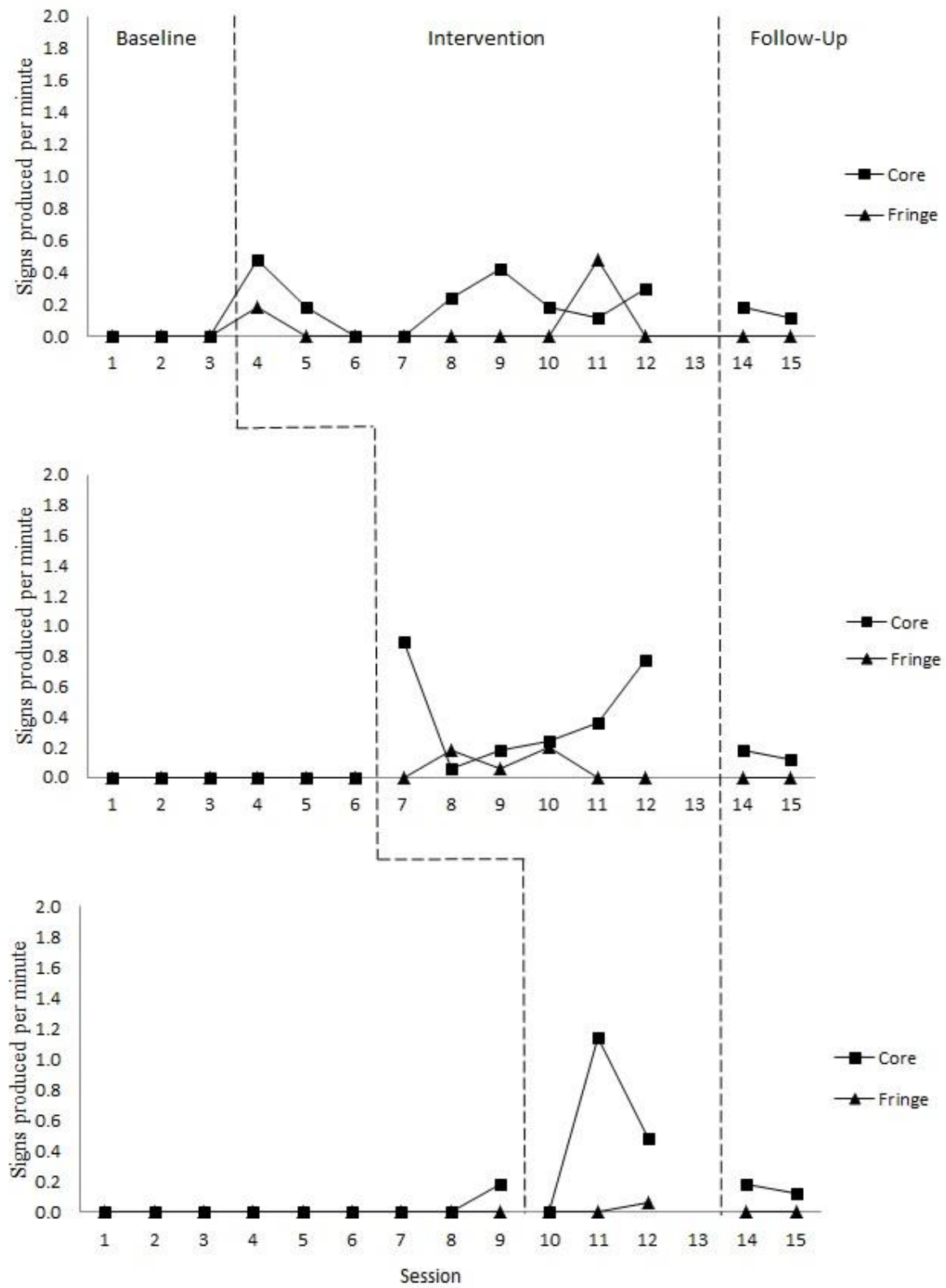


Figure 4. The average percentage of intervals in which each child produced a sign, gesture, or word during play with toys in each cupboard over time.

