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ORIGINAL PAPER

Teaching Communicative Responses with a Speech-Generating Device Via Telehealth Coaching

Adele F. Dimian[1] · Marianne Elmquist[2] · Joe Reichle[1] · Jessica Simacek[1]

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Abstract

Caregivers need support with teaching augmentative and alternative communication (AAC). The purpose of this study was to coach caregivers via telehealth (i.e., live video conferencing with Google Hangout) to implement communication assessments, functional communication training (FCT), and/or navigation training to address either idiosyncratic or problem behavior exhibited by two young boys with developmental delay (age 5.5 years) and autism (age 7 years) who were non-verbal. An adapted multiple probe design and a multiple probe design across three contexts (play, break from demands, help) were used to evaluate acquisition of communicative requests using high tech aided AAC on a speech-generating device (SGD; a Tobii Dynavox T10 device). A forward chain was also introduced to teach symbol selection and navigation on the SGD. Both children acquired the communicative alternatives across each context. Caregiver implementation fidelity was measured with procedural checklists and was acceptable across baseline and intervention sessions for both children. Children with developmental disabilities face many barriers to accessing needed communication intervention and may not have access to interventionists with the expertise in AAC with a SGD. Our findings have potential research implications for the use of telehealth to improve access to expertise in high tech aided AAC communication assessment and intervention.

Keywords Alternative and augmentative communication · Speech generating device · Telehealth

Many individuals with neurodevelopmental disabilities (NDDs) have complex communication needs and as a result require alternative and augmentative communication (AAC) strategies to augment or replace the use of spoken utterances (Johnston et al. 2012). When learners do not have intelligible conventional communicative means, they are at risk for developing a communicative repertoire that consists of idiosyncratic behavior that may evolve into problem behavior (Johnston et al. 2012; Reichle and Wacker 2017). This, in turn, can contribute to reduced participation in social opportunities and affect quality of life. It is therefore important for individuals with NDDs to have access to AAC strategies to increase their communicative repertoires.

Aided communication systems, a type of AAC, play a prominent role in establishing a beginning repertoire of communicative behavior among persons with significant NDDs (Johnston et al. 2012). Reichle and Drager (2010) characterized an aided communication system as one that requires the use of materials that extend beyond an individual's own physiological means of producing a communicative output (e.g., vocalizations, verbalizations, or gestures). Within aided communication systems, there are low-, mid-, and high-tech options. Low-tech options do not involve the application of electronics (e.g., the Picture Exchange Communication System; Bondy and Frost 1994). Mid- and high-tech aided AAC options involve a continuum of devices typically with a limited number of speech-recorded messages (e.g., mid-tech devices include the BIGmack® and Go Talk® series; McNaughton and Light 2013; Johnston et al. 2012). High-tech AAC systems often combine digitized and synthesized speech output options so that sound effects and singing can be easily displayed via digitized recordings. These

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✉ Adele F. Dimian
dimia006@umn.edu

[1] Institute on Community Integration, University of Minnesota, 150 Pillsbury Drive S.E, Minneapolis, MN 55455, USA

[2] Department of Educational Psychology, University of Minnesota, Minneapolis, MN, USA

high-tech AAC systems are often referred to as speech-generating devices (SGDs).

Many high-tech aided communicative options are dedicated (i.e., can only be used as a communication system) tablet-sized devices (e.g., Dynavox® T-Series). Alternatively, an increasing number of software applications (e.g., Proloquo2Go®) are widely available on multi-purpose mobile technology as well (McNaughton and Light 2013). Non-dedicated tablet devices with a touch screen (e.g., an Apple® iPad) can be used as a SGD by downloading applications for instance (e.g., Proloquo2Go®). These applications could increase access to AAC systems in general and SGDs in particular (i.e., parents do not have to wait for the school or Medicaid to provide a SGD for their child). Therefore, it is imperative that effective instructional strategies are being disseminated and implemented to teach individuals with NDDs to use AAC functionally.

High-tech SGDs are beneficial for individuals with severe productive communication limitations for several reasons. Having voice output allows the person producing a message to be able to communicate at a distance (e.g., by telephone). Additionally, having voice output avoids having to teach the learner a separate non-speech behavior to obtain attention and a second to communicate the learner's intended message (Johnston et al. 2012). Further, pairing a graphic symbol selection (low-tech AAC) with the speech output generated from a SGD (high-tech AAC) has been shown to result in the acquisition of spoken vocabulary comprehension skills for some individuals (Harris and Reichle 2004). Finally, among some learners with significant motor limitations, the use of a SGD can serve to improve the accuracy and timeliness of symbol selection (Johnston et al. 2012). Taken all together, SGDs are a viable AAC system that has the potential to increase the communicative repertoires of individuals with NDDs.

Implementing high-quality aided AAC interventions with SGDs for persons with severe communication challenges requires extensive support from well trained and experienced professionals. Overall, there is a substantial shortage of qualified professionals to deliver intervention services for this population (Ludlow, Conner, and Schechter 2005). For example, Wise et al. (2010) reported a shortage of behavior therapists in 89% of the 47 states that they surveyed as well as a shortage of speech-language pathologists in 82% of states surveyed (Wise, Little, Holliman, Wise and Wang 2010). An earlier American Speech and Hearing Association (ASHA) survey (2005) also documented a similar shortage of speech and language professionals, particularly those with extensive background in AAC. With the increasing prevalence of NDDs such as autism spectrum disorder, there is little evidence to suggest that the service needs among this population have diminished.

Unfortunately, the shortage of practitioners who can deliver AAC services is a significant barrier to timely service. There appears to be increasing concern among stakeholders regarding sufficient instructional support for using SGDs. Parette et al. (2001), for example, found that parents reported inadequate or non-existent training influenced their ability to implement intervention or use an AAC device effectively. When caregivers and stakeholders are not supported, there is a risk that AAC will be abandoned altogether. Along with personnel and service provider shortages, long wait lists are another barrier to timely services. Estimates for wait times among families and individuals across the lifespan with NDDs are few and far between; however, stakeholders repeatedly report dissatisfaction with long wait lists and access to services (Keating, Syrmis, Hamilton, and Mcmahon 1998). Timely access to high-quality services may improve quality of life for persons with NDDs and their families and thus is important. Additionally, it is more cost-effective over time when wait times for services are reduced (Piccininni et al. 2017).

The barriers already described are exacerbated for families residing in rural areas (e.g., Symon 2001). For example, in Australia, Ruggero et al. (2012) surveyed 154 parents and reported that service quantity and quality were worse in rural isolated communities. In these areas, families were more reliant on indirect home and/or school services. Given the shortages of intervention services available in homes to supplement services provided in school, it is essential to consider the benefits of providing support to stakeholders who wish to participate in the intervention process.

A potential solution to some of the barriers to high-quality service outlined thus far involves the systematic implementation of telehealth. The Institute of Medicine (2012) characterizes telehealth as implementing health care using electronic technologies such as videoconferencing. Providing services via telehealth has the potential to increase access to intervention services in general and specialized services/expertise in particular. Barriers such as geographical location, personnel/service provider shortages, or other barriers to accessing timely intervention service could be mitigated with the use of telehealth as a service delivery system possibly (Simacek, Dimian, and McComas 2017; Vismara, Young, and Rogers 2012; Wacker et al. 2013a, b). The utilization of telehealth to deliver intervention services is receiving increased interest in both research and practitioner communities.

The emerging literature on providing interventions to persons with NDDs via telehealth is promising. For instance, Wacker et al. (2013a) demonstrated qualitatively similar results with implementing functional communication training (FCT; Carr and Durand 1985) to treat problem behavior by teaching a single communicative alternative response via telehealth compared to FCT being delivered by clinicians in vivo. Further, Lindgren et al. (2016) found that similar outcomes could be achieved at a lower cost as well with telehealth in the home in comparison to in-home or clinic-based behavioral treatment of problem behavior.

Additionally, Suess et al. (2014) reported moderate to high levels of procedural fidelity among caregivers implementing FCT with live coaching via remote video conferencing. Simacek et al. (2017) extended the parent implemented FCT procedures via telehealth coaching to target potentially communicative idiosyncratic responses with three young girls with severe NDDs. The results indicated an increase in AAC responses taught across multiple functional contexts that were embedded within the participants' naturally occurring routines (e.g., snack time) with high fidelity and acceptability ratings among parents. The telehealth research to date primarily focused on teaching simple communicative responses (e.g., with low-tech AAC) as an alternative to problem behavior. More research is needed, however, to evaluate how to teach responses on a high-tech device like a SGD and to what extent we can teach multi-step communicative responses via telehealth in a home setting.

The purpose of the current study was to extend previous research examining the efficacy of parent-implemented communication interventions delivered via telehealth coaching in home settings. This study specifically assessed (a) the acquisition of multi-step requests with high-tech aided AAC on a SGD across three communicative contexts and (b) the efficacy of a parent-implemented communication assessment and interventions with live coaching via telehealth with two young boys with NDDs.

Method

Participants

Two boys with NDDs participated in this University IRB-approved study. Both participants met the following inclusion criteria: (a) were between the ages of 0 and 64 years old, (b) had a NDD, (c) engaged in problem behavior, (d) had a significant delay or absence of intelligible spoken communication, and (e) had caregivers who spoke English. Table 1 displays the demographic information for each participant and communication assessment data available prior to intervention. All diagnostic information were provided by the caregivers or their individualized education plans and were not validated by the research team.

Leo was a 7-year-old boy with a diagnosis of autism spectrum disorder (ASD), Lissencephaly, and epilepsy. Prior to intervention, Leo was non-verbal, produced two gestures that included pointing and reaching to show caregivers what he wanted, and engaged in pre-linguistic variegated vocalizations. Leo required assistance with all daily care needs and was fed via a gastrostomy tube. He was non-ambulatory, but crawled along the floor on his hands and knees. When in the community, Leo used a wheelchair that he required assistance with. He received occupational therapy, speech and language services, and physical therapy in school once a week for 30-min while participating in the study. Leo's parents requested help with teaching communication on his SGD and wanted recommendations on how to address his tantrum behavior (i.e., crying and screaming) during daily care routines. Leo had no previous behavioral interventions and no experience with the requests that were taught on the SGD.

Tommy was a 5.5-year-old boy with a primary educational diagnosis of developmental delay. He had a history of complex medical concerns that included genetic anomalies. He also had congenital glaucoma, strabismus, esotropia, and myopia (i.e., visual impairment that he wore eyeglasses to correct for). Tommy had other medical diagnoses that included microcephaly, plagiocephaly, hypotonia, nephrolithiasis, and endocrine abnormalities that influenced his growth. An evaluation by a licensed psychologist, however, reported that Tommy engaged in reduplicated babbling, and produced five sign approximations (i.e., hi, bye, more, hands on face for touch, and hands on ears for listen) prior to the study implementation. Other than reduplicated babbling, Tommy was non-verbal and primarily used leading or reaching to show caregivers what he wanted. He required assistance with all daily living tasks, could self-feed, and was ambulatory. A swallowing evaluation conducted by certified speech and language pathologist concluded that Tommy had moderate oral dysphagia and engaged in continuous drooling. He received special education and speech language therapy during the study but providers did not use the page sets developed for the study. Tommy did not engage in any problem behavior. His caregivers requested assistance with programming and teaching communication on the SGD. Prior to intervention, Tommy had no experience with the requests or page sets taught during this study.

All sessions occurred in the families' homes with live coaching via video conferencing (i.e., telehealth) from a doctoral candidate in educational psychology with 6 years of experience in conducting functional analyses and functional communication training. All sessions were implemented in the living room with the SGD located on the ground for Leo and on the couch or on a table for Tommy. Both Leo's mother and father served as interventionists (alone or together) throughout the study and for Tommy; his mother implemented all sessions.

Procedure

Study Sequence Phase 1 of this study consisted implementing several assessments to inform the communication intervention procedures utilized. Prior to initiating baseline sessions, each participant's family completed a functional assessment interview (FAI; O'Neill et al. 1997) and the Vineland Adaptive Behavior Scales (VABS; Sparrow et al. 2005). The other assessment procedures involved the implementation of a

Table 1 Participant demographics

Demographics	Leo	Tommy
Age	7 years	5.5 years
Race	Caucasian	Caucasian
Primary diagnoses	Autism, Lissencephaly, and epilepsy	Developmental delay; visual impairment, microcephaly, hypotonia, and moderate oral dysphagia
Ambulatory status	Non-ambulatory, could crawl	Ambulatory, abnormal gait
Primary modality of communication prior to intervention	Gestures: reaching and pointing (non-verbal)	Gestures: leading and proffering (non-verbal)
Vineland-II		
Receptive Communication	Low	Low
Expressive Communication	Low	Low
Adaptive Behavior Composite	Low	Low
Preschool language scale-5		
Receptive Language	Not applicable	PLS-5 standard score = 50 Age equivalent = 1 yr
Expressive Language	Not applicable	PLS-5 standard score = 50 Age equivalent = 1 yr, 1 mo
Total Language Score	Not applicable	PLS-5 standard score = 50 Age equivalent = 11 mo

Note: Vineland-II = Vineland Adaptive Behavior Scales- II (Sparrow et al. 2005); PLS-5 = Preschool Language Scale-5 (Zimmerman et al. 2011)

structured descriptive assessment (SDA; Anderson and Long 2002). Subsequently, a consequence-based functional analysis (FA; Iwata et al. 1982/1994) was implemented for Leo to determine the function of his problem behavior. Additionally, a paired-choice preference assessment (PA; Fisher et al. 1992) and a vocabulary comprehension or correspondence assessment (Reichle et al. 1991) were implemented to assess if the participants could discriminate between the symbols used.

In phase 2 of this study, we implemented communication interventions for each participant across three contexts. We conducted baseline and intervention sessions with the SGD and measured participant performance and caregiver procedural fidelity. Post-intervention, the Treatment Acceptability Rating Form-Revised (TARF-R; Reimers and Wacker 1988) was used to evaluate social validity ratings of the interventions. All procedures for both phase 1 and phase 2 were implemented via telehealth with live coaching. Task analyses of all procedures implemented are located in the appendences. We used verbal instructions based on the procedural steps listed in the appendences as the primary strategy to coach the caregivers live via telehealth. If an error occurred, the coach provided corrective feedback before the next trial was implemented. When procedures changed or troubleshooting occurred, the coach sent the caregiver the new instructional procedures via e-mail before the session took place and also provided verbal instructions live.

Experimental Design In phase 1, SDA and FA assessments were implemented using a multi-element design. In phase 2, FCT (Carr and Durand 1985) was implemented to teach Leo a functionally equivalent replacement behavior in the form of AAC on his SGD using an adapted multiple probe design across three communicative contexts (play, break, help) with an embedded reversal. A forward chain was also used to teach navigation between a superordinate and a subordinate page set for one of the contexts, play. Baseline and intervention sessions for Leo were conducted across seven consecutive weeks with two to three 30-min sessions each week.

Tommy was taught to produce communicative sequences using a forward chain to teach navigation between superordinate and subordinate page sets for each of three contexts (play, break, help). A multiple-probe design was used to evaluate Tommy's acquisition of the responses across each context. We also examined navigation using the same procedures with Leo after he met mastery criteria in the initial FCT demonstration across three contexts in the help context. For Tommy, baseline and intervention sessions happened three times a week for 30 min each day across 23 weeks.

SDA A SDA was implemented to identify potentially communicative acts (i.e., idiosyncratic behavior interpreted as intentional by the participants' parents) during different contexts using a multi-element design. The information from the FAI was obtained prior to the SDA and used to inform the conditions for the SDA. All sessions were 3 min, and antecedents in the form of demands, diverted attention, restricted tangibles, and free play were observed. No programmed consequences were provided for idiosyncratic/potentially communicative responses or problem behavior. The caregivers were instructed to respond to both types of responses as they typically would (e.g., if the child was reaching for a book during the restricted tangible condition, the caregiver could give the book to the child if that is what they typically would do when the child engaged in that response).

FA A brief FA was conducted to examine the effects of negative and positive reinforcement on Leo's tantrum behavior (crying and screaming), which were reported in the FAI and observed during the SDA. Tangible, attention, escape from demands, and free play/control conditions were adapted from procedures described by Iwata et al. (1982/1994) and individualized based on the information collected in the FAI and direct observation data from the SDA. All sessions were 3 min, and the order of the conditions was randomized within a multi-element design. A 10-s partial interval recording system was utilized to measure all tantrum behavior. Problem behavior was not observed or reported for Tommy, and so, an FA was not implemented.

PA A paired choice PA was used to evaluate relative preference for toys and activities. This information informed the selection of symbols and corresponding vocabulary taught during intervention sessions. During a PA session, six toys or activities were concurrently presented in pairs, one in the caregiver's left hand and one in their right hand (item position was counterbalanced) approximately 12″ in front of the participant. The caregiver was then instructed to ask the participant to "pick one." The selection response was reaching or pointing towards the toy/activity. Contingent on choosing an item, the participant was allowed to engage with the toy or activity for 30 s. Each item was presented ten times, and if no selection was made within 30 s of presentation of the pair, the next item pair was presented.

Vocabulary Comprehension and Correspondence Between Symbol and Referent Spoken word comprehension was assessed prior to intervention to evaluate if the participants could identify an item (i.e., a toy, activity or picture of caregivers) with a spoken direction to point to a certain item when given the choice between two items. The same paradigm used in the PA was implemented by providing a spoken instruction such as "point to the ball" when given an option between a ball and a book. Each item was presented on four separate occasions.

Correspondence probes were also conducted randomly throughout the study to assess understanding of the correspondence between a symbol that was selected and the referent object or activity being selected. The correspondence check consisted of the caregiver giving the participant a choice between two referents subsequent to the selection of a graphic symbol. The interventionist recorded whether he chose the same item/activity that corresponded to the symbol that the participant selected on his SGD. Correspondence probes were not conducted with Leo.

Leo A series of 3-min opportunities were implemented by Leo's parents with live coaching via telehealth. The same conditions used in the FA were implemented and consisted of three contexts: play (tangible), break or escape from demands (escape), and help (attention). During baseline, reinforcement (i.e., delivering access to restricted toys or parental attention for 20 s) was given contingent on reaching or pointing (idiosyncratic behaviors) in the play and help contexts. For the break (escape from demands) context, reinforcement consisted of providing a break for 20 s contingent on Leo's engaging in tantrum behavior.

Following baseline, idiosyncratic and tantrum behavior were placed on extinction (i.e., reinforcement was withheld) and differential reinforcement of alternative behavior (DRA) was implemented. Functional reinforcers were made available contingent on selection of the correct symbol among a fixed array of six options that included the following: play, mom, dad, break, and two distractors (yes and no symbols). The AAC symbols (i.e., vocabulary/requests) on the SGD were selected based on the results of the FAI, SDA, and FA.

Leo was taught to navigate from a superordinate to a subordinate symbol using a forward chain within the play context. The caregiver gave a requested toy or activity to Leo after he activated the play symbol and then a specific toy symbol (e.g., play; Can you play ball with me?). When Leo reached mastery criteria for all three communicative contexts (play, break, help), another subordinate page was added that linked to the mom and dad symbols which included an array of nine symbols with corresponding messages (e.g., mom; Can we go outside?).

During the implementation of FCT acquisition procedures, a least to most prompting hierarchy was used. The prompting sequence included a verbal prompt, a gestural prompt in the form of pointing towards the correct symbol on the SGD, and hand-over-hand prompting. The first opportunity during each 3-min session was verbally prompted (e.g., "touch play on your talker if you want your book"). A 5-s delay was implemented on subsequent opportunities before a prompt was provided if Leo accurately and independently activated the symbol. If no response or an incorrect response was produced (e.g., he activated the mom symbol during the play context), the previous level of prompt was used to correct any error. Mastery criterion consisted of at least three consecutive sessions that were differentiated according to visual analysis of the graphical display across 2 days of intervention.

Tommy The team taught Tommy three communicative sequences across the same three contexts as Leo (play, break, and help). We taught Tommy to navigate from a superordinate to a subordinate symbol with a forward chain procedure. Correct and independent activations of the target symbols were recorded using blocks of five opportunities. Mastery criterion was 80% (4/5 correct independent opportunities with the full prompt chain) across three sessions across two consecutive days.

During baseline sessions across each context, no prompts were provided. In the play context, Tommy's mother was seated or standing next to the SGD. The caregiver asked Tommy what he wanted to play. If Tommy did not respond within 1 min, it was recorded as "no response" as the interventionist progressed to the next opportunity and his caregiver again asked what he wanted to play. If he selected play, a toy category, and then a specific toy, his mother delivered it within 5 s. Tommy could engage with the toy for 20 to 40 s, and Tommy also received praise/attention from his mother prior to the next opportunity.

During the break context, a session began by Tommy's mother saying "it's time to clean up" (i.e., putting balls into a bin that were on the floor). Then, Tommy was prompted via a sequence that included spoken, gestural, and a hand-over-hand prompt to complete a task demand every 10 s (i.e., asking him to stand up, walk to a ball, pick the ball up, and put it in a 36″ round bin). Once Tommy had followed the caregiver's instruction, he could request a break on his SGD. A superordinate page containing the break symbol was linked to a subordinate page set housing the break, all done, and no thanks symbols. After Tommy selected the symbol corresponding to the spoken message "can I have a break please" on the subordinate page he was provided with a 30-s–1-min break from demands. If he selected any other symbol during the intervention sessions (e.g., no thanks), the caregiver would said "sorry that is not available right now" or "you need to ask for a break" and wait 5 s and then prompt him to the correct symbol (break and then can I have a break please).

For the help context, Tommy's mother sat in a chair across the room from the SGD on a couch or chair (approximately 4 ft. away). If Tommy did not go to the SGD within 1 min of her sitting in the chair, it was counted as no response and the next opportunity was implemented. Again, no prompting to use the SGD was provided during baseline sessions. If he selected help on the superordinate page, he then had to activate the symbol for mother on the second subordinate page set. His mother approached him within 5 s and asked what he needed. Tommy then selected a specific request from an array of three options including snack, drink, or play.

During intervention sessions, Tommy's mother held up a snack and a drink and asked him which one he wanted. Once he pointed to one of the options, Tommy's mother prompted him to make the same selection on his SGD. This step was discontinued once Tommy reached mastery criterion in the initial intervention phase. During early intervention sessions, Tommy's mother sat behind him on the floor to prompt the chain of superordinate to subordinate symbol selections. Once Tommy mastered the selection of both superordinate and subordinate symbols, his mother's position was systematically faded further away until she was positioned in a chair that replicated her position during all baseline sessions. If Tommy selected a symbol on the third subordinate page set that did not correspond to his symbol selection at the beginning of the opportunity, he was given 10 s to self-correct his response, and if he did not do this, then a hand-over-hand prompt was given to the corresponding correct response. Contingent on the activation of the snack or drink symbol on the third subordinate page set, Tommy was provided with access to the snack or drink.

Errorless teaching was used with a most to least prompting hierarchy to interrupt any errors during intervention across each context. The prompting hierarchy started with a hand-over-hand prompt and then was faded on subsequent opportunities within a session (a block of five trials) if Tommy was successful with activating the correct symbols to a gestural prompt (pointing to the correct symbol), and then a verbal prompt (e.g., press play). If Tommy hit the "home" button on the bottom of the screen or could not activate the symbol due to excessive moisture from drooling on his hands, his mother prompted him to hand her a 2D "help" picture card or activate a BIGmack microswitch (both placed to the right of the Dynavox) with a message that said "help me." His mother would wipe off his screen and reset his Dynavox to the superordinate page. If this happened, the opportunity was counted as incorrect and was immediately followed by the next opportunity.

Correspondence probes were randomly implemented across the play and help contexts. When Tommy requested a specific toy in the play context or a snack or drink in the help context on the SGD, the caregiver held up the requested item along with a non-requested item and asked which one he wanted to test one to one correspondence of symbol production with the item.

Measures

Materials The telehealth coaching sessions occurred in a private Telepresence Behavior Lab on a password-protected University computer with a secure server that only research personnel had access to. The following equipment was used: a Dell OptiPlex 3010 Desktop computer with a Dell 24″ monitor was used along with a Logitech HD Pro Webcam C920, Polaroid 8″ Heavy Duty Mini Tripod, Logitech ClearChat Comfort/USB Headset H390, and Debut screen-recording software (version 1.94). The video conferencing software used was Google Hangout, a free, secure, web-based application that was approved by the IRB. All families consented to using Google Hangout for telehealth sessions even though it is not HIPPA compliant.

Each family was sent a tele-kit that was comprised of the following: a Chromebook (Asus, 11.6 in., 16 GB storage, and 2 GB RAM), a Logitech HD Pro Webcam C920, and a Polaroid 8″ Heavy Duty Mini Tripod. A de-identified Google Gmail account with a username and password was created for each participant's family. Families were instructed through the initial set up by a coach via telephone for the first session. The Tobii Dynavox T10 device is a touch-based (capacitive touch) SGD and has a 9.7″ screen (width 10.15″, height 7.68″, thickness 0.83″, weight 1.14 lbs.). Each participant used a T10 dedicated device with Tobii Dynavox Compass software and synthesized speech in English. Both participants already had a Dynavox prior to the start of this study; however, the parents requested help with programming the devices and teaching their child how to use the SGD functionally (i.e., not pressing random symbols continuously). Different page sets were created for each participant using the Tobii Dynavox Compass software (Tobii Dynavox 2016). Leo's page sets were created so Leo could access his page sets and symbols quickly since he engaged in problem behavior. Due to Tommy's visual impairment, Tommy's page sets were linked to other page sets to facilitate functional use of the SGD. Figure 1 displays an example of a page set used in this study.

Leo's Symbol Page Sets Leo's page set had an array of six 2″ by 2″ symbols with the following messages and corresponding symbols: play, break, mom, dad, yes, and no. The symbols

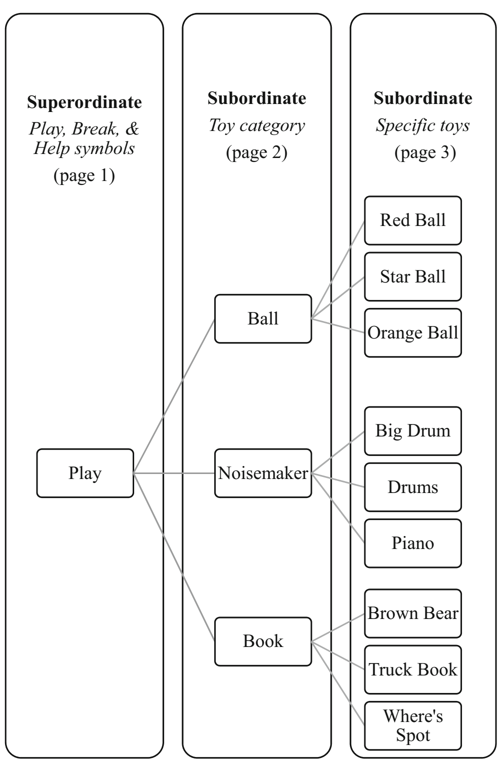

Fig. 1 Example of Tommy's page sets from superordinate to subordinate pages for the play request and context

for mom and dad were pictures, and the others were created with the Compass software. The array had two rows of symbols with three symbols in each row spaced 1″ apart. Symbol position was fixed due to caregiver preference.

Leo's symbol representing a general request to play when activated electronically linked to a second subordinate page set with an array of nine symbols (three rows of 1″ × 1″ picture symbols spaced 2″ apart) that consisted of specific toys or activities (book, gear toy, puzzle, music toy, ball, car ramp, marker-board, word cards, and ball ramp). A forward chain was used to teach Leo in the play context to navigate from a play request on the first superordinate page (the array of six symbols with general requests: play, break, mom, dad, yes, and no) to a second linked subordinate page containing more specific toy requests (e.g., "I want to play ball"). When Leo reached mastery criteria in the three contexts taught, another subordinate page was added that linked the mom and dad symbols (i.e., the help/attention request) to a page set with the following requests: break, play, hug, can we go outside, can I show you something, can you sing songs with me, can you tickle me, and all done.

Tommy's Symbol Page Sets Tommy's page sets included an array of three symbols on a superordinate page (i.e., the first page that would appear on the SGD) that when activated was linked to a second subordinate page set with an array of another three symbols. When a symbol was activated on the second subordinate page set, a third subordinate page set opened to another array of three symbols. Figure 1 displays an example of the page sets and symbols used for one of the contexts and the requests taught to Tommy in the play context.

The first page (the superordinate page set, page 1) included three symbols for general requests (play, break, help). Each of the three superordinate symbols (play, break, and help) linked to a subordinate page with three category requests. Subsequently, when one of the second subordinate page set's symbols was activated, a third subordinate page set would open with three more symbols that included big drum, drums, and piano for the noisemaker category; red ball, star ball, and orange ball for ball category; and Where's Spot, Brown Bear, and Truck Book for book category (see example in Fig. 1).

For the help request, the second subordinate page had three options that included mom, dad, and sister. The second subordinate page then opened to a third subordinate page and symbols for a request for a snack, drink, and play. Finally, the break request on the superordinate page when activated would result in only one subordinate page with three symbols for break, no thanks, and all done.

Due to Tommy's visual impairment, the symbol arrays and sizes of the symbols had to be adapted throughout the initial phases of the study. Originally, a vertical navigation window of superordinate symbols representing electronic pages was established on the left-most column of the Dynavox (displaying superordinate symbols; Tobii-Dynavox refers to this as a NavBar). A superordinate symbol constituted the initial symbol selection that was required to navigate to a display of related subordinate symbols. On each page of Tommy's display, three 1″ × 1″ superordinate symbols (play, help break, and help general requests) were placed on the side scrolling menu with each one separated by a blank symbol. The superordinate symbols located on the NavBar were 1.25″ × 1″ and then changed to a regular page set of three symbols that were 1.5″ × 2.5″. Subordinate symbols remained 1.5″ × 2.5″ size throughout the demonstration. Symbols on the first two pages for all requests were created with Compass software. The symbols on the third superordinate page sets for play and help (page 3) consisted of pictures of the actual items and of the caregivers (e.g., a picture of his mom was used for his mom request in the help context).

Response Definitions for Leo The dependent variables included the following: (a) *Reaching or pointing*, defined as anytime Leo extended one or both arms away from his body towards an object or person with an open hand or with a pointed index finger (e.g., Leo reaches his right arm with an open hand towards the bookshelf; non-example: Leo wraps his arms around his mother and gives her a hug); (b) *crying/screaming (tantrum)* was defined as any vocalization that was louder than a conversational level that was accompanied by tears and or a grimace that lasted longer than 2 s (e.g., Leo screams loudly for 5 s.; non-example: Leo engages in babbling with consonant/vowel sounds [e.g., "baa"]); and (c) *AAC symbol production* was any activation of a symbol on Leo's SGD with his finger that produced a voice output message (e.g., Leo presses the "balls" symbol with his right index finger and the Dynavox SGD speaks, "I want to play ball"; non-example: Leo swipes the balls symbol with his right index finger and it does not produce a voice output), with a 10-s partial interval recording system (i.e., coded if the target behavior occurred at all during a 10 s interval) for each dependent measure.

Response Definitions for Tommy The dependent variable was *AAC symbol production* and included any instance Tommy pressed a symbol on his SGD with his finger and it produced a voice output message (e.g., Tommy presses the "ball" symbol with his left index and middle finger and the Dynavox outputs, "I want to play ball"; non-example: Tommy swipes the 'ball' symbol with his left index and middle fingers and it does not produce a voice output). Selection accuracy of target symbols for each context was recorded within blocks of five opportunities. An event recording system was used to collect all data on Tommy's dependent variables.

During the SDA, dependent variables (i.e., idiosyncratic behavior) recorded included the following: (a) *vocalizations*, any consonant or non-consonant sound/s (e.g., any guttural sound or when Tommy says "ahh"; Non-Example: Anytime Tommy laughs (vocalizations paired with smiling and laughing); (b) *pulling away*, any instance Tommy stood up while in his mother's lap and arched his back away from an object, or discretely moving his head away (backwards or side to side) from an object or activity or any instance Tommy pulled his mother's hand away from the SGD (e.g., Tommy pulled head away from toothbrush his mom is holding in front of him; Non-example: Tommy jumping up and down); (c) *upsets with the SGD* included while at the SGD any instance of tapping (forward and backward motion in contact with the screen) with two open hands on the screen more than once while jumping up and down or engaging in vocalizations and or turning the Dynavox Screen on and off (e.g., Tommy repeatedly taps the Dynavox screen with both hands and jumps up and down and then turns the screen on and off; Non-example: Tommy selects a symbol on the Dynavox and it is activated); and (d) *reach/point* included any instance of extending one or both arms away from his body towards an object or person with an open hand or with a pointed index finger (e.g., Tommy reaches his arms with an open hands towards the Dynavox; non-example: Tommy wraps his arms around his mother and gives her a hug).

Data Analyses

Participant response data were graphically displayed and visually analyzed. Task analyses were created for all procedures implemented in this study to measure procedural fidelity (see Appendices A and B). To calculate interobserver agreement (IOA), the number of agreements was divided by the number of agreements plus disagreements and multiplied by 100 across two independent coders' scores. IOA was conducted using interval recording for Leo and discrete trials for Tommy. IOA of Leo's target responses was obtained for at least 40% of all sessions and was 96% (92–100%), on average. The average IOA for Leo's responses were 98% (77–100%) across baseline sessions and 98% (79–100%) across responses in the intervention sessions. Procedural fidelity IOA was calculated point by point and was 96% (92–100%), on average, for Leo across all three contexts. For Tommy, IOA was collected for at least 35% of all sessions and was 98% on average (80–100%) for AAC activation overall. Across baseline sessions, the average was 98% (80–100%) and 97% (80–100%) across intervention sessions. The average procedural fidelity IOA for Tommy across all three contexts was 91% (76–100%), respectively.

Results

SDA results for both participants are displayed in Fig. 1. Leo's SDA indicated that during the demand condition, tantruming occurred most frequently. The restricted tangible condition most often resulted in reaching and pointing. During the diverted attention condition, reaching/pointing occurred most often. Finally, when his mother coughed or yawned, Leo engaged in crying.

In Tommy's SDA, five idiosyncratic responses occurred across the six conditions. In order of prevalence, "upsets with the SGD" (i.e., repetitive tapping on screen) occurred most in the diverted attention condition and when access to the SGD was restricted. Reaching and pulling away from parent occurred most during restriction of items. During the demand condition, Tommy's idiosyncratic responses were variable.

Leo's FA results are displayed in Fig. 2. An elevation in tantrums during the escape condition (i.e., hair brushing/daily care routine) was observed. During the tangible condition, tantrums occurred during one of the three sessions; however, an extraneous variable (his mother coughing two times during this condition) occurred. Tantrums in the tangible condition closely followed the instances of coughing and were consistent with the SDA results. There were no tantrums observed during any other condition. As noted previously, a FA was not conducted with Tommy because he did not engage in problem behavior.

Leo's top three rankings of preferred item selections were ball (selected during 100% of offered opportunities), puzzle (70% of the opportunities), and book (50% of opportunities). Tommy's top three rankings were book (100%), ball, and drink, which were selected during 60% of offered opportunities during the PA.

During the vocabulary check, given four opportunities to identify an item or toy in an array of two, Leo scored 100% on six out of nine of the vocabulary (book, gear toy, puzzle, music toy, ball, and car ramp). For the remaining three vocabulary, Leo identified marker board, word cards, and ball ramp during 75% of opportunities. Of 17 items assessed, Tommy selected eight 100% of the times they were the targeted (noisemaker, Where's Spot book, Brown Bear book, Truck book, mom, dad, red ball, and big drum). Five vocabularies were

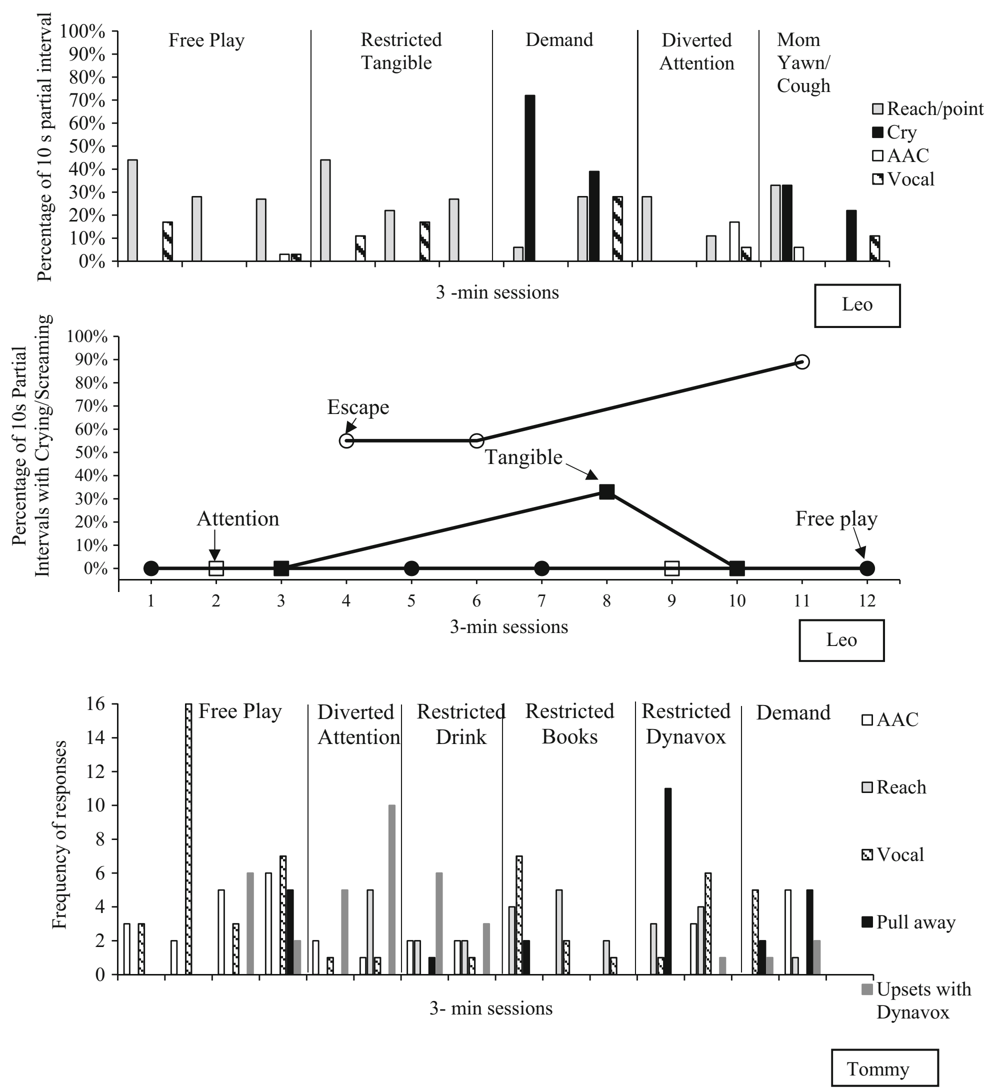

Fig. 2 Structured descriptive assessment and functional analysis results

correctly identified during 75% of opportunities (snack, drink, yellow ball, drums, and piano). The remaining items were identified during 50% of the opportunities (book, ball, sister, and blue ball). Across all vocabulary utilized for the play and help contexts, Tommy accurately identified the correct corresponding item in 87% of the probes conducted during intervention.

Figure 3 displays baseline and intervention results for Leo. Play (tangible), break (escape), and help (attention) contexts resulted in Leo acquiring a functionally equivalent communicative response using the SGD in each context. During the baseline for the play condition, elevation in reaching/pointing was observed across the six baseline sessions in the play condition (range = 6–27% of 10 s partial intervals in a 3-min session). Leo did not activate the SGD during baseline. When FCT was implemented and reinforcement was provided for activation of the correct symbol on the SGD, there was an immediate change in level. Elevation in correct and independent activation of symbols on the SGD was observed (range = 20–27%), and there was a decelerating trend in reaching and pointing (range = 0–22%). During a return to baseline, reaching/pointing increased (range = 17–28%) and Leo's correct AAC responses decreased (range = 0–6%). During the final phase in the play context, the reinstatement of FCT resulted in increased correct activation of AAC symbols

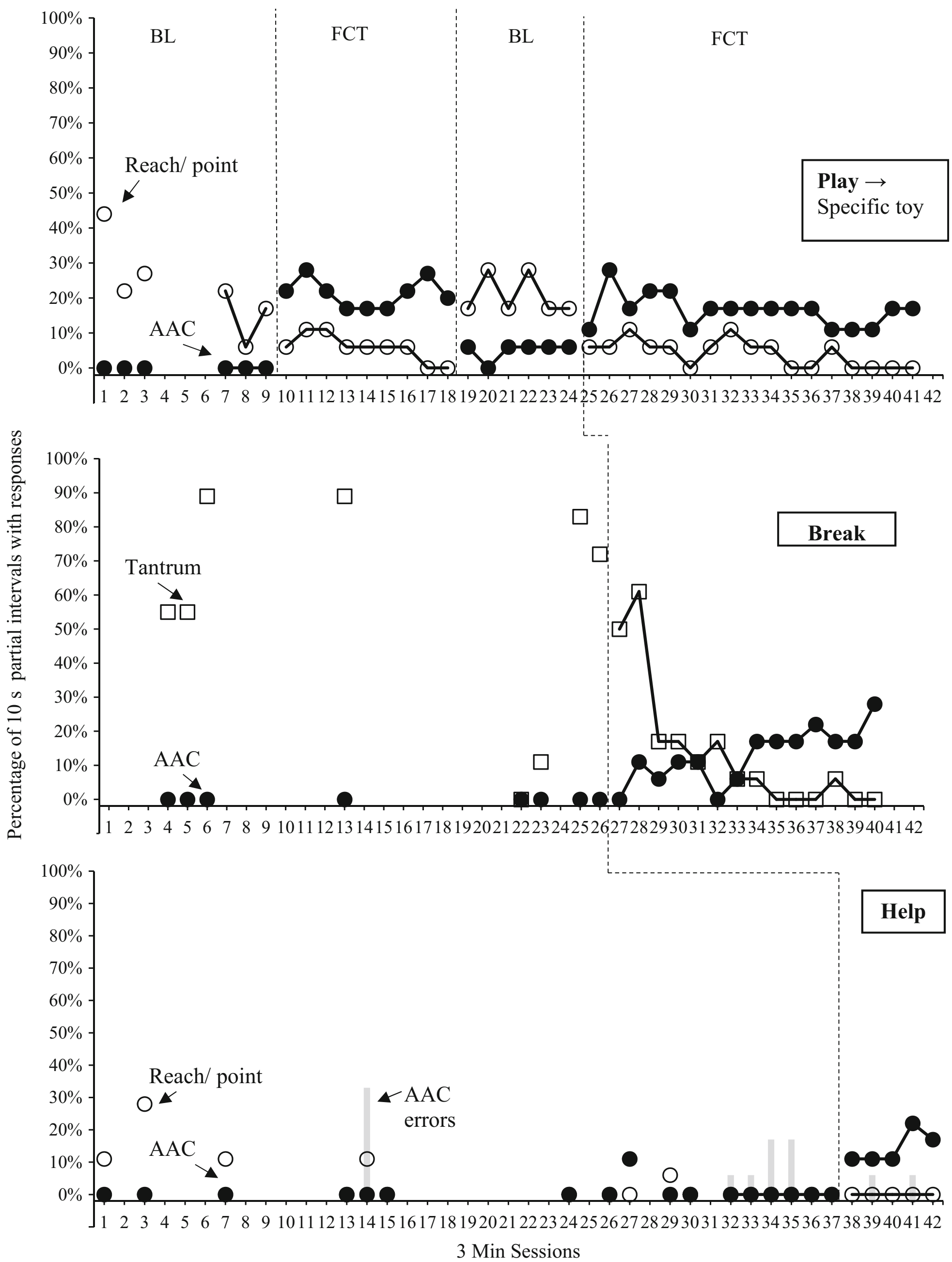

Fig. 3 Functional communication training results for Leo. Percentage of 10-s partial intervals with idiosyncratic (reaching and pointing), problem behavior (tantrums), and AAC activation on the SGD (fixed array of six symbols) responses across three contexts (play, break, help). AAC errors in the attention context were any activation of a non-target symbol (e.g., play, break). BL = reinforcement of idiosyncratic or problem behavior. FCT functional communication training; reinforcement of correct AAC symbol activation on the SGD

(range = 11–28%) while the use of reaching/pointing decreased again (range = 0–11%).

The middle panel in Fig. 3 displays the results for teaching a break from demands symbol. During baseline, when tantruming was reinforced with a contingent access to a 20-s break, Leo did not use his SGD. During intervention, reinforcement of the break symbol selection resulted in a 20-s break from hair brushing. Tantruming decreased from 60 to 0% of 10 s partial intervals recorded during 3-min sessions. Correspondingly, Leo's break symbol use increased from 0% of intervals during baseline to 30% of intervals during FCT intervention. Tantruming was not observed in any other context evaluated.

The bottom panel in Fig. 3 displays Leo's baseline and intervention data for help requests using his SGD (activation of a mom or dad symbol). During baseline, reaching/pointing decreased (range = 0–28%) and incorrect activation of non-target symbols on the SGD increased. An error pattern emerged for Leo's incorrect use of previously taught symbols (e.g., break, play), suggesting that Leo was not discriminating between the graphic symbols in the attention context. Once intervention was implemented, there was an immediate change in level of appropriate AAC emissions (range = 11 to 22%) with only two errors across five sessions.

Following mastery criteria in all three contexts, another subordinate page was added that linked to the mom and dad request page sets. Leo achieved mastery during baseline without any instruction (data not displayed). Leo correctly and independently completed the forward chain for 80% of each five block trials across five baseline sessions (range = 80–100%).

Figure 4 provides evidence that Tommy learned to independently navigate between superordinate and subordinate symbols. During initial baseline, in each of the three

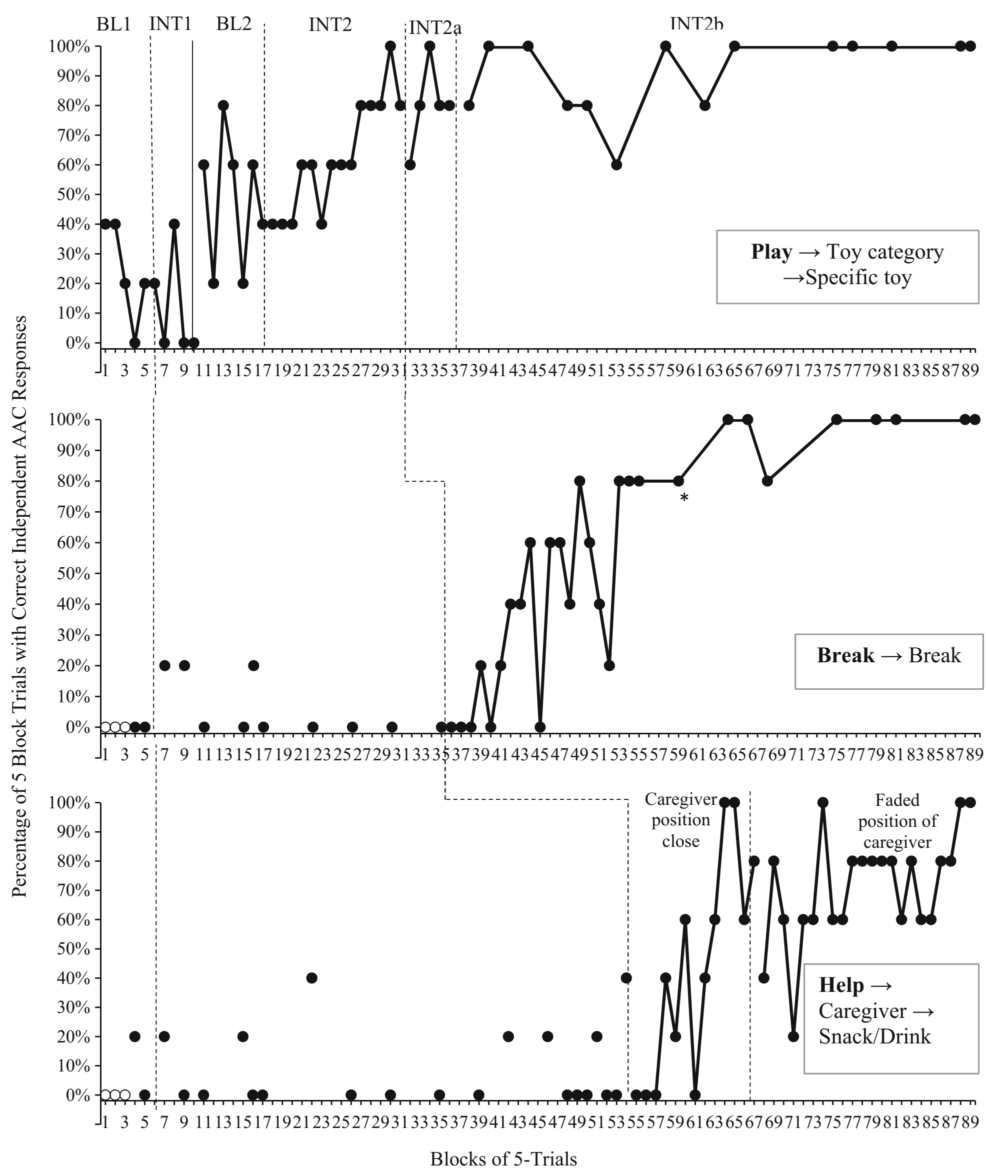

Fig. 4 Navigation training results for Tommy. Percentage of blocks of five trials with correct AAC activation of the target symbols on the SGD across three contexts (play, break, help). Open circles indicate incomplete activation of the full sequence of page sets within the context; black circles indicate activation of the full sequence of page sets. BL1 = baseline: superordinate symbols on navigation bar. INT1 = intervention: superordinate symbols on navigation bar. BL2 = baseline: superordinate symbols in an array. INT2 = intervention: superordinate symbols in an array. INT2a = intervention: middle symbol moved to bottom row of array. INT2b = intervention: symbol position randomized. The asterisk in the break context indicates when edibles during break time were faded out

conditions, independent responses were variable and at or below 40% accuracy across blocks of five opportunities. The top panel in Fig. 4 shows baseline and intervention results in the play context. Independent responding did not increase from baseline levels (range = 0–40%) initially due to Tommy's activation errors on the SGD. After modifications were made to the page set (increased symbol size and moved to a page display), levels of accurate symbol activation increased (range = 0–80%). To further increase accuracy, the middle symbol was moved to the bottom of the array for each page, which initially resulted in a slight decrease in performance followed by an accelerating trend in correct activation of the target symbols. Intervention resulted in an increase in responding (range = 60–100%) compared to baseline levels (range = 0–80%). Tommy's overall performance remained at or above mastery after the symbol positions were randomized in the final phase of the play condition.

The middle panel of Fig. 4 shows the results of Tommy's break condition. Independent responding was variable during baseline sessions (range = 0–20%). After intervention was implemented, accurate independent responding steadily increased to mastery criterion (range = 0–100%); however, responding remained variable. To increase and stabilize performance, a preferred edible was given contingent on correct responses during his break. After Tommy reached mastery criterion, the use of a preferred edible was discontinued and his overall performance remained at or above 80%.

The bottom panel shows the results of the help condition. Teaching Tommy the help request resulted in an increase in independent responses (baseline range = 0–40%; intervention range = 0–100%). There was a decrease with some variability in independent responding when caregiver proximity was faded; however, Tommy remained at or above 80% after mastery.

The average procedural fidelity across all three contexts for Leo was 92% (78–100%) and 96% (67–100%) for Tommy, respectively. Finally, both families rated the overall treatment acceptability as "highly acceptable" on the TARF-R (Reimers and Wacker 1988).

Discussion

The purpose of the current study was to extend previous research on parent-implemented communication interventions delivered via telehealth by examining the acquisition of multi-step requests on a SGD across three communicative contexts with two young boys with NDDs and evaluating the efficacy of a parent-implemented communication assessment and interventions. Both participants acquired multiple communication symbol responses on SGDs, by requesting the following: (a) play/toy (tangible), (b) help (attention), and (c) break from demands (escape). Both participants learned to navigate from a superordinate to a subordinate symbol in at least one context. These findings contribute to the extant literature on procedures for teaching both single and multi-step communication messages and navigation skills on SGDs with live coaching (Still et al. 2014).

The current study had several limitations related to the opt-in recruitment strategy and the lack of demographic information on caregivers. More specifically, parents were required to contact the researchers if they were interested in participation after being given information from a clinical site which limits external validity. Further, the researchers did not collect demographic information about parents, such as parental educational level or economic status. Therefore, parents who participated in this study likely had a high degree of motivation to do so. Due to the high level of parent involvement, this model may not be as effective for different types of families in different kinds of situations; however, more research is required.

Generalization represents another important aspect of future investigators to address. For example, Falcomata et al. (2013) found that generalization of mand signs taught with FCT was generalized when responses were trained in a positive reinforcement condition (attention) to the other positive reinforcement condition (tangible), but not to the negative reinforcement condition (escape). Although generalization was not the focus of the current study, we found that the SGD requests did not generalize across the conditions implemented and so future studies should evaluate how to program for generalization across functional contexts when teaching AAC.

Caregivers' implementation fidelity represents an important outcome in implementing AAC interventions via telehealth. Future research should also investigate maintenance of implementation fidelity as live coaching is faded. We know little regarding the degree to which fidelity can be degraded without an appreciable decrement in skill acquisition. Unfortunately, as our investigation used a live coaching model, we were unable to examine the effect of degraded fidelity over time. Anecdotally, researchers observed that after one to two sessions of implementing a new procedural step or prompt fade, coaching density was less necessary. Overall, it was encouraging that caregivers rated the intervention as "highly acceptable" on the TARF-R following completion of the study procedures, suggesting that perhaps the parents would continue to use the procedures without coaching.

SGDs are increasingly available to consumers with more downloadable AAC applications offered. Families are unable to access adequate intervention guidance and continued support on how to operate and utilize the technology to teach functional communication (Ludlow et al. 2005). Communication on SGDs can include layers of required operational skills, often requiring the user to navigate between and within screens/folders, to discriminate among options, and to build phrases. Validated procedures addressing SGD operational skills are lagging behind the rapidly developing software technology. Results of the current investigation provide replicable procedures for teaching simple navigation skills (i.e., with a forward chain). There is a need, however, for replication and extended studies in this area.

In a survey of 289 speech-language pathologists who indicated they used telehealth, only 23% reported AAC as one of the areas that they addressed (ASHA 2016). We suspect that this represents an under-utilization given the need for AAC expertise. Evidence-based practices are needed to drive how, when, and what to teach related to AAC assessment and intervention via telehealth. In summary, individuals with NDDs may face barriers to accessing needed services. Telehealth requires fewer resources than traditional clinical service delivery models and can reach families residing outside of metropolitan areas who may lack access to expertise in AAC. Our findings have potential research implications for using telehealth to improve access to expertise with AAC assessment and intervention. Future research should investigate if telehealth is effective for teaching novice interventionists in other settings (e.g., schools) in order to improve access to high-quality, evidence-based interventions.

Authors' Contributions AFD designed and executed the study, analyzed the data, and wrote the methods and results sections of the paper; ME participated in acquisition of data, data analysis, and wrote the introduction of the paper; JR participated in study design and conception, revised the manuscript critically for intellectual content, and wrote the introduction; JS participated in study design, acquisition, and interpretation of data, and wrote the discussion section.

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