5-2022

Effect of Intervention of Low-Tech AAC Access Through Triadic Gaze on Communication from School-Aged Children with Multiple Disabilities

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Effect of Intervention of Low-Tech AAC Access Through Triadic Gaze on Communication from School-Aged Children with Multiple Disabilities

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Communication Sciences and Disorders

by

Bailey Norton
University of Arkansas
Bachelor of Science in Communication Sciences and Disorders, 2020

May 2022
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

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Abstract

This study aimed to evaluate the effects of instruction in teaching triadic gaze to communicate by accessing low-tech AAC. The low-tech AAC was an Eye-Com□ board with two target words laterally fixed to the board via Velco backing. Three school-aged participants completed the study, each with multiple disabilities, severe motor restrictions, and limited speech. This study utilized a multiple baseline across participants design. Laminated color photos depicting individualized, motivating vocabulary for each participant were used as probe materials. All three participants demonstrated increased performance in accurately utilizing triadic gaze for selecting from a field of two from baseline to intervention phases. Estimated intervention effect sizes for each participant were large: Tau-U results averaged 0.93 and ranged from 0.78-1.00. Professionals may consider using instruction to teach triadic gaze as a communication access method for individuals with multiple disabilities who have limited motor access options. Future research should further investigate triadic gaze as a tool for language intervention for individuals with multiple disabilities.

Table of Contents

Introduction

The Individuals with Disabilities Education Act (IDEA) defines multiple disabilities as "concomitant [simultaneous] impairments (such as intellectual disability-blindness, intellectual disability-orthopedic impairment, etc.), the combination of which causes such severe educational needs that they cannot be accommodated in a special education program solely for one of the impairments" (IDEA, 2018). Children with multiple disabilities are at risk for falling behind neurotypical peers in areas of social engagement and academic curricula (Mundy & Acra, 2006; Mundy & Newell, 2007). Due to heterogeneity in day-to-day performance in and between individuals with multiple disabilities (Dowden & Cook, 2012), individualized intervention that considers physical and cognitive limitations is necessary to counterbalance these risks and promote participation and achievement. Effective, personalized intervention is critical to ensuring school-age children with multiple disabilities are afforded opportunities for: developing meaningful relationships; building language, academic, and vocational skills; experiencing a good quality of life; and communicating effectively with others (NJC, n.d.). Given limited research guidelines, providing effective intervention for children with multiple disabilities can be a major challenge for clinicians such as speech-language pathologists and other professionals (Olswang et al., 2014).

Fortunately, some research in the field of augmentative and alternative communication (AAC) has provided empirical information about effective interventions to support communication and language building for school-age children with multiple disabilities. Children with multiple disabilities often have limited speech and language (Mundy & Acra, 2006; Mundy & Newell, 2007), and AAC intervention supports access to and growth of communication and language for individuals with speech and language limitations (Holyfield et al. 2019; Boruta & Bidstrup, 2012). AAC intervention includes technologies and instructional strategies to support communication and language development and use through means other than or in addition to speech (Beukelman & Light, 2020). AAC varies in a bilevel system: aided and unaided. Unaided modes of communication are nonspoken forms of communication without the use of external devices (i.e., gestures, expressions, sign language) that are used to supplement natural speech or stand alone as a fully independent communication system (NJC, n.d.). Aided communication entails the use of an external device and may be low-tech options (writing, picture cards, communication boards, etc.) or high-tech devices (using an app on an iPad, speech-generating devices, etc.) (Beukelman & Mirenda, 2013).

Multiple studies have found empirical evidence in support of AAC intervention for individuals with multiple disabilities. For instance, in a 2019 study by Holyfield, Caron, Drager, and Light found that the use of visual scene displays (VSD) when employed with just-in-time programming increased the frequency of communication turns between interventionist and beginning communicators (preadolescents and adolescents 9-18 years of age). Just-in-time programming refers to the act of incorporating vocabulary and supports into AAC devices as needed in the moment. Participants engaged with the author during leisure activities regarding motivating contexts for the subject where the investigator programmed vocabulary occurring during the unstructured activity into the child's device in real time and modeled usage on the device. With access to context-related vocabulary in the moment, the five participants were able to increase conversational turn-taking on average of +27 turns per 15-minute session. Just-in-time programming with VSDs are timely and efficient in increasing frequency of communication. Large differences were noted between participants and their technology, so investigators were unable to pinpoint particular features that supplied increased frequency of communicative turn-taking (Holyfield et al., 2019).

Another 2019 study by Holyfield et al. established preliminary research regarding the intervention efficacy of VSD embedded with hotspots featuring the Transition to Literacy (T2L) feature on identification of single-word recognition. The T2L feature utilized in this study combined dynamic text and voice output for selected vocabulary. The dynamic text would maximize on the screen synchronized with the voice output, remain static for a few seconds, and then minimize. The dynamic depiction was utilized to capture the user's attention and allow the user to focus on the orthographic representation of the word heard auditorily to create an association between visual and auditory representation of vocabulary for literacy. A single subject, multiple baseline approach was utilized for three participants, all school-aged children with multiple disabilities, in this study. All three participants demonstrated significant increases when provided intervention using the T2L feature embedded via hotspots in VSDs. While this is a preliminary study, it may provide clinical implications for utilizing the T2L feature embedded in hotspots for children's leisure activities, as many children are highly motivated by watching videos. This implies that literacy skills may be acquired outside structured intervention; more research is needed before sound implications may be drawn (Holyfield et al., 2019).

A 2018 study focusing on utilizing peer training for presymbolic and idiosyncratic communicators with multiple disabilities found that training peers in identification and interpretation of communicative behaviors made by AAC users increased the accuracy and consistency of peer communication. Communication partners using VSDs were evaluated to assess motivation and peer social interaction on usage of VSDs for school aged children with multiple disabilities. Per the three participants who used AAC, 24 peers were found who regularly interacted with the subjects during school hours. Peers in the experimental group were shown video scenes of the subjects and instructed on applying a linguistic map to the communicative behavior displayed by the subject in the video. Videos either showed communicative or non-communicative behaviors and were instructed to analyze the videos and state whether there was presymbolic behavior present or not. Pre- and posttest measures found marked differences in interpretation of communicative behaviors in the experimental group. The education provided improved confidence and accuracy of the peers' identification of presymbolic communication. As the training only took one 15-minute session, it also proved to be highly efficient as well (Holyfield et al., 2018).

One reason AAC intervention can be so beneficial to school-age children with multiple disabilities is that it can allow the children to bypass all physical movement other than eye movement to communicate. That is, for children who have such severe motor restrictions that selecting a touchscreen is challenging, inefficient, or impossible, eye gaze can be used to make aided AAC selections. Eye gaze, like any other AAC component, can be low- or high-tech (Chen & O'Leary, 2018). Low-tech eye gaze consists of utilizing partner assistance for selection through social gaze behaviors such as joint attention and triadic gaze. AAC devices are commonly created with clear/Plexiglass materials where the communication partner to interpret the intended selection by the user through tracking their gaze (Ogletree, 2021). High-tech eye gaze consists of employing eye-tracking cameras in addition to speech-generating devices (SGDs). These electronic devices are programmed with an infrared (IR) light that reflects the beam from the camera of the back of the retina to the computer to track gaze point. These devices are highly susceptible to calibration issues or deemed inappropriate for use by individuals with comorbid disorders to language deficits including but not limited to the following: cataracts, nystagmus, strabismus, involuntary movements of the head and neck. Eye fatigue is also common amongst high-tech eye gaze users, limited engagement with their device to short periods of time (Chen & O'Leary, 2018).

A recent study by Holyfield (2019) sought to evaluate transitionary communication behaviors from prelinguistic to illocutionary by studying the frequency and complexity of social gaze behaviors during intervention. This study introduced the concept of salient social behaviors (SSBs), defined as, "behaviors from a communication partner aimed at promoting social engagement from individuals with limited engagement." SSBs are socially expected behaviors comprised of movement, motivating contexts, and exaggerations of gestures, facial expressions, and/or speech/sounds that would occur during naturalistic contexts without intervention. The author's goal was to build triadic gaze, an essential concept as it has proven indicative of social engagement; Axelsson et al. (2013) found that low engagement proves to be a large inhibitor for children with multiple disabilities in their communicative skills. Holyfield's 2019 preliminary study into potential prerequisite behaviors or AAC use and social gaze behaviors found that participants collectively showed increasing frequency of use and complexity of social gaze behaviors (i.e., transitioning from partner + object to partner + object + partner gaze).

Gaze tracking allows for effective communication exchange between partners where one party does not have functional speech while eliminating the barriers related to their physical impairment. Joint attention, the purposeful shift of focus to an object of attention shared between two individuals, is an essential level of early language skills and an important precursor to higher level attention skills such as dyadic and triadic gaze. Joint attention's earliest stages develop in typical children at around five months of age and "are thought of as a major contributor to, rather than a product of, the development of social cognition" (Mundy & Newell, 2007, p. 272). In addition to being an early predictor of social development, joint attention has also shown to be strongly predictive of language development (Beuker et al., 2013; McCathren & Warren, 1996; Mundy & Gomez, 1998; Mundy et al., 1990). Shared gaze, the least cognitively complex level, occurs when two individuals look at an object together; shared gaze develops at approximately five months of age in typically developing children. Dyadic gaze typically develops at six months of age, where the individual follows the shift of focus from one individual to an object and/or item of interest in a two-party conversation. Triadic gaze is the intentional three-point shift of attention from the communication partner to the object of attention and back to the communication partner. This level of joint attention is the most cognitively complex; the individual must understand both gaze and intention to establish a common reference whilst communicating with another. This skill emerges at approximately nine months of age in typically developing children (Bakeman & Adamson, 1984; Bates et al., 1975; Trevarthan & Hubley, 1978).

The Current Study

Despite the author's recommendation, research to date that has evaluated AAC intervention related to intentional triadic gaze for school-age children with multiple disabilities to make selections is limited or non-existent. Therefore, purpose of this study was to evaluate the efficacy of an AAC intervention in teaching school-age children with multiple disabilities to use triadic gaze effectively to access low-tech AAC in the form of color photos printed and Velcroed to an eye gaze board to comment during motivating contexts. Throughout this study, the term "investigator" will be used to describe the individual who gathered data during sessions and interacted face-to-face with the participants. This individuals, Dr. Christine Holyfield, served as a mentor and the thesis chair for the author of this study, a student seeking a Master's degree in communication sciences and disorders. Data analysis, interpretation, and review were completed by this student.

Methods

Research Design

A single-subject, multiple baselines across participants (Baer et al., 1968) design was implemented with a leg of three participants with an order determined through random assignment. This design was selected as it allowed for individual-level analysis of results and experimental control over a small group of participants (Kratochwill et al., 2010). The independent variable, present during the intervention phase only, was an intervention designed to teach participants how to use a low-tech AAC eye gaze board. The dependent variable was participants' accurate use of triadic gaze to select content to communicate on the low-tech AAC board. The dependent variable was measured throughout all three phases of the study: baseline, intervention, and generalization and maintenance.

Participants

Before participants were recruited, approval for research ethics was collected. Once approval was received, participants were recruited through information about the study given to school speech-language pathologists and families. The following criteria were used to for participant eligibility: (a) were school-aged; (b) had an educational diagnosis of multiple disabilities per parent and/or -professional report; (c) did not have functional speech; (d) demonstrated functional vision and hearing as per parent and/or professional report and researcher observation; (e) were early symbolic communicators, demonstrating consistent expressive use of less than 50 symbols for communicating, as per parent and/or professional report and researcher observation; (f) found meeting from color photos, per professional report and researcher observation; (g) demonstrated gaze shift and gaze/point following, per researcher screening using procedures adapted from the CSBS; and (h) were not currently using triadic gaze as a selection method and had not previously received instruction on it, per parent and/or professional report.

Three school-age children with multiple disabilities met the above outlined criteria and participated in the study (see Table 1 for more information about the participants). Their names were Alice, Isabella, and Charlie (all pseudonyms). Mean age of participants was 8 (range: 5-12). All three participants were non-ambulatory, with a primary medical diagnosis of cerebral palsy. All participants were primarily prelinguistic communicators, but consistently used a small number of linguistic concepts expressively (<20). All participants demonstrated consistent gaze shifting and gaze/point following when screened by the researcher during motivating activities. A favorite activity for all participants was viewing video, and participants each had strongly preferred content when watching videos.

Materials

Laminated color photos. Laminated color photos were used to represent the AAC vocabulary concepts expressed by the participants in the current study. The photos were printed photos were roughly 6-in by 6-in in size. They were laminated with Velcro on the back. Two color photos were printed and laminated for each participant based on a conversation with professionals (their teacher, school-based SLP, or parent) about favorite and familiar people/characters from the videos they preferred. The two color photos used to communicate represented David Tenant and Matt Smith for Alice, Woody and Buzz for Isabella, and lion and monkey for Charlie.

Table 1
Characteristics of the Three Participants

Participant[a]	Age[b]	Grade[b]	Primary medical diagnosis[b]	Ethnicity	Primary communication modes[c]	Unique concepts expressed consistently[c]	Gaze shift and gaze/point following[d]	Favorite video content[b]
Alice	12	7th	CP	White	Prelinguistic gestures and facial expression; gaze to physical choices	<20	Consistent during motivating activities	Dr. Who; Star Trek
Isabella	5	K	CP	Black	Prelinguistic vocalizations, reach, and facial expressions; single switch selection; gaze to choices	<10	Consistent during motivating activities	Toy Story; children playing with toys
Charlie	9	2nd	CP	White	Prelinguistic; single switch selection	<10	Consistent during motivating activities	Wild animals; superhero cartoons

Note. K = kindergarten. MD = multiple disabilities. CP = cerebral palsy.
[a]Pseudonyms
[b]Based on parent and/or professional report
[c]Based on parent and/or professional report and researcher observation
[d]Based on researcher screening

Eye-Com™ board. An Eye-Com™ board, a plexiglass eye gaze board, was used to hold the laminated color photos. The board had a rectangular cut out in the middle to allow for unobstructed eye contact between the communication partner who holds the board and the communicator who faces it. Velcro was attached to each side of the middle cutout to allow for both laminated color photos a participant used to be displayed for their selection.

Motivating videos. Video clips featuring the AAC vocabulary words selected for each participant were also used in the study. The clips were between 15 s and 45 s in length. The clips were displayed on a 12-in tablet.

Procedures

During an 8-week period, the participants completed one to three study sessions per week, depending on their availability. All sessions occurred in the afternoon. Sessions consisted of one-on-one interactions between the participant and the researcher. For Alice, all sessions occurred in the living room of her home after school. For Isabella and Charlie, all sessions occurred in the therapy room of their school SLP.

Probes. All baseline sessions consisted of one probe. All intervention sessions started with one probe. During each probe, the researcher sat directly in front of the participant at eye level. Each probe focused on one of the two AAC vocabulary concepts selected for the participant. Sessions were paired with the two concepts being randomly assigned to one of the sessions. Each probe contained five trials. The researcher used the following procedures each trial: (a) place the participants' two AAC concepts in a random order on the eye gaze board, (b) position eye gaze board in front of face, (c) say "Look, it's [word one] and [word two]" while pointing accordingly to each printed photo, (d) say "Use your eyes to tell me [target word]", (e) wait 30 s for the participant to respond by using eye gaze to select the word, and (f) provide no feedback on performance. The researcher did provide intermittent praise for participation, but not contingent on or anyway related to performance.

Instruction. Instruction included the following components: expectant delay, most-to-least prompting (with a visual + auditory, visual only, and no prompt hierarchy), contingent responsivity, praise, and the use of motivating contexts. These strategies were used based on their frequency in the evidence-base of AAC instruction, and specifically for their success in previous research teaching gaze behavior to school-age children with multiple disabilities (Holyfield, 2019).

Five instructional trials occurred in each instruction session. For the first trial of each instructional session, the researcher completed the following: (a) place the participants' two AAC concepts in a random order on the eye gaze board, (b) position eye gaze board in front of face, (c) say "Look, it's [word one] and [word two]" while pointing accordingly to each printed photo, (d) say "You can tell me who you want to watch a video of like this", (e) provide a visual (pointing) and auditory (spoken) prompt through each step of triadic gaze with one of the photos, (f) provide linguistic confirmation and praise for the response (e.g., "Nice job telling me you want to watch a video of [word]"), (g) play a video clip featuring the selected. For the second instructional trial, procedures were identical except prompting was faded to visual pointing only. For all subsequent trials, expectant delay was used to relinquish responsibility in selecting with triadic gaze to the participant, with a visual + auditory prompt provided for each step in which its completion did not occur within 5 s. For any subsequent instructional trials after a lack of response or incorrect response required adding back a visual + auditory prompt, that trial contained a visual only prompt. Aside requiring correct use of triadic gaze to make a selection during instruction, participation was errorless as there was not a wrong answer, but the participant was simply making a choice about what they preferred to do. This allowed the participant to focus on specifically on learning the novel selection method.

Generalization and maintenance. Participants completed probes only in the generalization and maintenance phase. The probes were identical to those administered throughout the rest of the study, except they were conducted by a trained, familiar communication partner who consented to participate in this role in the study. The researcher stood behind the communication partner to provide support as needed about the procedural steps. A volunteer professional who had worked closely with Alice over the span of multiple years served as her communication partner. Isabella's school SLP served as her communication partner. Charlie's special education teacher served as his communication partner. All participants completed three maintenance and generalization sessions that occurred 1, 2, and 3 weeks after in the end of intervention except for Charlie who completed only two sessions due to the school year ending before a third session could be completed.

Phase shifts. Alice's participation shifted from the baseline to intervention phase after she completed five baseline probes with the last three reflecting a stable or downward slope. Isabella and Charlie shifted from baseline to intervention after having completed at least six probes with the last three sloping downward or being stable and after the participant before them in the leg demonstrated one session of an intervention effect. An intervention effect was defined as use of intentional triadic gaze at least double that of the highest baseline session. Participants shifted from the intervention to the generalization and maintenance phase after completing at least five sessions and using intentional triadic gaze correctly in 5/5 trials in two probes.

Procedural fidelity. One checklist was created to gauge the researcher's fidelity to the probe procedures, and another to gauge the researcher's fidelity to the instructional procedures.

The probe checklist contained steps a-f of the probe trial procedures, repeated five times (once for each trial). The intervention checklist procedures contained a-g of the instructional trial procedures, repeated five times (once for each trial), with step e requiring a 5 s expectant delay and variable prompting as needed in trials 2-4. An undergraduate student in speech-language pathology was taught to use each checklist through instruction and calibration on video not randomly selected for inclusion in procedural reliability. The student stated aloud her scoring for each step, and disagreements were discussed. Following the student reaching a high level of agreement through calibration, she independently coded a randomly selected 25%+ of sessions for each participant (25% for Alice, 27% for Isabella, and 28% for Charlie). The selected sessions were evenly distributed across the baseline and intervention phases. Mean probe procedural fidelity across participants and phases was 98% (range: 94-100%). Mean instruction procedural fidelity across participants and phases was 94% (range: 91-100%).

Data Collection, Measure, and Analysis

Data collection. The researcher collected data live during probe sessions using a data collection form, marking use of triadic gaze to make a selection as incorrect or correct for each of the five trials. All sessions were also videotaped with two cameras to allow for interrater reliability and procedural fidelity. The camera for interrater reliability was placed directly behind and above the head of the researcher. The camera for procedural fidelity was placed directly behind and above the head of the participant. Data collection for the current study took place prior to the spread of COVID-19 and the lockdown that followed. A Master's degree-seeking student visually analyzed and interpreted the data through video recordings of the sessions.

Measure. The dependent variable measured in this study was accurate use of triadic gaze as a selection method to access low-tech AAC. Participants could score as high as five each session on their use of triadic gaze as there were five trials in each probe. Triadic gaze selection was only counted as correct if the participant completed each step of the process, in order and in immediate sequence: looked to the researcher for at least 1 s, looked at one printed photo for at least 1 s, and looked back to the researcher for at least 1 s.

Data analysis. Participant data were graphed and visually analyzed as per single subject standards (Kratochwill et al., 2010). The following changes were considered upon visual analysis: level, trend, variability, and slope. With visual analysis, one was also able to observe any immediate effects with initiation of the intervention phase. Tau-U was calculated alongside visual analysis to estimate effect sizes (Parker et al., 2011). Tau-U's effect size are read to be determined by numerical correspondence, i.e., the higher the number, the larger the effect size.

Interrater reliability. A graduate student in speech-language pathology was trained to code the dependent variable from the videos of the probes. The same probe videos randomly selected for procedural fidelity purposes were used for interrater reliability purposes. The graduate student was blinded to the goals the study and the study phase of each video. Training occurred through calibration on video not randomly selected for fidelity/reliability purposes. The student used the same data collection form used by the researcher for live coding. After the researcher described triadic gaze, the participant coded the videos getting feedback from the researcher until the students' coding aligned with that of the researcher. The student then independently coded the randomly selected videos. Point-by-point reliability for each trial of each session was completed, with agreements in coding each trial being divided by the total number of trials (5) then multiplied by 100 to yield a percentage. Interrater reliability across participants and phases was a mean of 90% (range: 80-100%).

Social validity. The investigator corresponded with the participants' teachers, SLPs, and parents during and after the generalization and maintenance phase to obtain measures of social validity. Social validity refers to the assessment of satisfaction of intervention methods, usually obtained through solicitation of one's opinions (Wolf, 1978). In this current study, those in participants' lives noted that the individuals who received intervention focusing on low-tech access triadic gaze for selection continued to independently utilize triadic gaze well after the study had ended.

Results

All three participants received intervention for their two target words. Both words were targeted each intervention session. Figure 1 depicts each participant's performance on the dependent variable as organized by participant performance across three phases: baseline, intervention, and generalization and maintenance.

During the baseline phase, two of the participants (Isabella and Charlie) never used triadic gaze to select a concept to communicate from the low-tech eye gaze board (*M*=0%). Alice used triadic gaze only once across all the baseline phase (*M*=4%), and likely did so without the intent to use the specific selection technique.

Alice began intervention first and demonstrated an intervention effect after just one instructional session. This increase in performance level continued to grow throughout the intervention phase with some variability, until after 6 and 7 sessions of instruction she consecutively used triadic gaze accurately to communicate in 100% of trials. Her mean performance accuracy throughout the entire intervention phase was 66% (range: 40-100%), representing a 62% increase from mean baseline performance.

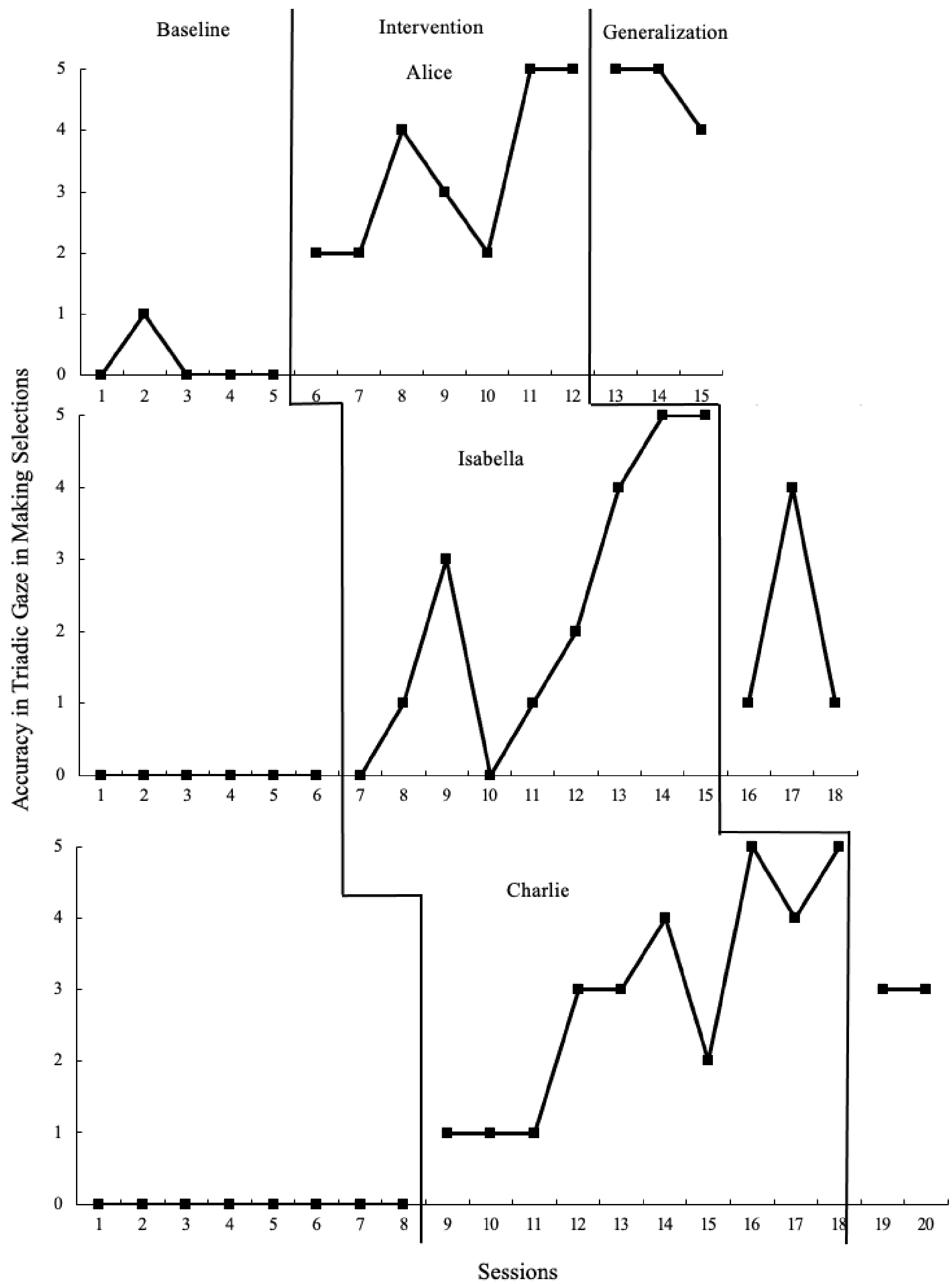

Fig 1. Participants' use of triadic gaze, trialed 5 times per session, over time

Isabella demonstrated an increase in performance level after two instructional sessions, though her performance level again decreased before showing a steep and consistent upward slope in performance. She also showed two consecutive sessions with 100% accurate use of triadic gaze to make selections on the low-tech eye gaze board in sessions 8 and 9. Her mean performance accuracy throughout the entire intervention phase was 44% (range: 0-100%), representing a 44% increase from mean baseline performance.

Charlie demonstrated an initial increase in performance that he maintained for three sessions before demonstrating a further increase in level. Overall, though variable, his data trended upward throughout the intervention phase. He demonstrated two non-consecutive sessions of 100% accurate use of triadic gaze in sessions 8 and 10. His mean performance accuracy throughout the entire intervention phase was 60% (range: 20-100%), representing a 60% increase from mean baseline performance.

Maintenance and generalization performance for all three participants was higher than performance in baseline. Alice showed 80-100% accuracy in triadic gaze use when interacting with a familiar partner 1-3 weeks after intervention ended, representing a mean increase of 89% from baseline. Isabella demonstrated variability in performance, varying from 20% to 80% accuracy using triadic gaze, representing a mean increase of 40% from baseline. Charlie's use of triadic gaze was consistent at 60% for both his generalization and maintenance sessions, representing a mean increase of 60% from baseline.

Based on Tau-U calculations, the instructional intervention had a marked effect on communicating a choice through triadic gaze for all three participants. When comparing intervention performance to performance in baseline, the intervention effect sizes were estimated as moderate to large. The estimation resulted in a Tau-U value of 1.00 for Alice, 0.78 for

Isabella, and 1.00 for Charlie. When comparing generalization and maintenance performance to performance in baseline, the intervention was estimated to have a large effect for all three participants, with a Tau-U score of 1.00 for all participants. See Table 2 for visual breakdown of Tau-U analysis.

Table 2

Tau-U Analysis Per Participant and Combined Weight

Phase Comparison	Alice	Isabella	Charlie	Combined Weight
BL[1] v INT[2]	1.00	0.78	1.00	0.93
BL v MG[3]	1.00	1.00	1.00	1.00

[1] Baseline phase
[2] Intervention phase
[3] Maintenance and generalization phase

Discussion

All three children demonstrated increased performance in communicating using triadic gaze for selection using an Eye-Com board. Despite the limited scope of the study, the findings are promising as two participants (Isabella and Charlie) did not demonstrate any understanding of triadic gaze upon entering the current study per observation and baseline performance, and one participant (Alice) showed little use of triadic gaze in baseline. This study provides evidence that a relatively short amount of instruction can be effective in teaching triadic gaze for low-tech AAC access for school-aged children with multiple disabilities; in addition to this, the current study also provides evidence for maintenance of independent use of triadic gaze over a short period of time.

All three participants maintained their use of triadic gaze two to four weeks following intervention with a large Tau-U effect size of 1.00 for all participants when compared to baseline while generalizing it to communication with a familiar partner. Participants met the criteria for ending intervention (Kratochwill et al., 2010) after 7 (Alice), 9, (Isabella), and 10 sessions (Charlie).

At time of writing, this study represents the first intervention focused on school-age children with multiple disabilities to teach intentional triadic gaze as an access method for low-tech AAC. Previous research showed that instruction could effectively teach triadic gaze as a signal of coordinated joint attention to young children (10-24 months of age) with physical disabilities (Olswang et al., 2014). The findings in the current study support those results by continuing to demonstrate the teachability of triadic gaze to children with motor impairments in interactions. The current study's findings differ from results found in Olswang et al. (2014) by focusing on older children, and by teaching triadic gaze as an intentional access method rather than a signal of engagement.

A 2019 study by Hahn et al. regarding the use of triadic eye gaze in children with Down Syndrome, autism spectrum disorder, and other intellectual disabilities found that of the populations studied, children with Down Syndrome demonstrated the highest use of triadic gaze (Hahn et al., 2019). This study differs from the current as Hahn et al. did not seek to provide intervention utilizing triadic gaze, and they again were not focused on triadic gaze as an access method.

Low-tech AAC is a cost-efficient method of alternative communication that is highly accessible for individuals who have limited or lack functional speech skills (Moorcroft et al., 2018). The Eye-Com™ board and laminated color photos used in this study are more cost effective than high-tech devices such as SGDs, iPads, or other mobile devices. For beginning communicators and replication of current study, smaller probe sets may be utilized, which will reduce the device's construction time; increased time needed for creating a low-tech AAC device has been noted as a potential disadvantage by communication partners (Scott, 1998). Low-tech AAC has been found to be deemed as advantageous over high-tech due to low-tech's flexible and adaptable nature, the 1:1 interaction between user and communication partner, and easy repair and maintenance (Murphy, 1993).

It is likely that the intervention methods used in the current study were effective due to their highly motivating and engaging nature. Research has found that children with multiple disabilities demonstrate low engagement levels (Axelsson et al., 2013). Participants were engaged with the investigator face-to-face within the context of communicating around and watching favorite videos. It may also be said that the current study's method of intervention proved effective as the participants were rewarded immediately upon selection of a probe through triadic gaze. Timing of reward following target behavior has been found to be strongly correlated to persistence of target behavior (Bermudez & Schultz, 2014).

Clinical Implications

AAC access options for school-aged children with multiple disabilities can be limited, especially regarding triadic gaze. For children who have limited speech, access to AAC is vital for social engagement and educational access. As children with multiple disabilities often demonstrate low engagement (Axelsson et al., 2013), targeting pre-linguistic skills such as joint attention may increase engagement for later language development with AAC if the individual lacks functional speech. Using triadic gaze for communicating may not only allow the individual to increase their joint attention skills but may also provide access to a meaningful communication method.

Further, more in-depth research is warranted to explore the relationship and effect of triadic gaze on engagement levels for school-aged children with multiple disabilities before strong clinical implications may be drawn. The current study does provide evidence to support that implementing triadic gaze for school-aged children with multiple disabilities does however increase communication levels. Clinical professionals may consider including the intervention methods outlined in the current study as a component of a more comprehensive therapy model for individuals who require AAC and have multiple disabilities.

Each participant communicated within highly motivating contexts individualized for them. These including videos and still color photos representing those videos. Clinical professionals should consider tailoring selections to engaging and motivating objects and/or activities for each individual client. For example, children may be interested in peer interaction, play activity, and/or videos of themselves.

Limitations and Future Research Directions

There lies a multitude of limitations within the current study. First, only three school-aged children with multiple disabilities were able to participate. Future research should focus on increasing the internal and external validity through a larger sample. Second, only two probes were utilized in the intervention phase. Further research should be done targeting an increased number of probes to evaluate the effects of a larger field of potential selections. Third, limited data regarding maintenance trends were obtained. Further research should evaluate maintenance performance over a longer period following intervention. Fourth, no data was obtained regarding the generalization of triadic gaze usage by participants following intervention. In future research, participants' caregivers and educational professionals may be trained in interpreting triadic gaze in daily routines and activities both with and without an Eye-Com□ board present to evaluate generalization effect size. When considering the efficacy of AAC research, both generalization and maintenance effect sizes are crucial (Schlosser & Lee, 2000). Thus, a lack of generalization and minimal maintenance findings limit the implications of the current study. Future research should explore: (a) the extent to which individuals who learn triadic gaze through intervention using an Eye-Com□ board and intervention methods outlined in the current study to independently use triadic gaze in real world settings (e.g., in daily routines and activities, whilst making selections in educational settings); (b) the extent to which previously stated individuals continue to use triadic gaze independently long after exposure to intervention. Fifth, this method of intervention was used as a singular component of pre-linguistic intervention. Further research should consider implementing triadic gaze for low-tech access as a larger component of language therapy. Sixth, probe materials for the individuals were represented through pictures rather than orthographic representations of the words. Future research has the potential to assess and evaluate the efficacy of utilizing Eye-Com□ boards and triadic gaze through literacy intervention. Words representing the motivating contexts and rewards can be used in place of images to increase phonemic awareness and literacy skills. Lastly, only videos and images were used as selection materials for participants. Future research should explore the efficacy of utilizing activities objects as selections should these be motivating and engaging for the participants. There is potential for this intervention method to be utilized within academic contexts for selection on curricula and engaging in whole-group activities.

Conclusion

Joint attention is an important precursor for language development and a crucial skill for social engagement (Mundy & Newell, 2007). Establishing triadic gaze, a higher-level cognitive attention task, through language intervention has the potential for increasing engagement in children with multiple disabilities, a common hinderance to intervention methods (Axelsson et al., 2013). This study shows that triadic gaze can be molded into an intentional method for making communication choices using low-tech AAC. In this way, triadic gaze can provide the individual with opportunities to share about their inner thoughts and feelings, indicate their needs, wants and interests, and interact socially with others. Further research is required to continue to evaluate this approach's efficacy on use of triadic gaze for selection as well as the maintenance and generalization of this skill beyond intervention. The current study proves that providing school-aged children with multiple disabilities instruction for communicating through low-tech AAC by accessing it using triadic gaze to be beneficial.

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