SIMULTANEOUSLY TRAINING MULTIPLE AAC MODALITIES: EVALUATION ON ACQUISITION, PREFERENCE, AND RESPONSE PERSISTENCE

by

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(Under the Direction of Kevin Ayres and Rachel Cagliani)

ABSTRACT

Augmentative and alternative communication (AAC) provides individuals without speech, or with limited speech, a way to functionally communicate. Current practitioner recommendations emphasize the need for multimodal AAC communication, yet limited research exists on teaching two AAC modalities simultaneously and no studies are available that evaluate the use of multiple modalities with preschoolers with autism spectrum disorder (ASD). The purpose of the current study is to evaluate the effects of simultaneously teaching two AAC modalities, Picture Exchange Communication System and the Proloquo2Go™ application on an iPad, to preschoolers with ASD. Through the use of a multiple probe across participants design, the primary researcher evaluated the PECS instructional protocol for teaching each modality, assessed participants' rate of acquisition and preference of modality through a concurrent operant condition, assessed the occurrence or emergence of vocalizations, and assessed for maintenance of each modality. Additionally, a B-A-B-A design was used to determine the impact of embedding a treatment challenge (e.g., one modality is unavailable when using a lag schedule of reinforcement) directly into training to evaluate the effects of response persistence when two modalities are simultaneously taught.

Results demonstrated three of the four participants acquired PECS and Proloquo2Go during simultaneous training, maintained each modality at comparable levels to intervention, and interchanged modalities when faced with a contrived communication breakdown. The Lag 1 schedule of reinforcement yielded higher variation of responding in comparison to no extinction in the Lag 0 conditions. Findings provide support for training modalities simultaneously and suggest the PECS manual an effective protocol for teaching speech-generating devices, specifically, Proloquo2Go. The current study also extends response persistence and variability literature and preliminarily suggests adding contrived communication breakdowns into training can strengthen an individual's multimodal communicative repertoire.

INDEX WORDS: Augmentative and Alternative Communication, PECS, Proloquo2Go, Response Persistence

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B.S.Ed., The University of Georgia, 2017

M.Ed., The University of Georgia, 2018

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2022

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August 2022

DEDICATION

To Gray.

To Ben.

To those who helped along the way: Mom, Dad, Joy, Jeff.

To AB. May we serve like you, teach like you, love like you.

Inspired by Darius.

ACKNOWLEDGEMENTS

This journey was long and would not have been possible without the encouragement and support from many along the way. I would like to express my appreciation and gratitude to my co-advisors: Drs. Kevin Ayres and Rachel Cagliani. Kevin, thank you for the flexibility you have given me, for letting me drop the balls that bounce, for showing me what I'm capable of accomplishing at this caliber, and for preparing me to leave. Rachel, I look forward to being your colleague in this field and us continuing to advocate for effective communication for all. I have learned so much from you that extends far beyond the walls of academia. But mostly, thank you for supporting me in all the roles I've taken on during my time here.

I would also like to acknowledge the support and mentorship received from my dissertation committee: Drs. Jenny Brown and Rebecca Lieberman-Betz. I appreciate your attentiveness, expertise, and your commitment for seeing me through.

Dr. Alicia Davis, thank you for introducing me to behavior analysis, and even more so thank you for always being willing to have tough conversations. Your wisdom and guidance helped remind me what's important and to always see the big picture.

I had the privilege to teach and mentor students at the preschool and college level and I acknowledge that each of them taught me more about behavior analysis, advocating, kindness, and keeping the focus on the why behind it all far more than any class lecture or text ever could. My dedication to growing, learning, and educating does not end with my time at The University of Georgia.

I would like to acknowledge and give my sincerest appreciation to my family and friends and all who gave their encouragement, kind words, and never-ending support. Mom and Dad thank you for teaching me that I can do hard things, for instilling in me a strong work ethic, and for cultivating an inner motivation to achieve great accomplishments. Jeff and Joy thank you for all the love and encouragement you've shown me and our family of three. SK, thank you for helping make this possible, all the encouragement, reliability data, and endless hallway conversations. I could not have asked for a better peer and am so thankful to call you friend. Jess, we finally finished, and I will forever be thankful for the special bond we have. Kelsie, I couldn't have made it through without you and am a better practitioner because of you.

My sweet Ben, I love you. We joke you got this degree too. Thank you for your patience, for joining in all the meetings and classes, and for making this all worth it. You've taught me how strong I really am, how much I can do with very little sleep, and most importantly, you've shifted my world for the better.

And best for last, I would like to thank Grason for absolutely everything. For the encouragement; for not only having my back but walking alongside me in this journey; for trusting and never doubting that I could make it to the end. Here we are. It's the end.

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CHAPTER 1

INTRODUCTION

Individuals who receive a diagnosis of autism spectrum disorder (ASD) must exhibit deficits in social communication (related to back-and-forth conversations, failure in responding to social interactions, lack of nonverbal communicative behaviors used in social interactions, and lack of developing or maintaining relationships), engage in restricted, repetitive patterns of behavior, and display symptoms during the developmental period (APA, DSM-5, 2013). The age at which individuals receive an ASD diagnosis varies, but research suggests that earlier identification increases the chance for more success in helping the individual learn skills related to deficits caused by ASD (e.g., communication; Zwaigenbaum et al., 2015).

Much of the communication research focuses on toddlers to preschool-aged children. This age group is similar to the age of language development for typically developing children as research shows the period of time from birth to three is a critical language period (Ganz et al., 2012; Mundy, 2017; Pence Turnbull & Justice, 2012). About 40% of individuals diagnosed with ASD do not speak or have not developed speech in the typical developmental timeline for when speech is expected to occur (CDC, 2018). For children with ASD who did not develop speech, practitioners recommend introducing augmentative and alternative communication (AAC), in order to provide the child with a system of functional communication. Beukelman and Mirenda (2013) emphasized the importance of early intervention surrounding communication and because of the focus on early intervention with individuals with ASD, a considerable amount of the AAC

research also focuses on the preschool to early-elementary school-aged children (3 to 8 years old; O'Neill et al., 2018).

Augmentative and Alternative Communication

The goal of AAC is to provide an individual with tools or strategies that enhance their current level of communication in an attempt to extend their functional communication and increase their involvement across all aspects of their life (Beukelman & Light, 2020; International Society for Augmentative and Alternative Communication, 2020). Individuals without functional communication are negatively impacted in several domains of life including behaviorally, academically, and socially (Ganz, 2015; Ganz et al., 2012a). Biggs et al. (2018), Collette et al. (2019), and Dada et al. (2016) findings support the introduction of AAC to increase skill acquisition across academic domains and social participation with peers.

Speech production is also an important factor when considering introducing AAC, and many parents or practitioners have raised concerns that speech might not occur if AAC is taught. However, as discussed further in Chapter 2, these concerns are not warranted as AAC does not decrease speech, rather provides the individual with a supplemental mode of communication. Speech may not occur for all individuals who use AAC, but those who receive appropriate and adequate training in AAC increase their functional expressive communication. AAC allows individuals without speech, or with limited speech that is functionally used, to engage in expressive communication, participate in their community, and make requests and comments that are understood by others. Similar to other assistive technology, the type of AAC can vary depending on the individual.

Practitioners and researchers consider AAC to be aided or unaided. Aided AAC requires the use of external materials (e.g., pictures, devices, paper and pencil) and unaided AAC consists

of manual sign language or gestures without the need for anything external (Mirenda, 1999). For the purpose of this paper, the phrase low-tech AAC is used to describe any type of picture exchange, symbols, communication boards, and high-tech AAC is used to describe tablets with communication applications and speech-generating devices (SGD) with symbols and voice output.

Gaps in the literature exist when determining which type of AAC to select and introduce to a child but evaluating best practices and strategies around AAC types remains important so children have appropriate access to functional communication. The American Speech-Language Hearing Association (ASHA, 2021) advises practitioners to view AAC as multimodal, thus practitioners should introduce several modes (e.g., low-tech and high-tech AAC) of communication in an effort to increase an individual's functional communication. ASHA's statements on multimodal communication with AAC supports the need for research that examines teaching multiple modalities simultaneously.

Teaching a child to use multiple AAC modalities allows flexibility around communication. Issues may arise when the child has only mastered a single modality and that modality becomes unavailable either for a brief (e.g., left at school for the weekend) or extended period of time (e.g., high-tech AAC broken and sent for repair). It may not be feasible for the individual to have access to duplicates of the same high-tech device. In either instance, the child without AAC lost access to their means of communication and cannot as effectively express wants, needs, or participate as fully in life. By training multiple modalities, for example, picture exchange and SGD, the child would seamlessly transfer between modalities and never be without functional communication.

Research surrounding multimodal communication has included adult participants with aphasia (Purdy & Wallace, 2016) and adult participants with traumatic brain injury (Diehl & Wallace, 2018), but has not included individuals with ASD or those at the preschool age. Results from studies with older participants demonstrated increased functional communication (Diehl & Wallace, 2018), and participants were able to navigate communication breakdowns (King et al., 2013). Boesch et al., (2013), Lorah (2012), and Tincani (2004) evaluated multiple AAC modalities with individuals with ASD but focused on comparing responding across modalities rather than teaching multiple modalities to increase multimodal communication.

Boesch and colleagues (2013) compared the efficacy of instruction with two different modalities (PECS and SGD) on participant requests, eye-contact, smiling, and speech production. Researchers found participants engaged similarly with each modality. Additionally, they found social-communicative behaviors occurred slightly more with PECS, but that increases were not substantial. Speech production did not increase for any participant. Similarly, Lorah (2012) evaluated mands (i.e., requesting), individual preferences, vocalizations, and disruptive behavior following instruction for the use of picture exchange and SGD. More participants used and preferred the SGD than picture exchange, and vocalizations did not significantly change for participants. Lastly, Tincani (2004) compared the effects of PECS and sign language instruction on AAC mands to evaluate the effects on mands and vocalizations and found that participants requested more using PECS but vocalized more when using sign language. These studies by Boesch et al. (2013), Lorah (2012), and Tincani (2004) compared responding following instruction with various AAC modalities. The emphasis was on determining the best modality for participants, but future research should evaluate whether an individual could become proficient when taught multiple modalities simultaneously.

Response Persistence and Variability

Behavior analytic research on response persistence and response variability provide preliminary support for training multiple modalities. By increasing the child's communication repertoire with multiple modalities, the individual is more likely to persist and vary communication attempts, even in the event of a communication breakdown (Adami et al., 2017; Ringdahl et al., 2018; Romani et al., 2013). When evaluating the effects of response persistence on communication, researchers have implemented extinction procedures ([i.e., withholding reinforcement for a response previously reinforced; Vollmer & Athens, 2011] Ringdahl et al., 2018) the effects of intermittent reinforcement ([reinforcing some responses but not all; Hanley & Tiger, 2011] Ferguson et al., 2019; Romani et al., 2013), and the effects of varying schedules of reinforcement (Adami et al., 2017; Falcomata et al., 2018) to evaluate response variability and the individual's response resistance to change (e.g., if reinforcement is withheld the individual will continue to request). Findings from these studies revealed that the participants continued to persist in the communicative response even when reinforcement was withheld.

Additionally, researchers have also assessed response variability by altering the schedule of reinforcement (Adami et al., 2017; Falcomata et al., 2018). Contemporary research surrounding intermittent reinforcement and response persistence in regard to communication suggests that occasionally not reinforcing the exchange strengthens the behavior, thus making it more resistant to treatment challenges and communication breakdowns (Hanley & Tiger, 2011). Adami et al. (2017) and Falcomata et al. (2018) used lag schedules of reinforcement to increase participant's response variability during functional communication training (FCT).

A lag schedule requires the individual to use a novel response, or a response different from the response previously used to receive reinforcement (Cooper et al., 2020). On a Lag 1

schedule, for example, the individual receives reinforcement for a response that differs from the last previous response. Adami et al. (2017) suggested training multiple modalities of communication to prevent individuals from engaging in challenging behavior when one communication modality failed, specifically referring to treatment infidelity during FCT. Treatment infidelity is relevant to broad-based communication training, as well, leading to communication breakdowns.

Communication Breakdowns

During a communication breakdown, the disconnect between the speaker and listener disrupts communication and directly impacts the individual's response persistence (Pence Turnbull & Justice, 2012). Communication breakdowns could occur due to fidelity errors during training, the individual attempting to communicate with someone unfamiliar with AAC, or an unintentional extinction of the request (e.g., item requested is not available). In the event of an interruption in communication, it is essential the individual communicating via AAC has the skills to identify a communication breakdown is occurring and implements strategies for repair.

Within training sessions, communication partners should consider purposefully incorporate communication breakdowns to allow the individual to practice in an instructional setting where help or feedback is available. In the event of a communication breakdown, the AAC user may continue exchanging pictures or alter requests in an attempt to complete the request. Research shows that more varied communicative repertoires persist longer despite contacting extinction and when an individual has multiple modalities of AAC in their repertoire, the individual may even attempt to repair the breakdown by using another modality (Adami et al., 2017; Ringdahl et al., 2018; Romani et al., 2013).

Frost and Bondy (2002) recommend strategies in relation to some of these communication breakdowns (e.g., treatment challenges, unplanned extinction when the modality is unavailable). In the event a requested item is unavailable (e.g., the playground during a storm), the communication partner can offer what is available, use a visual over the pictures to signal the item is not available, or implement picture schedules or token boards as strategies to help the individual see when the item might be available at a later time. During later PECS phases, the communication response should be well established making intermittent reinforcement of the exchange less likely to cause the individual to completely stop responding. Intermittent reinforcement also occurs as a natural consequence in some instances (e.g., requests to go to school on Saturday). Regardless, Frost and Bondy (2002) suggest communication partner always acknowledges the exchange, even if the item is not delivered (e.g., responding "You want the playground, but it is raining"). Given the many options for AAC and the importance of establishing response persistence and variability, selecting the best fit AAC for each individual should be comprehensive and fluid.

AAC Selection

The Participation Model

The recommended method to AAC selection is The Participation Model, which encompasses a series of indirect and direct assessments and observations to gather information related to the individual's current communicative ability, skill abilities related to different AAC modalities (e.g., sign language requires fine motor skills), the individuals' environments, communication opportunities, and any barriers to communication they may face (Beukelman & Mirenda, 2013). However, research evaluating the effectiveness of the Participation Model and instruction for those utilizing this assessment is lacking (Lund et al. 2017). Typically, an AAC

team comprised of a speech-language pathologist (SLP), the individual and caregiver(s), and additional professionals from a range of disciplines (e.g., physical therapist, occupational therapist, behavior analyst, educational personnel) collect data associated with their expertise (e.g., the physical or occupational therapist evaluates motor skills needed to manipulate AAC modalities) when working through The Participation Model.

The Participation Model flow chart provides practitioners with a series of steps to follow that include assessment, a trial period that allows the individual to utilize an AAC modality, an instructional period for the individual and caregiver, and progress monitoring (Beukelman & Mirenda, 2013). There are gaps in the research surrounding how to identify and select the best AAC modality for an individual, and once selected, there is again limited research on how to provide effective instruction for AAC (Ganz, 2015). Following the selection of an AAC modality, the individual and those they interact with (e.g., caregivers, teachers) need to learn how to effectively use the modality to increase functional communication and decrease the likelihood of AAC abandonment.

Common AAC Modalities

AAC modalities mostly identified in research with young children include the Picture Exchange Communication System (PECS), other picture exchange, and SGDs (Bishop et al., 2019; Cummings et al., 2012; Doherty et al., 2018; Greenberg et al., 2014; Ganz et al., 2015; Gevarter & Horan, 2019; Waddington et al., 2017). PECS, a picture-exchange based AAC, uses behavioral principles (e.g., reinforcement, shaping, errorless learning, prompting) to teach and is considered a low-tech AAC modality that is low-cost. Interventionists print and laminate pictures of preferred items and attach them with Velcro to a small binder than can be worn by the communicator. SGDs, identified in most studies as being high-tech, incorporate graphic displays

on an electronic device that offers text-to-speech voice output through the selection of letters, words, pictures, or messages (Lorah et al., 2015; van der Meer & Rispoli, 2010).

Practitioners often discuss the advantages of SGD compared to PECS. These advantages include the ability to store and expand a large vocabulary, the ease of incorporating core and fringe words, and the spoken voice production. SGDs do come with their disadvantages including access due to cost, access (e.g., insurance coverage), and vulnerability to require high-cost repairs. The use of SGDs as an AAC modality has significantly increased since (Schlosser & Koul, 2015) as well as the types of SGDs available (e.g., Proloquo2Go, Language Acquisition through Motor Planning [LAMP™], Snap&Core, DynaVox). Researchers have incorporated several strategies for teaching SGD responses including modifying the PECS protocol (King et al., 2014) and other behavioral strategies such as prompting (Alzrayer et al., 2019; Lorah & Parnell, 2017), and time delay (Alzrayer et al., 2019; Lorah & Parnell, 2017), yet no best treatment has been identified for teaching SGDs. PECS and Proloquo2Go are two modalities commonly used by young children with ASD and both require selection-based responding to communicate.

Picture Exchange Communication System

PECS is a manualized AAC instructional program to rapidly teach individuals to expressively communicate via picture exchange (Bondy & Frost, 1994). Bondy and Frost (1994) created PECS to increase an individual's functional communication using principles of behavior analysis and Skinner's verbal behavior (Frost & Bondy, 2002; Skinner, 1957). A primary goal of PECS is to teach spontaneous communication. Rather than an individual relying on another person to communicate, either because of prompt dependency or waiting to be asked a question,

PECS aims to teach the individual they are an integral part of the communication process and can initiate communication as needed (Frost & Bondy, 2002).

Differing from other communication interventions, PECS instruction does not require any communication prerequisites before implementation. Therefore, an individual does not need to engage in joint attention, make eye contact, imitate, or follow directions before accessing functional communication. Through a six-phase instructional sequence, PECS first focuses on teaching mands (i.e., requests) then teaches sentence building to target additional communicative responses such as tacts (i.e., labeling) and intraverbals (i.e., responding to someone). Throughout the PECS instructional program, the complexity of communication required to access reinforcement gradually increases. Beginning with a single picture and the support of a prompter, the individual makes spontaneous requests for items in sight in close proximity of the communication partner. Subsequent phases introduce traveling distances to communicate, persisting in the request, discriminating among a communication book of pictures, requesting with a 3-word sentence, requesting in response to a question, and engaging in responsive and spontaneous commenting (e.g., I see, I hear). Initially, young children with ASD were the target population for PECS, but PECS can be an effective communication system for individuals of varying ages and disabilities (Frost & Bondy, 2002). However, most research studies evaluate PECS with the preschool-age population (Ganz et al., 2012a; Ganz et al., 2014).

Proloquo2Go

Unlike PECS, there is no manualized or agreed upon, evidence-based approach, to introduce or teach an SGD communicative response. Additionally, there are more than a dozen SGD variations (with only slight differences in terms of operation) and limited research available evaluating the effectiveness of each. Because of the increase in popularity of SGDs as an AAC

modality and the wide range of models available, researchers need to determine effective, evidence-based strategies or instructional sequences to teach SGD. One type of SGD available is the Proloquo2Go app that is a symbol-based SGD and requires an iPad for use (AssistiveWare, 2021). Personal customizations of the app are available to tailor voice, the grid array size (e.g., 3 x 3 to 12 x 12), vocabulary size and level (e.g., basic communication, intermediate core, advanced core with more than 10,000 words available), and users can create, modify, and move buttons as needed to suit their communicative needs. Based on availability of resources, the primary researcher selected Proloquo2Go as the SGD to teach in this study.

Several studies have evaluated the effectiveness of Proloquo2Go instruction and have shown positive effects in regard to increasing requests (King et al., 2014), tacts (Lorah & Parnell, 2017), and classroom activity participation (Collette et al., 2019). Researchers have also demonstrated that Proloquo2Go leads to improvements in language-related academic goals (Kleinstiver, 2017) and advanced social skills or peer interactions (e.g., answering personal questions; Alzrayer et al., 2019; Biggs et al., 2017). With the exception of Kleinstiver (2017) who evaluated the effects of Proloquo2Go through survey responses from educational specialists and Collette et al., 2019 who evaluated participation levels among different assistive technologies, strategies used for teaching Proloquo2Go included the use of least-to-most prompting (Alzrayer et al., 2019; Lorah & Parnell, 2017), constant time delay (Alzrayer et al., 2019; Lorah & Parnell, 2017), error correction (Alzrayer et al., 2019), and reinforcement (Alzrayer et al., 2019; King et al., 2014 Lorah & Parnell, 2017). King et al., (2014) used an adapted and modified protocol based on the PECS instructional protocol but ended training at Phase IV (i.e., sentence construction) of the protocol.

Current Study

The purpose of the current study is to evaluate the effects of simultaneously training two AAC modalities to preschoolers with ASD. Throughout the AAC training, a treatment challenge (i.e., communicative response placed on extinction with a Lag 1 schedule of reinforcement) will be embedded at the end of each phase of the PECS protocol to evaluate the effects of response persistence with each modality. Additionally, rate of acquisition of modality, preference, and maintenance variables will be assessed to determine the impact of training multiple modalities simultaneously rather than separately. By training both PECS and Proloquo2Go, researchers expect that individuals will be able to seamlessly transfer between modalities and ideally never be without a means of functional communication.

CHAPTER 2

LITERATURE REVIEW

In 2008, Schlosser and Wendt conducted a review of the literature evaluating the effects AAC interventions had on speech production for children with ASD or pervasive developmental disorder-not otherwise specified (PDD-NOS). Schlosser and Wendt (2008) evaluated single-case research design (SCRD) studies with percentage of nonoverlapping data. PND relies on calculating overlapping data points to evaluate the level change between conditions, but PND does not allow for the complete determination of effects in SCRD studies (Barton et al., 2018a). By excluding studies that did not allow for the calculation of PND, this requirement limited the number of studies included in the review and did not consider the complete visual analyses of the studies (Ledford & Gast, 2018). It is important to note that Schlosser and Wendt (2008) has been commonly used as a citation to support the claim AAC may increase speech production for individuals with ASD.

White et al., (2021) updated, extended, and evaluated the AAC literature using a different lens. In the 2021 review of the literature, White and colleagues evaluated SCRD and group design studies for rigor, quality of evidence, and the effects of AAC on the dependent variables of AAC responses and speech production. The effects of SCRD were evaluated through visual analysis and rigor and quality of evidence through the Single Case Analysis Review Framework tool created by Ledford and colleagues (2016). In regard to the impact AAC has on speech production, the 2021 review provided evidence that speech production did not occur for all

participants and speech that did increase above the participants' speech baseline did not surpass AAC usage (White et al., 2021).

This updated and extended AAC literature review evaluating AAC responding and the impact on speech production for children with ASD, first published in the *Journal of Autism and Developmental Disorders, 51*, 4199-4212, 2021 by Springer Nature, is included below to cover the relevant literature on AAC and speech production:

The Centers for Disease Control (CDC) reported about 40% of individuals with autism spectrum disorder (ASD) do not speak (e.g., do not use spoken words to communicate), and many do not speak until much later than typically developing children (CDC, 2018). For individuals with ASD whose communication skills lag, speech-language pathologists (SLP) frequently recommend augmentative and alternative communication (AAC) to support current communication and increase functional communication (Ganz et al., 2012b, 2014; Mirenda, 2003). The International Society of Augmentative and Alternative Communication (ISAAC) defined AAC as tools and strategies to provide additional modes of communication to allow individuals to express effective communication and have that communication be understood by another individual (ISAAC, 2020).

Aided AAC is an external device or materials (e.g., pictures, a speech-generating device), whereas unaided AAC does not require external materials, for example, sign language (Mirenda, 1999). The overall purpose of AAC interventions focus on increasing an individual's current communicative ability, not on increasing speech production (Schlosser & Wendt, 2008). Although no survey data exist, researchers report that parents commonly fear that implementing AAC interventions will prevent speech from occurring as found on several frequently asked questions sections (AssistiveWare, 2020; Miller et al., 2006; Schlosser & Wendt, 2008; Seattle

Children's Hospital Speech and Language Services, 2018). Researchers have conducted several reviews of aided AAC modes when used with participants with ASD (Flippin et al., 2010; Ganz, 2015; Ganz et al., 2012a, b, 2014; Schlosser & Koul, 2015; Tincani & Devis, 2011; van der Meer & Rispoli, 2010) and additionally, Mirenda (2003) conducted a review evaluating aided and unaided AAC. These reviews provided synthesized information on preferences of AAC among individuals, effectiveness of AAC on functional communication, and the success in decreasing challenging behaviors that often results from lacking functional communication (Carr & Durand, 1985; Sigafoos, 2000).

Based on extant reviews, several articles have included a component looking at speech as a variable with AAC. Ganz et al., (2012a) conducted a meta-analysis of 13 articles that evaluated the Picture Exchange Communication System (PECS). PECS uses applied behavior analysis (ABA) principles to teach individuals to exchange pictures to make requests or comments. The authors used improvement rate difference (IRD) to quantify differences for targeted and non-targeted outcomes, age, disability, and phases completed. Seven articles in the review reported large effects for targeted outcomes (i.e. increasing functional communication) and five articles reported differences in speech communication as a non-targeted outcome. Additional results revealed participants at the preschool age made greater gains for PECS outcomes than did elementary-aged participants. Two articles included implementation of all six phases of PECS while eight articles only involved implementation of the first three phases; and statistically significant differences were found for targeted PECS outcomes, and non-targeted outcomes (e.g., challenging behavior, speech production, social skills) between implementing three phases and six phases of PECS. Ganz et al., (2012a) discussed PECS has more significant gains in increasing communication but also demonstrated modest effects for different non-targeted

outcomes (such as problem behavior and social interactions) and attributed lack of studies as a limitation and need for more research. PECS is a widely researched intervention within AAC research, but as AAC interventions begin including more high-tech options such as speech-generating devices (SGDs), more research has also started to emerge evaluating the effectiveness of this modality of AAC.

Schlosser and Koul (2015) completed a scoping review of 48 articles related to SGD interventions for individuals with ASD. They grouped articles into three categories, (a) those that evaluated the effects of SGDs within a treatment package (e.g., functional communication training), (b) articles that compared SGDs to other AAC types (e.g., PECS, sign), and (c) articles that evaluated the effects of the speech output component on responding. Schlosser and Koul (2015) evaluated effects using percentage of non-overlapping data (PND; c.f. Wolery et a., 2008 for weaknesses with overlap methods as effect size measures). Researchers concluded 8 of the 26 articles had conclusive evidence of effects, but only two articles allowed for the calculation of PND for speech production. Three of the 17 articles comparing SGDs to other AAC modalities demonstrated some evidence of effects but had either design flaws or inadequate inter-observer agreement (IOA); the other 14 articles had inconclusive results. The authors did not aggregate PND for this group due to the limited number of articles. The overall number of articles included in this review show the increase in research assessing the effectiveness of SGDs at increasing functional communication; however, due to the lack of synthesis aggregation of the articles, it is not yet clear how SGD interventions impact AAC use and speech production.

In a discussion paper about the state of the science in AAC, Ganz (2015) discussed current research and future implications of AAC use and reported aided AAC to be more effective at providing functional communication for more individuals with ASD when compared

to unaided AAC as aided AAC options provided individuals with wider vocabularies and less effort to add new words. The authors also highlighted that, at the time, PECS was the only AAC with a manualized protocol for instruction and teaching. Similar to findings reported in Ganz et al., (2012a), Ganz (2015) also reported that preschoolers with ASD demonstrated greater gains in functional communication for using either PECS or SGDs compared to other age groups (Ganz et al., 2014). In regard to speech production as an outcome of using AAC, participants had greater gains in speech if the participant already had some speech prior to the study rather than no speech (Ganz et al., 2014). Future implications mentioned consideration of the individual's preference of AAC modality and recommended that practitioners program for generalization across communicative skills beyond requests.

Schlosser and Wendt (2008) conducted a systematic review of AAC literature and the effects of speech including a total of nine single case design articles and two group design articles. The researchers calculated PND for outcomes of the single case design articles and Cohen's *d* and Hedge's *g* for the group articles. Results of the review in terms of the effects AAC has on speech production suggested AAC does not hinder speech but does not significantly increase speech either with increases shown to be modest at best. The equivocal results in Schlosser and Wendt (2008) may be difficult for practitioners to interpret as the study is often cited to support claims that AAC has positive effects on speech production. The current systematic review sought to replicate and extend Schlosser and Wendt (2008) by evaluating the following research questions:

1. What are the effects of AAC interventions on speech production for individuals with ASD?

2. What impact does the rigor of the studies' research design have on the evidence of effects?

Fundamentally, the current review addresses the question of whether the body of research evaluated by Schlosser and Wendt (2008) has changed and layers an examination of rigor and quality of evidence instead of using effect size measures in an attempt to further differentiate what the field understands about the role of AAC in speech production.

Method

Inclusion Criteria

Researchers designed inclusion criteria based on Schlosser and Wendt's review in 2008 and included (a) the intervention included directly teaching an AAC response, (b) did not include functional communication training (FCT) with AAC, (c) participants did not use speech functionally prior to intervention, (d) speech production was measured as a dependent variable, (e) included participants with a diagnosis of ASD, intellectual disability (ID) concomitant with ASD, pervasive developmental disorder not-otherwise specified (PDD-NOS) or "autism-like," (f) the intervention targeted the child as the primary intervention participant and not the communication partner even when included the measurement of the child's speech production, (g) article published in English in a peer-reviewed journal or an approved dissertation or thesis (to avoid publication bias), and (h) dated between 1975 through May 2020. Articles were excluded if they (a) included speech as the only communication modality considered correct, (b) the dependent variable required "natural speech," and an AAC mode or "natural speech," and/or an AAC mode in order to be counted correct, (c) used only A-B designs ore pre-and post-test designs, and (d) fewer than half of the participants did not meet participant criteria.

Search Procedures

Researchers searched five electronic databases from May 2019 to August 2019 (initial search) and from April 2020 to May 2020 (to include recently published articles up to date). Table 1 describes keywords and terms used in the search based on search procedures, terms, and databases used in Schlosser and Wendt (2008). Terms included a combination of "augmentative and alternative communication," "communication training," "sign language," "speech development," and "vocal, speech, or spoken." Each article was initially based on title and abstract information provided. Articles meeting initial inclusion criteria were further examined for meeting all criteria.

Review Framework

Researchers used the Single-Case Analysis and Framework (SCARF; Ledford et al., 2016) tool to evaluate the quality of evidence of single case design studies. SCARF included three domains: Rigor, Quality of Measurement (QoM), and Outcomes with 13 characteristics assessed within the domains. The Rigor domain contained questions regarding dependent variable reliability, fidelity, and sufficiency of data. QoM included assessment of ecological and social validity, generalization, and maintenance, and descriptions of participants, conditions, and dependent variables. The Outcomes domain assessed primary effects, generalization effects, and maintenance effects for the study. Group design studies were coded according to the Council for Exceptional Children's (CEC; 2014) Quality Indicators because SCARF only accounts for single case designs. As in Schlosser and Wendt (2008) researchers also coded all articles for (a) participant characteristics, (b) AAC intervention used, (c) design, and (d) AAC and speech outcomes.

Single Case Coding and Analyzing SCARF

Within SCARF, researchers answered a series of yes/no questions about each characteristic which generated a score of 0-4 in Rigor and QoM. The Outcomes score differed with a score of zero equated to a non-effect or contratherapeutic effect and a score of four indicated at least three demonstrations of effect. Once researchers completed the questions, QoM and Rigor scores were averaged together (Rigor is weighed twice) to generate an Overall Quality and Rigor score and Outcomes were scored separately. All scores for each dependent variable being measured were reflected into a scatterplot with four quadrants. Studies with high scores of Overall Quality and Rigor and Outcomes were plotted in the top right corner, or quadrant two (i.e. the most desirable combination of rigor and evidence).

Group Coding

The CEC's Quality Indicators assessed 32 group design related methodological features that promote the quality and soundness of published studies (CEC, 2014). The features analyzed and measured include context and setting, participant descriptions, intervention agent, description of practice, implementation fidelity, internal validity, outcome measures and dependent variables, and data analysis. Studies received a score of 0, 1, or partial credit if some of the indicator components are met but not all (Royer et al., 2017).

Interobserver Agreement

Researchers calculated all IOA on a point-by-point basis (agreements divided by agreements plus disagreements multiplied by 100; Ledford et al., 2018). The primary and secondary coders were advanced graduate students with experience conducting and reviewing single case research and were trained by one of the developers of the SCARF. The secondary researcher conducted IOA for inclusion and exclusion criteria for 20% of all studies. Inclusion

IOA was calculated at 95% with disagreement about one article and exclusion IOA was calculated at 93% with disagreement about one article. The researchers further discussed the two articles disagreed on and reached agreement. The secondary researcher also conducted IOA on 20% of all studies conducted in SCARF and for additional coding and on 33% of group design studies. IOA resulted in a mean score of 80% for single case design studies (range 71-93%) and a score of 93% for group design studies. The coders discussed discrepancies within the articles and came to final agreement.

Results

The database searchers produced a total of 13,985 articles that met the initial criteria of search terms. Researchers then assessed articles based on title and abstracts to determine if the article met all inclusion criteria and identified 92 articles. Sixty-four articles were excluded from the review based on (a) experimental design (included pre- and post-tests, reviews, meta-analyses, case studies), (b) participant diagnoses (all or more than half needed to meet participant inclusion criteria), and (c) dependent variables (speech variables were not graphed, measured, or not parsed out from social-communicative variables). From that total, 25 single case articles, 3 group design articles and 274 participants met all inclusion criteria (see Table 2 for included single case articles and Fig. 1 for PRISMA article inclusion).

Single Case Design Studies

Participant Characteristics

Participants (n = 70) ranged from 2 years to 26 years old with a mean age of 6 years. Fifty-six males (81%) and 13 females (18%) were included. Carbone et al. (2010) included three participants in their study, however, only outcomes for two participants were coded because the third participant had Down syndrome. Eighty-four percent of participants had ASD diagnoses,

and less than 10% had diagnoses of PDD+NOS. All articles reported prior speech abilities, with 42% reporting the technique used for assessing speech ability. Fifty percent of articles also included echoic assessment results for participants prior to the start of the study. Table 3 describes the techniques used for reporting speech and the echoic assessments.

Interventions

Eleven articles included evaluations of PECS (44%), seven evaluated interventions designed to improve the use of SGD (28%), and four evaluated sign language (16%). Three articles compared AAC modes with two articles comparing PECS and SGDs (8%) and one comparing PECS and sign language (4%). Three articles included the use of a verbal model as an additional component of the intervention to target speech production directly.

Design

Researchers assessed the designs used to evaluate both AAC variables and speech production variables. As some studies implemented more than one design or included several variables or participants (i.e., Dyches [1998] used an A-B-A-B design for five participants resulting in evaluation of five A-B-A-B designs), this resulted in the evaluation of 94 single case designs. For AAC variables, the most commonly used design was an alternating treatments design (n = 13) and a multiple baseline across participants (n = 13). Other designs included adapted alternating treatment designs (n = 5), changing criterion designs (n = 4), multiple baseline across behaviors (n = 2), A-B-A-B (n = 3), one multi-treatment design and one multiple baseline across settings. The most used design to evaluate speech outcomes was the multiple baseline across participants design (n = 16). Other designs included alternating treatment designs (n = 11), changing criterion designs (n = 9), adapted alternating treatment designs (n = 5), multiple baseline across behaviors (n = 4), A-B-A-B (n = 3), two multi-treatment designs and

one multiple baseline across settings. One study evaluated speech production using an alternating treatment design embedded within a multiple baseline across participants.

Measures

Because the primary purpose of the current review focused on AAC interventions and speech production, authors only coded SCARF variables based on those two dependent variables. AAC dependent variables included responding via picture exchange, sign language, or a SGD. The speech production variables were named differently across studies but included speech, words, word approximations, vocalizations, verbalizations, verbal/vocal requests, and any related speech. Each study operationally defined speech production variables differently; 19 studies counted full word or word approximations as a correct speech production response, four required a full word response, and two studies required the response to have clear communicative intent (e.g., requests). Extraneous dependent variables measured but not coded for this review included social communicative behavior, picture discrimination, maladaptive behaviors or number of sessions to criterion.

SCARF

Figure 2 displays the SCARF scatterplot for all single case studies and included three scatterplots for primary, generalized, and maintenance outcomes. As mentioned above, studies with high quality evidence of positive effects were graphed in quadrant two (top right panel) and studies with low quality evidence of negative or minimal effects were graphed in quadrant three (bottom left). Quadrant one included studies with low quality evidence of positive effects and quadrant four included studies with high quality evidence with minimal or negative effects (Ledford et al., 2016).

Rigor and QoM

Regarding Rigor, studies averaged a score of 1.73 (range = 0.67-3, possible range = 0-4). Only one study scored a three (Tincani, 2003). The Rigor scores included the characteristics dependent variable reliability (*M* = 2.66, range 0-4), fidelity (*M* = 0.99, range 0-4), and sufficiency of data (*M* = 1.56, range 0-4). The average score for QoM was 1.65 with a range of 0.71-2.57. QoM scores included variable descriptions (*M* = 2.36, range = 1-4), participant descriptions (*M* = 3.42, range 2-4), condition descriptions (*M* = 2.88, range 1-4), ecological and social validity (*M* = 1.22, range 0-3), stimulus generalization measurement (*M* = 0.63, range 0-4), response generalization measurement (*M* = 0.08, range 0-3), and maintenance measurement (*M* = 0.95, range 0-4). Considering the range of QoM scores did not exceed 2.57, all studies measured in the low to moderate scores for quality.

Generalization and Maintenance

Generalization outcomes evaluated whether a study measured dependent variables across different materials, social partners, settings, or behavior than intervention and averaged a score of 1.46 (range 0-4). Most articles did not report any generalization measures. Studies that reported generalization measures and received a score of four (by demonstrating data with consistent positive effects shown within the context of the design used) included Greenberg et al. (2014; assessed generalization across materials, social partners and settings), Tincani (2003; assessed generalization across social partners), and Tincani et al. (2006; assessed generalization across social partners).

Sixty-five percent of articles did not include maintenance measures. Maintenance outcomes within SCARF evaluated if researchers collected maintenance data following intervention and on more than one occasion and averaged a score of 1.93 (range 0-4). Studies

that received a score of four assessed outcomes on multiple occasions that showed maintained or similar results to intervention levels and included Boesch et al., (2013), Greenberg et al., (2014), Hilton (2016), Hu and Lee (2019), Lorah (2012; for some participants), and Schlosser et al., (2007; for some participants).

SCARF Outcomes

Unlike Schlosser and Wendt (2008), who synthesized AAC outcomes using PND, we evaluated outcomes using the SCARF. Unlike effect size measures, which estimate magnitude of effect, and unlike overlap measures, which evaluate overlap between conditions, SCARF outcome scores are based on visual analysis (Ledford et al., 2020). A score of 0 was indicative of non-effects, scores of 1-2 were indicative of mixed or inconsistent effects, and scores of 3-4 were indicative of functional relations. Compared to AAC outcomes, more speech production outcomes were evaluated due to many studies including more than one speech related dependent variable. Table 2 (see above) included outcome scores for AAC and speech production for each article.

AAC Outcomes

Of the 25 single case design articles evaluated, 10 articles demonstrated a functional relation between intervention and positive AAC outcomes while 15 did not demonstrate a functional relation. Studies demonstrating functional relations between intervention and positive AAC outcomes included Bishop et al., (2019), Dyches (1998), Ganz and Simpson (2004), Ganz et al., (2010a), Ganz et al., (2009), Hu and Lee (2019), King et al., (2014), Lorah (2012), Tincani (2004), and Valentino et al., (2011). AAC outcomes scores were generally higher than or equal to speech production scores, with the exception of one study (Tincani et al., 2006; greater speech production outcome scores than AAC outcome scores).

Speech Production Outcomes

Outcomes related to speech production included any speech related dependent variable; studies included 1-3 speech production variables. Six out of 25 articles demonstrated a functional relation between speech production outcomes and AAC (scoring 3-4) across AAC modalities (e.g., PECS, SGD, and sign). Three articles demonstrated a functional relation for only a single participant while the remaining 16 did not demonstrate a functional relation between AAC and speech production outcomes and speech gains did not occur for most participants. Studies receiving high speech production outcomes (scoring 3-4) included Bishop et al., (2019), Carbone et al., (2006), Carbone et al., (2010), Dyches (1998) for verbalizations only, Ganz and Simpson (2004) for words dependent variable, Lorah (2012) for one participant of five, Tincani (2004), Tincani et al., (2006), and Valentino et al., (2011). More than half the studies received low scores for speech production outcomes (*N = 15;* scoring 0-1). For studies evaluating speech production outcomes with the use of a multiple baseline design, a lack of three demonstrations of effect across tiers most often resulted in the low outcome score.

Group Design Studies

Three group design articles met inclusion criteria from the above search results and researchers coded for participant characteristics, design and interventions used, measures and outcomes, and standards of quality for group studies according to CEC's Quality Indicators. Table 4 further displays group design study information.

Participant Characteristics

Within the three group design articles, 204 participants (ages 1.5-11 years) were included and 98% had an official ASD diagnosis through the Autism Diagnostic Observation Schedule (ADOS) and 2% with PDD-NOS. Participants in Howlin et al., (2007) and Gordon et al., (2011)

were from the same 15 schools. Yoder and Stone (2006) did not give gender information for participants (17%) but from other articles, 71% or participants were male and 10% were female.

Design and Intervention

All three group design studies evaluated an AAC intervention through a randomized control trial (RCT). Gordon et al., (2011) and Howlin et al., (2007) evaluated the effects PECS training had on speech production through immediate treatment, delayed treatment, or no treatment. Yoder and Stone (2006) compared PECS training to Responsive Education and Prelinguistic Milieu Teaching (RPMT) to determine the effects either training had on speech production.

Measures and Outcomes

Yoder and Stone (2006) measured non-imitative spoken acts and non-imitative words during RPMT and PECS training. Speech increases occurred in both RPMT and PECS groups; however, greater increases occurred in the PECS group with increases from 3.6 to 5.5 words in a 15 min play session.

In Howlin et al., (2007), PECS use and speech (including non-word vocals) were measured across groups (immediate treatment, delayed treatment, no treatment) and periods of time. Participants increased their use of PECS across all groups, and it should be noted that at the final time measurement, participants in the no treatment group were just as likely to use PECS as participants in the treatment groups. A follow-up evaluation 9 mo after intervention revealed PECS use had decreased across all groups. Also, speech did not increase for participants in any group.

Gordon et al., (2011; an extension of Howlin et al., 2007) measured spontaneous initiations using picture cards and speech across three groups (immediate treatment, delayed

treatment, no treatment) and periods of time. Most participants increased rates of spontaneous communication via picture cards across groups, with the greatest increase occurring in the delayed treatment group. Rates for spontaneous communication via speech only slightly increased in the immediate treatment group and the no treatment group. Within the delayed treatment group, communication rates did not surpass baseline levels and remained at zero. An additional analysis conducted in Gordon et al., (2011) calculated the significance of baseline characteristics on speech outcomes. The analysis suggested participants with less severe ASD symptoms and more expressive language at baseline had greater speech gains after intervention.

CEC Quality Indicators

As mentioned above, group design studies received a score of 0, 1, or partial credit for the inclusion of 32 measured indicators. Yoder and Stone (2006) met 93% of Quality Indicators but failed to meet the context and setting indicators. Howlin et al., (2007) met 75% of the Quality Indicators; those indicators not met related to description of practices, implementation fidelity, and dependent variable descriptions. Gordon et al., (2011) only met 63% of Quality Indicators. Indicators not met included information around the intervention agent, description of practice, implementation fidelity, limiting access to treatment to non-treatment groups, and interobserver reliability.

Discussion

The current review focused on furthering the contributions of Schlosser and Wendt (2008) by evaluating recent AAC literature with intensified quality and rigor assessment to expand our understanding of the role of AAC in speech production. A limitation of the review was not updating the search terms from the previous study. Using the search terms as outlined by Schlosser and Wendt (2008), 25 single case design articles and three group design articles were

identified as measuring AAC and speech dependent variables with dates of articles ranging from 1998 to 2020. A larger proportion of designs assessing impacts on AAC demonstrated functional relations compared to the proportion of designs assessing speech production outcomes. For articles receiving high SCARF quality and rigor outcomes scores (ten articles received scores 3-4), three articles demonstrated results where speech surpassed AAC use within the study. In the three identified group design articles, one (Yoder and Stone, 2006) reported significant increases in speech while the other two reported no gains. Additionally, Yoder and Stone (2006) met the most Quality Indicators (93% compared to Howlin et al., 2007 meeting 75% and Gordon et al., 2011 meeting 63%) promoting the confidence of evidence from the study and slightly diminishing the confidence of the other two. It is notable that both Howlin et al., (2007) and Gordon et al., (2011) failed to meet Quality Indicators in the areas of description of practice and implementation fidelity. Schlosser and Wendt (2008) reported most speech gains were modest, however this extended review with more stringent and rigorous assessment of design, procedures, and reliability, concluded speech gains remained inconsistent for most participants. Similar findings in both reviews revealed no studies (single case or group) reported any decreases in speech.

The results of this review identified directions for future research and raised the question of what AAC is necessary in order to promote speech production. While no studies showed AAC resulted in a decrease in speech, it is still unclear if the addition of AAC will benefit a participant's speech production. Only six articles demonstrated a functional relation between AAC and speech production outcomes, the remaining single case design articles only demonstrated a functional relation for a single participant or no functional relation at all. More research with adequate quality evidence should be conducted to further evaluate what could be

included in AAC interventions to increase speech production if at all possible. One should also note that a very low percentage, less than half, of the included studies reported generalization or maintenance data. Only a single study, Greenberg et al., (2014), scored highly in terms of generalization and maintenance. In future research, the inclusion of generalization and maintenance results might provide additional information about the extent to which AAC use and speech production might generalize to non-instructional contexts and maintain over time for individuals with ASD. Another area that may help researchers understand the impact of AAC on speech production may come from research on FCT that is often used to treat problem behavior. Frequently, FCT based interventions incorporate some form of AAC (e.g., button press, card exchange) to allow an individual to access the reinforcer that they previously obtained via problem behavior (Ringdahl et al., 2009). Reinforcing AAC responses as well as any vocal response can create a response class. Vocalizations will strengthen based on response class membership as either AAC or vocalizations contact reinforcement and futher exploration of this may aid in more efficiently increasing spoken communication (Cooper et al., 2007).

In terms of implications for future practice, when recommending AAC as a communication option, practitioners should provide parents or teachers with realistic expectations of the effects of AAC. When taught with evidence-based practices, expectations include that AAC can be an effective mode of communication for individuals with ASD and studies have not reported speech decreases with AAC is implemented; however, cautious should be given when making statements that AAC will increase speech as not enough high-quality research has been produced as saying such. For individuals with ASD, finding an appropriate and effective mode of communication remains a high priority for parents, practitioners, and researchers. Since Schlosser and Wendt's review in 2008, researchers have continued to ask

questions surrounding AAC and its effects on increasing functional communication for individuals with ASD, as well as the effects it may have on their speech production. The latest research publications (Bishop et al., 2019; Cagliani et al., 2017; Gevarter and Horan, 2019; Gevarter et al., 2016) have specifically focused interventions to increase speech production through the use of AAC whether through PECS or SGD. Within their studies, participant results continue to be idiosyncratic, with increased vocalizations for some participants and others remaining at zero, or baseline, levels. Future research should consider what different AAC transitions look like for certain individuals (e.g., moving from low tech to high tech or from AAC to speech) and consider participant characteristics when targeted interventions are developed for communication. While one approach is not likely applicable to all individuals, there might also be different points in the participant's developing at which AAC is more or less beneficial to speech production. Future research should consider the possibility of when to begin phasing out AAC if speech reaches a certain level to determine if speech will surpass AAC usage. This does not suggest that AAC is an inadequate means of communication but that for some individuals at a certain point the systematic phasing out of AAC could result in increased speech production. Development and testing of clear strategies to increase vocalizations during AAC use and training may influence family decisions to adopt AAC (Blischak et al., 2003).

Research Questions

The purpose of the current study was to evaluate the effects of teaching multiple AAC modalities to preschoolers with ASD. The primary research questions were:

1. What are the effects of simultaneously teaching two AAC modalities in regard to acquisition and preference to preschoolers with ASD?

2. When modalities are taught simultaneously, and a treatment challenge is embedded into the end of each training phase of PECS to mimic natural challenges found in the environment (e.g., one modality is not immediately reinforced), what are the effects on response persistence in regard to each modality when placed on a lag schedule of reinforcement (i.e., PECS, SGD, or vocalization)?

Secondary research questions are listed below:

3. How does the rate of acquisition compare across modalities and across participants?
4. How does the response effort across modalities differ and impact acquisition?
5. When teaching multiple modalities, does the participant exhibit a preference for one modality and at which point in training does it become apparent?
6. When taught multiple modalities, do both modalities maintain over time and at what level of independence?

Table 1

Search Strategies Across Databases

Databases	Search strategy	Yield	Revised search
PsycINFO	(DE "augmentative communication"). AND (DE "autism") AND (DE "speech development")	4	
	(DE "augmentative communication") AND (DE "autism" OR DE "speech" OR DE "vocal" DE "spoken")	28	Dropped "speech development" added "speech" added "vocal" added "spoken"
	(DE "communication skills training") AND (DE "autism") AND ("speech development")	2	Dropped "augmentative communication" added "communication skills training"
	(DE "communication skills training") AND (DE "autism" OR DE "speech" OR DE "vocal" DE "spoken")	13	Dropped "speech development" added "speech" added "vocal" added "spoken"
	(DE "communication systems") AND (DE "autism") AND ("speech development")	4	Dropped "communication skills training" added "communication systems"
	(DE "communication systems") AND (DE "autism" OR DE "speech" OR DE "vocal" DE "spoken")	35	Dropped "speech development" added "speech" added "vocal" added "spoken"
	(DE "sign language") AND (DE "autism") AND (DE "speech development")	0	Dropped "communication systems" added "sign language"
	(DE "sign language") AND (DE "autism" OR DE "speech" OR DE "vocal" DE "spoken")	10	Dropped "speech development" added "speech" added "vocal" added "spoken"
Medline	(MH "communication aids for disabled") AND (MH "speech") AND (MH "autism")	6	
	(MH "communication aids for disabled") AND (MH "autism")	6	Dropped "speech"
	(MH "sign language") AND (MH "speech") AND (MH "autism")	0	Dropped "communication aids for disabled" and added "sign language"
	(MH "sign language") AND (MH "autism")	3	Dropped "speech"

Databases	Search Strategy	Yield	Revised Search
LLBA	"augmentative and alternative communication" AND "autism" AND "speech"	4	
ERIC	(DE "augmentative and alternative communication") AND (DE "autism") AND (DE "speech" OR DE "vocal" OR DE "spoken")	10	
	(DE "augmentative and alternative communication") AND (DE "autism")	1	Dropped "speech" "vocal" "spoken"
	(DE "sign language") AND (DE "autism") AND (DE "speech" OR DE "vocal" OR DE "spoken")	4	Dropped "augmentative and alternative communication" added "sign language" and "speech" or "vocal" or "spoken"
	(DE "sign language") AND (DE "autism")	3	Dropped "speech" "vocal" "spoken"
CINAHL	(MH "alternative and augmentative communication") AND (MH "autism") AND (MH "speech")	2	
	(MH "alternative and augmentative communication") AND (MH "autism")	2	Dropped "speech"
	(MH "sign language") AND (MH "autism") AND (MH "speech")	0	Dropped "alternative and augmentative communication" added "speech"
	(MH "sign language") AND (MH "autism")	0	Dropped "speech"

Note. DE = descriptor; MH = major heading; ERIC = Educational Resources Information Clearinghouse; CINAHL = Cumulative Index of Nursing and Allied Health; LLBA = Linguistics and Language Behavior Abstracts.

Table 2

Single Case Design Studies Included in the Review and Coding Process

Author	Bishop et al. 2019	Boesch et al. 2013	Carbone et al. 2006	Carbone et al. 2010	Dyches (1998)			Ganz et al. 2008	Ganz et al. 2009
Design	MBxP	MBxP w/ ATD	ATD	MBxP	ABAB			MBxP	MBxP
AAC modality	SGD	PECS SGD	Sign	Sign	Switch			PECS	PECS
AAC outcomes	3	0	-	-	3			1	4
SCARF Q&R outcomes	2.06	2.17	1.94	1.94	2.08			1.14	1.48
Speech variable(s)	Target vocalization	Speech production	Vocal tacts	Vocal responses	Switch+ speech	Spont. Switch + speech	Speech	Word approx.	Word use
Speech outcomes	3	0	4	3	P1 1 P2 2 P3 2 P4 2	0 1 2 3	3 - - -	1	1

Author	Ganz, Heath et al. 2010	Ganz, Lashley et al. 2010	Ganz & Simpson (2004)	Gevarter et al. 2016	Greenberg et al. 2014	Hilton (2016)
Design	MBxP	MBxP	CCD	MBxP CCD	MBxP	MBxP
AAC modality	PECS	PECS	PECS	SGD	PECS	PECS
AAC outcomes	1	1	4	-	2	1
SCARF Q&R outcomes	0.97	0.97	1.49	1.68	1.25	1.73

Speech variable(s)	Imitated Vocals	Any related speech	Verbal request	Imitated verbal request	Words	Non-word vocals	Vocals	Vocal initiations	Vocal approx.	Vocals	PECS + vocals	Mands	Spont. mands
Speech Outcomes	1		1		P1 3 P2 4 P3 4	0 0 1	2	1	1	2	1	1	

Table 3

Techniques Used for Reporting Speech Measures Prior to the Start of the Study

Study	Prior speech assessment	Echoic skills assessment
Bishop et al. (2020)	-	EESA
Boesch et al. (2013)	MacArthur-Bates (CDI)	MacArthur-Bates (CDI)
Ganz & Simpson (2004)	1 participant: VABS 1 participant: Battelle 1 participant: none	-
Ganz, Heath, et al. (2010)	-	Elicited verbalization probe
Ganz et al. (2008)	-	1 participant: ELAP; 1 participant: PEP-R & DAYC; 1 participant: none
Gevarter et al. 2016	-	VABS EESA
Greenberg et al. 2014	VABS	VABS
Hilton (2016)	VB-MAPP	VB-MAPP
Jurgens et al. (2009)	-	ADST
Lorah (2012)	VB-MAPP	VB-MAPP
Schlosser et al. (2007)	Communication Interview Receptive-Expressive Emergent Language Scale	Elicited vocal imitation
Tan et al. (2014)	MSEL VABS	MSEL VABS
Tincani (2003)	Observation Teacher report	Observation Teacher report IEP
Tincani (2004)	Observation Teacher report	Observation Teacher report

Note. ADST = Australian Development Screening Test; DAYC = Developmental Assessment of Young Children; EESA = Early Echoic Skills Assessment; ELAP = Early Learning Accomplishment Profile; IEP = Individualized Education Program; PEP-R = Psychoeducational Profile Revised; VABS = Vineland Adaptive Behavior Scales; MSEL = Mullen Scales of Early Learning; VB-MAPP = Verbal Behavior-Milestones Assessment and Placement Program.

Table 4

Group Design Studies

Author	Design	Dependent variables	AAC modality	Outcomes	
				AAC	Speech
Yoder & Stone (2006)	RCT with 2 groups: RPMT and PECS	Nonimitative spoken communication	PECS	-	Speech increased at a higher level in the PECS group than the RPMT group
Howlin et al. 2007	RCT with 3 groups: ITG, DTG, NT	Use of PECS; Speech	PECS	PECS use increased across groups	The rate of speech did not increase at a significant level for any group
Gordon et al. 2011	RCT with 3 groups: ITG, DTG, NT	Spontaneous picture card use; Spontaneous communication via speech	PECS	PECS use increased across groups with a greater increase in DTG group	Speech production increased in the ITG and NT group and did not increase in the DTG group.

Note. DTG = Delayed treatment group; ITG = Immediate treatment group; NT = No treatment; PECS = Picture Exchange Communication System; RCT = Randomized control trial; RPMT = Responsive Education and Prelinguistic Milieu Teaching

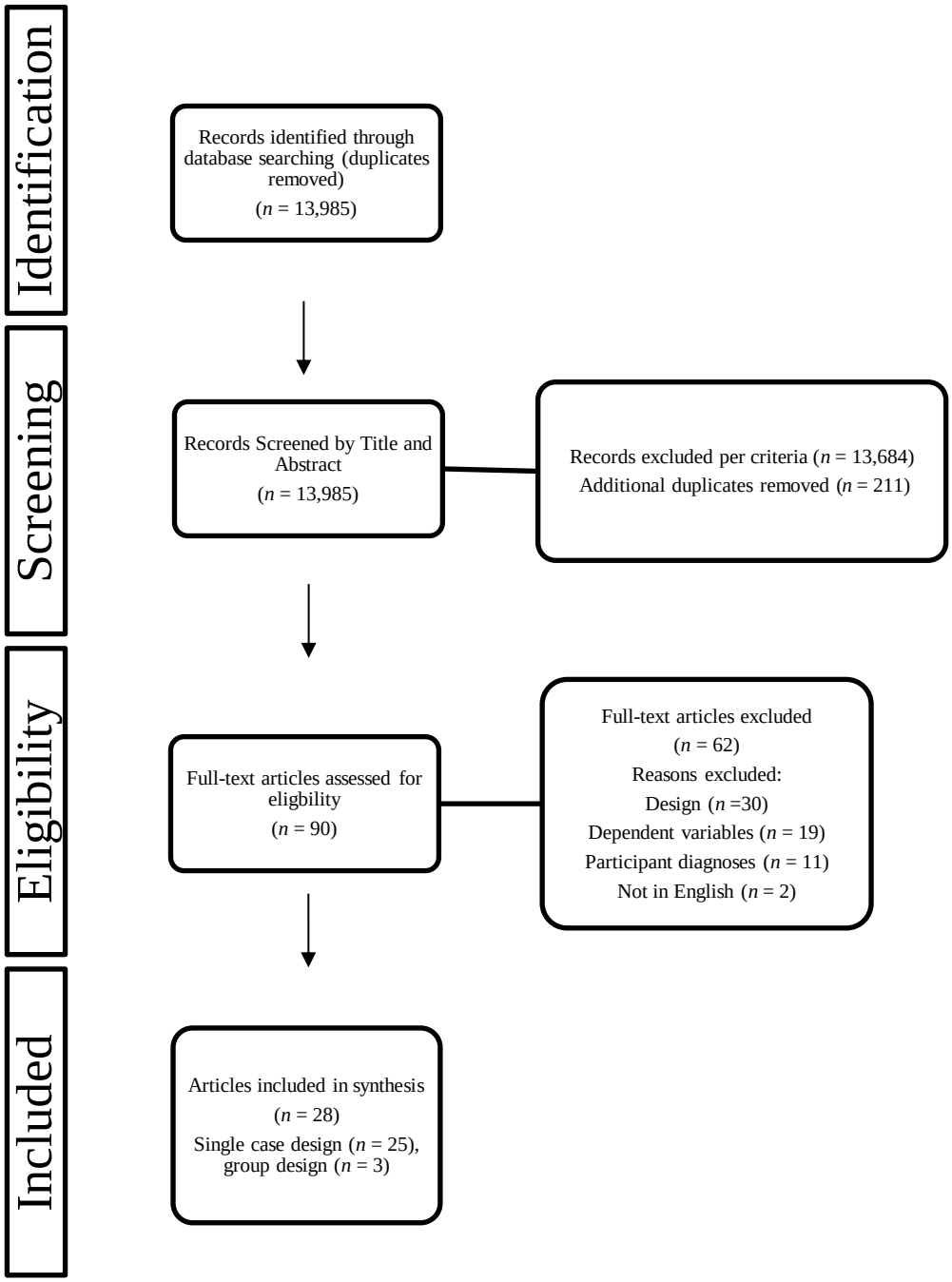


Figure 1

Adapted PRISMA Flow Diagram for Article Inclusion

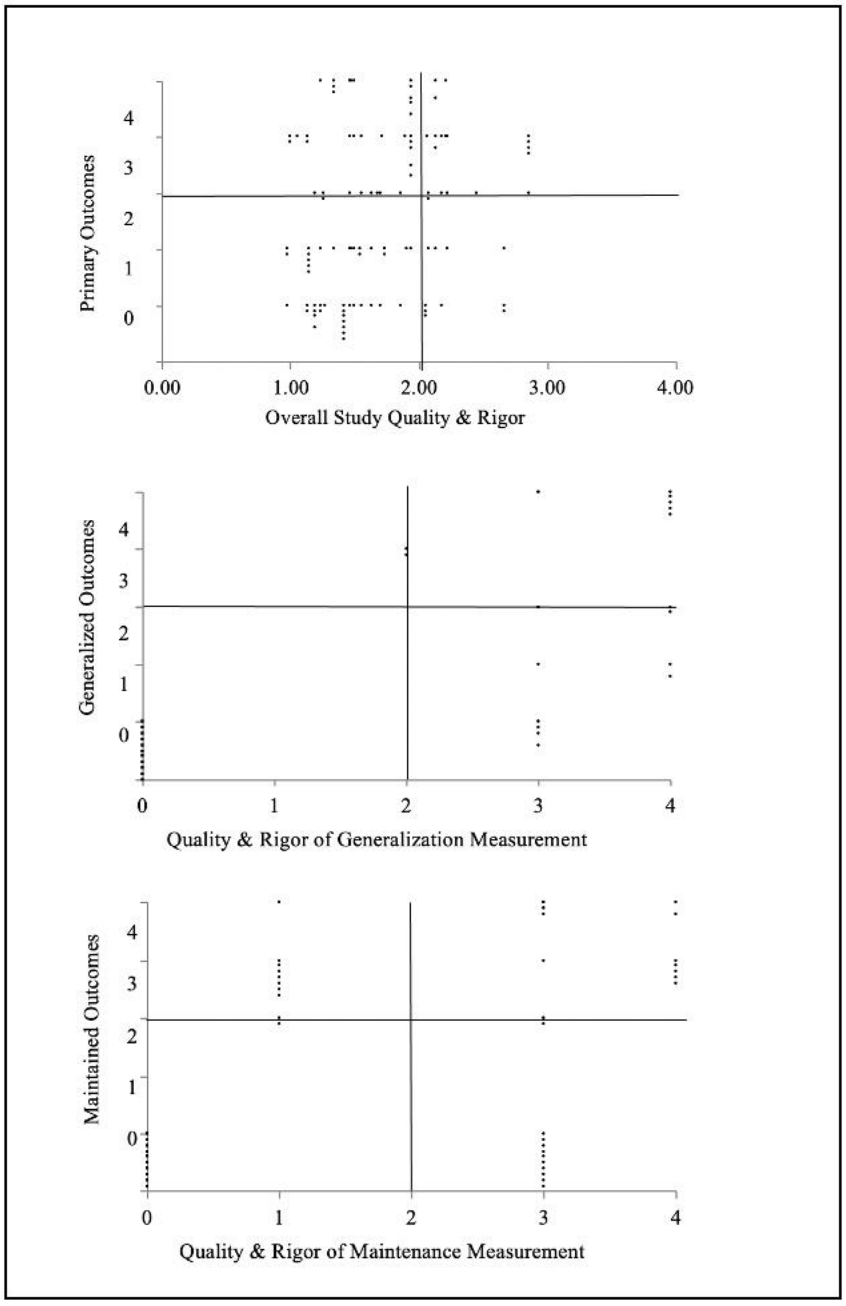


Figure 2

SCARF Primary, Generalization, and Maintenance Outcomes for AAC and Speech Variables

CHAPTER 3

METHOD

Participants

Four preschool-aged (3 to 5 years) participants with an educational eligibility of ASD and speech language impairment (SI) were included in this study. Only participants with returned parental permission forms were included in the study and parents or caregivers received information about the purpose of the study and a description of the intervention. Each participant had significant communication deficits as demonstrated by assessment results from the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008) and other education evaluations. Participants had limited to no functional communication. Participants had the physical ability to pick up a picture card and reach out to exchange with a communication partner and could isolate one finger to press a single button on the SGD device. The participants received ABA interventions to increase academic, functional, and communication skills during the typical seven-hour school day. Participants did not functionally use speech, PECS or Proloquo2Go to communicate.

Each participant is described below with information pertaining to their specific demographics, current communication skills as observed in their classroom, known AAC experience, challenging behaviors, Individualized Education Plan (IEP) objectives, and detailed VB-MAPP scores.

Andy

Andy, a Latino male, was 3 years and 6 months old at the start of the study. He received special education services under an ASD and SI eligibility. Within the classroom, classroom staff observed Andy babble infrequently, echo inconsistently, and hum the tune of common children's songs (e.g., Itsy Bitsy Spider). He had no known previous AAC experience related to picture exchange or SGDs and used gestures or pointing to communicate. Andy engaged in challenging behaviors including aggression (e.g., pinching, scratching hitting) and self-injurious behavior (e.g., head to surface hitting, hand to head hitting, object to head hitting). His IEP objectives included attending to his name, gross-motor imitation, receptively identification of body parts, using greetings and farewells, participating in classroom routines, participating in turn-taking activities with an adult, and receptively identifying colors, common objects, and shapes. He demonstrated interests in musical toys, blocks, and adult attention (e.g., tickles, chase, singing songs).

VB-MAPP. Andy scored a 23 for milestones which is in the range of the Level 1 learner category. He scored a zero for mands, tacts, motor imitation, listener responding of feature, function, or class (LRFFC), intraverbals, linguistic skills, reading, writing, and math. Andy scored a 1.0 in listening skills and met criteria for attending to a speaker's voice with eye contact. He scored a 4.0 in visual perceptual skills and matching-to-sample. He met criteria for visually tracking stimuli, grasping small objects using a pincer grasp, visually attending to a toy or book for 30 s, and either placed three items in a container, stacked three blocks, or placed three rings on a peg. Andy scored a 9.0 in independent play skills and met criteria for manipulating items for 1 min, played with five different items, engaged in exploratory movement and play in a novel environment, independently engaged in movement play (e.g., dancing,

jumping), engaged in cause-and-effect play, used a toy according to the function for five items, played on playground equipment for 5 m, and sustained play activities without adult prompts for 10 min. Andy scored a 3.0 for social skills and social play and met criteria for using eye contact as a mand, indicated he wanted to be held or physically played, and engaged in parallel play near other children. He scored a 3.0 in spontaneous vocal behavior and met criteria for emitting 10 different sounds with varying intonations. Andy scored a 3.0 in group skills and met criteria for sitting at a group snack table without negative behavior for 3 mins, put away personal items, transitioned between classroom activities, sitting and attending in a small group for 10 min without disruptive behavior or trying to leave. Andy scored a zero on the EESA indicative of no echoic or vocal imitation ability at the time of the assessment.

Andy scored 57 points in the barriers to language and skill acquisition section. He had elevated scores on 15 of the 24 barriers. Andy scored a 4.0 on barriers that included mands, tacts, motor imitation, echoic, visual perceptual and matching-to-sample, listener skills, intraverbal skills, conditional discrimination, generalization, and articulation. Andy scored a 3.0 on one barrier that was scanning. He scored a 2.0 on barriers that included negative behaviors, prompt dependency, and reinforcement dependency. Andy scored a 1.0 on barriers that included instructional control, motivating operations, self-stimulation, and hyperactive behavior. He scored a 0.0 on barriers that included scrolling, demand weakens motivators, obsessive-compulsive behavior, failure to make eye contact or attend to people, and sensory defensiveness.

Daniel

Daniel, a Black male, was 3 years 7 months old at the start of the study and received special education services under an ASD and SI eligibility. The research team and classroom staff observed that he did not vocalize with spoken words and did not echo in the classroom and

had no known prior AAC experience related to picture exchange or SGDs. Daniel communicated by moving in the directions of preferred items, grabbing, or pointing. Daniel engaged in challenging behaviors including elopement (e.g., leaving his designated area without being instructed to do so), aggression (e.g., hitting, scratching, head butting), dropping to the floor, PICA, and disruption (e.g., swiping or throwing toys or learning materials). Daniel's IEP objectives included attending to his name, gross motor imitation, receptively identifying colors, common objects, and shapes, and using greetings or farewells. He demonstrated interests in lining up colored toys (e.g., fruit, blocks), the cars and car track, and a train set.

VB-MAPP. Daniel scored a 23.5 for milestones which is in the range for the Level 1 learner category. He scored a zero for mands, tacts, motor imitation, LRFFC, intraverbals, linguistic skills, reading, writing, and math. Daniel scored a 1.0 for listener skills and attended to a speaker's voice by making eye contact with the speaker. He scored a 4.0 in visual perceptual skills and matching-to-sample and met criteria for visually tracking stimuli, using a pincer grasp, attending to a book or toy for 30 s, and either placed three items in a container, stacked three blocks, or placed three rings on a peg. Daniel scored an 11.0 in independent play skills and met criteria for manipulating items for 1 min, interacted with 5 different times, engaged in exploratory movement and play for toys in a novel environment, engaged in movement play for 2 min, engaged in cause-and-effect play for 2 min, searched for missing parts of a set for 5 items, used toys according to the function, engaged on playground equipment for 5 min, repeated a gross motor behavior to obtain a better effect for 2 activities (e.g., throwing a ball in a basket), and engaged in sustained play activities for 10 min without adult prompts. He scored a 3.0 in social skills and social play and met criteria for making eye contact as a mand, indicated he wanted to be held or physically played with 2 times in a 60 min observation, and engaged in

parallel play near other children for 2 min. Daniel scored 2.5 in spontaneous vocal behavior (1, 2) and met criteria for spontaneously emitting 5 different sounds, averaging 10 total sounds each hour. Daniel scored a 2.0 in group skills and met criteria for sitting at a group snack without negative behavior for 3 min and sitting in a small group for 5 min without disruptive behavior or leaving the group.

Daniel scored 72 points in the barriers to language and skill acquisition section with elevated scores on 20 out of 24 barriers. Daniel scored a 4.0 on barriers that included mands, tacts, echoic, visual perceptual and matching-to-sample, listener skills, intraverbals, social skills, prompt dependency, scanning, conditional discrimination, generalization, motivating operations, reinforcement dependency, articulation problems, and hyperactive behavior. Daniel scored a 3.0 on one barrier that was motor imitation. He scored a 2.0 on barriers that included negative behaviors, instructional control, obsessive-compulsive behavior, and failure to make eye-contact or attend to people. He scored a 1.0 on one barrier that was demand weakens motivators and a 0.0 for barriers that included scrolling, self-stimulation, and sensory defensiveness.

Addie

Addie, a Black female, was 3 years and 8 months old at the start of the study and received special education services under an ASD and SI eligibility. She did not communicate with spoken words and did not imitate spoken words or sounds. Addie communicated by pointing or grabbing at items she wanted. She did not have any known prior experience with picture exchange or SGD. Her IEP objectives included attending to her name, gross-motor imitation, receptively identification of body parts, colors, common objects, and shapes, and using greetings and farewells. Addie engaged in challenging behavior including elopement (e.g., leaving her designated area without being instructed to do so), aggression (e.g., hitting, kicking, scratching,

biting), PICA, and disruption (e.g., swiping or throwing toys or learning materials). Addie demonstrated interest in Legos, magnets, and to bounce balls.

VB-MAPP. Addie scored a 23 for milestones which is in the range for the Level 1 learner category. She scored a zero for mands, tacts, motor imitation, LRFFC, intraverbal, linguistic skills, reading, writing, and math. Addie scored a 1.0 for listener skills and attended to a speaker's voice with eye contact. She scored a 4.0 for visual perceptual and matching-to-sample skills and tracked visual stimuli, used a pincer grasp, attended to a book or toy for 30 s, and either placed three items in a container, stacked three blocks, or placed three rings on a peg. Addie scored a 10.0 on independent play skills and manipulated objects, interacted with varying items, engaged in exploratory movement in a novel environment, movement play, arts or crafts, cause-and-effect, used playground equipment, used at least 5 toys according to the function, repeated a gross motor behavior to obtain a better effect, and sustained play for 10 min. She scored a 3.0 in social skills and social play and made eye contact as a mand, indicated she wanted to be held or played with, and engaged in parallel play near other children. She scored a 2.0 in spontaneous social behavior and emitted 5 different sounds for an average of 10 sounds per hr. Addie scored a 3.0 in group skills and demonstrated the ability to sit at a group snack without negative behavior and transition between classroom activities.

Addie scored 81 points in the barriers to language and skill acquisition section with elevated scores on 21 of the 24 barriers. Addie scored a 4.0 on barriers that included negative behaviors, instructional control, mands, tacts, motor imitation, echoics, visual perceptual and matching-to-sample, listener skills, intraverbals, social skills, prompt dependency, scanning, conditional discrimination, generalization, reinforcement dependency, articulation, obsessive-compulsive behavior, and hyperactive behavior. She scored a 3.0 on the barriers that included

demand weakens motivators and failure to make eye-contact or attend to people. She scored a 2.0 on one barrier that was motivating operations, a 1.0 on the barrier of self-stimulation, and a 0.0 on the scrolling barrier.

Fred

Fred, a Black male, was 4 years and 1 month old at the start of the study. He received special education services under an ASD and SI eligibility. Fred babbled, engaged in some spoken communication (e.g., yea, sure), and did not reliably imitate spoken words or sounds. He mostly communicated by yelling, pointing, or pushing things away. He had no known prior experience with picture exchange or SGDs. His IEP objectives included attending to his name, receptively identifying body parts, colors, common objects, and shapes, and using greetings and farewells. Fred liked to sort toys into bins, blocks, magnets, and books.

VB-MAPP. Fred scored a 21.5 for milestones which is in the range for the Level 1 learner category. He scored a zero for mands, tacts, motor imitation, LRFFC, intraverbals, linguistic skills, reading, writing, and math. Fred scored a 1.0 for listener skills and attended to a speaker's voice with eye contact. He scored a 5.0 in visual perceptual and matching-to-sample skills and demonstrated he tracked visual stimuli, used a pincer grasp, attended to a book or toy for 30 s, either placed three items in a container, stacked three blocks, or placed three rings on a peg, and sorted five items from five different categories. Fred scored an 8.5 on independent play skills and manipulated objects, interacted with varying items, engaged in exploratory movement in a novel environment, movement play, cause-and-effect, used playground equipment, repeated a gross motor behavior to obtain a better effect, and sustained play for 10 min. He scored a 3.0 in social skills and social play and made eye contact as a mand, indicated she wanted to be held or played with, and engaged in parallel play near other children. Fred scored a 3.0 in spontaneous

vocal behavior and met criteria for emitting 10 different sounds with varying intonations. He scored a 1.0 in group skills and sat at a table for group snack without negative behaviors.

Fred scored 80 points in the barriers to language and skill acquisition section with elevated scores on 22 of the 24 barriers. Fred scored a 4.0 on barriers that included mands, tacts, motor imitation, echoics, visual perceptual and matching-to-sample, listener skills, intraverbal, social skills, prompt dependency, scanning, conditional discriminations, generalization, demand weakens motivators, reinforcement dependency, articulation, obsessive-compulsive behavior, and hyperactive behavior. Fred scored a 3.0 on the self-stimulation barrier. Fred scored a 2.0 on barriers that included negative behaviors, instructional control, motivating operations, and failure to make eye contact or attend to people. Fred scored a 1.0 on the sensory defensiveness barrier and a 0.0 on the scrolling barrier.

Setting

The study took place in a preschool special education classroom setting in a Title I public school in the Southeastern United States. The special education classroom was a component of a specialized program based in applied behavior analysis (ABA), funded through a university grant and in partnership with the public school district. The classroom staff included certified special education teachers, Board Certified Behavior Analysts (BCBA), and graduate students pursuing degrees in special education and applied behavior analysis with oversight from university faculty. The classroom roster included eight students who met criteria for the specialized ABA program due to significant deficits in communication and a history of severe or dangerous challenging behavior (e.g., self-injury, aggression, elopement). The primary researcher held undergraduate and graduate degrees in birth-to-kindergarten special education and adapted

curriculum special education with an emphasis in ABA. The primary researcher was also a BCBA and completed the Level 1 PECS Training.

Within the classroom, three designated play areas, called centers, contained age-appropriate toys (e.g., blocks, cars, figurines, toy houses). Three to four students were in one center at a time with at least one adult who facilitated play with toys and with peers. Classroom staff integrated goals related to each student's IEP in the social-emotional-behavioral domain (e.g., engaging in collaborative play with a peer) into the play time. The room also had one child-sized rectangle table in a back corner of the room, one child-sized rectangle table along a side wall of the classroom, and a child-sized kidney table in the middle of the room. Each rectangle table had 2-4 chairs and the kidney table had 8 to 10 chairs. At the front of the room, a large area rug with eight cube-shaped chairs were set up for large group activities.

Sessions occurred in the participant's typical classroom environment and Experiment 1 sessions occurred at one of the rectangle tables in the back corner of the room. The participants first checked their visual schedule to indicate work time to assist with the transition to the table. Experiment 2 sessions occurred in the front of the room on or near the rug. Two adults, the primary researcher and a secondary data collector participated in all sessions. The primary researcher and data collectors were familiar adults to each participant. Each session lasted for 10 trials and occurred at least three times a week.

Materials

Materials required for each session included data collection sheets (see Appendices A-J), preferred edible and tangible reinforcers specific to each participant's interests and based on the results of the preference assessment (see Figure 3-6), laminated picture cards corresponding to each item with Velcro attached to the back, communication book and carrying strap, and an iPad

with the Proloquo2Go app and carrying strap. To see images of the grid-display on Proloquo2Go used by each participant, see Appendices V-W. In Experiment 2, the primary researcher used the timer app on an iPhone for the 5 min session.

Dependent Variables, Response Definitions, Measurement

In Experiment 1, researchers measured PECS responding and Proloquo2Go responding as primary dependent variables and independent vocalizations as a secondary dependent variable. In Experiment 2, researchers measured PECS responding, Proloquo2Go responding, and independent vocalizations as primary dependent variables. Researchers also measured varied mands and total mands as secondary dependent variables in Experiment 2. All dependent variables are defined below.

The primary researcher defined a PECS response as any instance where the participant independently picked up, reached, and exchanged the single picture into the hand of the primary researcher. A Proloquo2Go response was defined as any instance where the participant independently navigated to and selected the corresponding icon and oriented to the primary researcher by turning their body towards them, touching their arm, or making eye contact. For Experiment 1, any instance where the prompter used hand-over-hand guidance to help the participant complete the AAC communicative response was considered a full-physical prompt and any instance where the prompter guided the participant from the forearm to the shoulder to complete the AAC communicative response was considered a partial physical prompt.

An independent vocalization occurred if the participant emitted a full spoken word or spoken vocal approximation that included recognizable sounds matching the target item and occurred before the primary researcher named the item. For example, if the participant said, “Cookie,” or “Cook,” when requesting a cookie and before the communication partner said

cookie, an independent vocalization occurred. If the participant said, “Buh,” when requesting for a cookie, this vocalization was not recorded.

Varied mands were defined as any new modality that differed from the previously selected response. For example, if a participant first selected PECS the next response that was altered (e.g., Proloquo2Go or independent vocalization) was scored as a varied mand. Total mands were defined as many mand occurring in a session that included PECS, Proloquo2Go, and independent vocalizations.

For baseline and intervention conditions in Experiment 1, researchers recorded a frequency of each occurrence for each dependent variable on the data collection sheet. Baseline sessions consisted of 10 trials. Intervention sessions consisted of 5 trials for PECS and 5 trials for Proloquo2Go for a total of 10 trials. Independent vocalizations were scored out of 10 trials. The frequency count was then converted to a percentage for a percentage of independent responding out of 10 trials in baseline, 5 trials for PECS and Proloquo2Go in intervention, and out of 10 trials for independent vocalizations. The primary researcher and a trained secondary data collector collected data in person on paper data sheets and recorded the occurrence or nonoccurrence of each variable. The data was then transferred into an Excel document and graphed to allow for visual analysis of the dependent variables. For the concurrent operant condition in Experiment 1 and 2, researchers collected frequency data on the AAC modality selected by the participant and converted to a percentage of selection out of 5 trials.

In Experiment 2, responding during lag conditions were reported as rate per minute (rpm) for each modality (e.g., PECS, Proloquo2Go, and independent vocalizations) and for varied mands and total mands. Sessions lasted for 5 min and participants could respond the entirety of the session or not at all. During the session, data collectors recorded each modality that occurred

on paper data sheets. At the end of the session, the frequency of each modality and varied mands were calculated and then divided by 5 min to obtain the rpm. Total mands were calculated by counting all mands that occurred in the session and dividing by 5 min to obtain the rate of total mands.

Experimental Design

In SCRD, participants are exposed to at least two different conditions (e.g., baseline and intervention) with the dependent variable or target behavior measured repeatedly (Gast & Ledford, 2018). SCRD requires the researchers to visually analyze the data to objectively determine whether or not the independent variable had an effect on the dependent variable in relation to trend, variability, and level. Throughout the duration of the study, the primary researcher visually inspected graphed data to make decisions (e.g., to change conditions) and to identify potential threats to experimental control (e.g., extraneous study variables). The study consisted of two experiments that occurred, at least partially, concurrent to one another. The first experiment evaluated the effects of acquisition and preference of each AAC modality. The second experiment evaluated the impact of lag schedules of reinforcement on response persistence.

In Experiment 1, the primary researcher used a multiple probe across participants design to evaluate participants' acquisition of independent communicative responses with PECS and Proloquo2Go and preference of modality at each phase of the PECS protocol. This resulted in four independent multiple probe across participants designs, one design per PECS phase completed including Phase IIIA and Phase IIIB separately. A multiple probe design assessed the same baseline and intervention conditions across participants and utilized a time-lagged introduction to intervention conditions. Additionally, to protect against maturation, history, and

testing threats, a multiple probe across participants was used to allow for intermittent data collection in baseline with participants two, three, and four.

Baseline consisted of at least five sessions prior to the implementation of the intervention. In the event data were variable or ascending after five sessions of data, the participant remained in baseline until the data demonstrated steady low-level responding. Once the first participant reached mastery criterion of 80% independent responding across three consecutive sessions of intervention, the second participant began intervention, and the third and fourth participant began intervention once the second participant met mastery criterion. This created a staggered introduction of the intervention across participants. Baseline sessions for the first participant were continuous and baseline sessions (conducted as probes) for the second, third, and fourth participant occurred once every third session the participant engaged in intervention completed a session. Immediately following mastery of the PECS phase, a concurrent operant condition was conducted to evaluate the participant's preference for either AAC modality.

Prior to the first condition in Experiment 2, three additional concurrent operant sessions occurred with both modalities available to establish a pattern of reinforcement in the novel contexts. This occurred to promote the generalization of the learned AAC communicative responses to a new setting and to demonstrate to the participant reinforcement was available in this setting with either AAC modality. Experiment 2 was conducted to evaluate the influence of simultaneously training two AAC modalities on response persistence when met with a treatment challenge (e.g., one modality is not immediately reinforced), using a B-A-B-A design for each participant after completion of each phase of PECS. This phase of the experiment began after each PECS phase (I-VI) once the participant completed the concurrent operant condition and resulted in three B-A-B-A designs.

The B condition consisted of the treatment challenge where the primary researcher implemented a Lag 1 schedule of reinforcement, requiring the participant to use a novel AAC or vocal response from the previously used response to access reinforcement. The A condition consisted of the primary researcher implementing a Lag 0 schedule of reinforcement, providing reinforcement for whichever modality or vocalization the participant used to request. The B-A-B-A designs removed and reintroduced the intervention (i.e., the treatment challenge in this study) to directly evaluate the effects a Lag 1 schedule had on AAC communicative responses. Each B-A condition consisted of at least five sessions contingent on data stability.

Interobserver Agreement and Procedural Fidelity

Interobserver agreement (IOA) assessed the reliability of the data collected between two observers. For this study, the primary researcher was also the primary data collector, and a secondary researcher was the secondary data collector. The two data collectors recorded data independently from one another during the same session on separate data collection sheets. Following each session, IOA was calculated using point-by-point agreement and reported as a percentage (the number of agreements divided by the number of agreements plus disagreements multiplied by 100; Ledford et al., 2018). IOA was collected across baseline and intervention conditions and phases and across each participant for at least 20% of sessions.

IOA data collectors were trained following recommendations provided from Ledford and colleagues (2018). Data collectors received written procedures for each condition and phase along with dependent variable definitions, practiced collecting data alongside the primary researcher, asked questions as needed, and finally practiced collecting data during a modeled session with the primary researcher and second adult until the data collector reached at least 90%

agreement for 3 modeled sessions. Any disagreement found after a session was discussed between data collectors and additional training followed if deemed necessary.

In Experiment 1 Phase I, IOA was collected for 30% of Andy's sessions (100% *M*), 33% of Daniel's sessions (97.5% *M*, range 90-100%), 27% of Addie's sessions (98% *M*, range 90-100%), and 25% of Fred's sessions (95% *M*, range 80-100%). For Phase II, IOA was collected for 24% of Andy's sessions (97.5% *M*, range 90-100%), 32% of Daniel's sessions (98.3% *M*, range 90-100%), 29% of Addie's sessions (100% *M*), and 27% of Fred's sessions (100% *M*). In Phase IIIA, IOA was collected for 25% of Andy's sessions (100% *M*), 33% of Daniel's sessions (100% *M*), 36% of Addie's sessions (100% *M*), and 30% of Fred's sessions (100% *M*). In Phase IIIB, IOA was collected for 27% of Andy's sessions (100% *M*), 31% of Daniel's sessions (100% *M*), 27% of Addie's sessions (100% *M*), and 26% of Fred's sessions (100% *M*). For sessions with disagreement, researchers discussed the discrepancies and reached an agreement prior to the next session.

In Experiment 2 Phase I, the mean IOA was 97% (range 88-100%) for Daniel and 100% for Fred. In Phase 2, the mean IOA for Daniel was 99% (range 96-100%), 100% for Fred, and 99% (range 97-100%) for Addie. In Phase 3, the mean IOA was 97% (range 92-100%) for Daniel, 98 % (range 93-100%) for Fred, and 98% (range 94-100%) for Addie.

Procedural fidelity was used to determine the percentage of steps implemented correctly during all experimental conditions by the primary researcher (Barton et al., 2018b). The secondary data collector used procedural fidelity checklists specific to baseline and intervention phases (see Appendix L-U for fidelity checklists). The procedural fidelity checklists were based on checklists provided in the PECS manual with modifications to fully represent treatment conducted in the current study. Data collectors received training on the procedural fidelity

checklists prior to the study. Training consisted of providing the data collectors with information about the study, reviewing each procedural fidelity checklist and explaining each component, and the data collectors practiced using the checklists during a modeled session with the primary researcher and a second adult.

In Experiment 1 Phase I, procedural fidelity was collected for 30% of Andy's sessions (100% *M*), 33% of Daniel's sessions (100% *M*), 22% of Addie's sessions (100% *M*), and 25% of Fred's sessions (97.5% *M*, range 90-100%). In Phase II, procedural fidelity was collected for 24% of Andy's sessions (100% *M*), 32% of Daniel's sessions (100% *M*), 29% of Addie's sessions (100% *M*), and 27% of Fred's sessions (100% *M*). In Phase IIIA, procedural fidelity was collected for 25% of Andy's sessions (100% *M*), 33% of Daniel's sessions (100% *M*), 36% of Addie's sessions (100% *M*), and 30% of Fred's sessions (100% *M*). For Phase IIIB, procedural fidelity was collected for 27% of Andy's sessions (100% *M*), 31% of Daniel's sessions, 27% of Addie's sessions (100% *M*), and 26% of Fred's sessions (100% *M*). For sessions with less than 100% procedural fidelity, researchers reviewed procedural steps for the relevant phase prior to the next session. In Experiment 2, procedural fidelity was calculated for 20% of all sessions across all participants. Procedural fidelity was 100% for Daniel, Fred, and Addie for all conditions across all phases.

Screenings

VB-MAPP

The participants' classroom teacher conducted the VB-MAPP with each participant. Through three sections (e.g., Milestones, Barriers, and the EESA), the VB-MAPP assessed participant's skills related to verbal behavior, language and learning, social skills, vocal imitation, and behavioral challenges that hinder the learning environment or ability to acquire

new skills. A description of each participant's individual scores related to milestone level, barriers to learning, and echoics was included above in their participant descriptions.

Within the Milestones portion of the assessment, 16 domains with 170 milestones span across three developmental levels based on age (0-48 months). Milestone scores were reported as Level 1, 2, or 3, and out of a possible 170 points with a higher score indicative of a higher learning level. The domains assessed for skills related to mands, tacts, listener skills, visual perceptual and matching to sample, play, social, reading, writing, imitation, echoic, listener responding by feature, function, class, group, linguistics, math, and vocal. Milestones increased in difficulty with level 1 assessing for simpler skills such as selecting an item from an array of four for 20 items, and level 3 assessing for more complex skills such as selecting items by color and shape from an array of six similar items.

The Barriers component of the VB-MAPP evaluated language and learning factors that impact an individual from progressing on skills. Barriers evaluated included impaired verbal behavior (e.g., mand, tact, listener skills), challenging behaviors, social skills, prompt dependency, motivating operations, self-stimulatory or repetitive behaviors, and sensory defensiveness. Barriers to learning were scored out of a possible 96 points and a lower score indicated fewer barriers to learning. Barriers were scored on a 0-4 scale with zero indicating this barrier was not an issue and four indicating a serious impact to the participant's language and learning acquisition.

The EESA specifically assessed vocal imitation and consisted of 100 single syllable or multi-syllable combinations of sounds and words (e.g., *me, up, foo-ey, my foot*). The EESA contained five groups with groups 1-3 broken into difficulty of syllable combinations. Group one consisted of simpler single syllable sounds such as, *be,* and *oo,* and group three consisting of

words such as *tubby toy*, and *my big toe*. Group four assessed if the participant vocally imitated the emphasis of certain syllables when the researcher placed emphasis on the targeted syllables (e.g., *no WAY, MY mommy, BUG-a-boo*). Group five assessed vocal imitation of pitch variation in a song, imitation of a continuous warble, whispering, using a loud and quiet voice, and sustaining an *oooh* sound for 3 s.

Following EESA protocol, participants received three opportunities to imitate the vocal sound. The scoring protocol for groups 1-3 allocated a score of zero for no response or incorrect responses, a score of one-half for recognizable responses contained extra syllables or incorrect consonants, and a score of one point for correct responses. Incorrect responses included incorrect vowels or missing syllables. For group four scoring, participants received a zero for a monotone response (no emphasis on the intended word), a one-half for emphasis on non-target syllables, and a one for emphasis on correct syllables. Scoring for group five differed in that either a zero was given if the response did not clearly match the model or a one was given if the response was correct or close. The total possible points to receive was 100.

Each participant scored as a Level 1 learner meaning intervention should focus on mands, echoics, motor imitation, listener discrimination, tacts, play, spontaneous vocalizations and visual perception and matching skills. Participants scored between 57 and 81 for barriers to learning and each participant scored a zero on the EESA.

Multiple Stimulus Without Replacement

A multiple stimulus without replacement (MSWO) preference assessment was conducted to determine individual participants' preferences for edible and tangible items (DeLeon & Iwata, 1996). Prior to baseline, the primary researcher conducted the MSWO by selecting 5 edible items and 5 tangible items. The array of 5 items were presented to the participant with the instruction

to, “Pick one.” The participant received one bite or the tangible item for 1 min once selected. After the edible was consumed or 1 min passed, that item was removed from the array and the primary researcher presented the 4 remaining items. This sequence continued until one item remained and the results provided a hierarchy of preferred items for edible and tangible items.

Prior to the start of each session, two to three items identified as preferred from the MSWO were presented to the participant. The primary researcher used the selected item for the duration of the session or until motivation waned. When the primary researcher noticed the participant lost interest in the chosen item (attempted to elope, no longer reached for the item, reached or looked toward the cabinets where edibles were located), the researcher represented two to three options for the participant to choose again. Figures 3-6 shows the results of each participant’s MSWO for edible and tangible items. During the study, items most selected for Andy included fruit snacks, Oreos, and the rain stick, for Daniel included popcorn, fruit snacks, Oreos, and Legos, for Addie included Oreos, Starbursts, Goldfish, and crackers (a newly identified preferred item), and for Fred included Starbursts, M&Ms, and Legos.

Vocal Screening

Using the *Vocal* Memo app on an iPhone, the primary researcher conducted a vocal screening to determine a reference point of targeted vocalizations and to phonetically define the idiosyncratic vocals for each participant; however, no participant vocally responded during the screening. The primary researcher asked each participant to say the name of the specific items identified as reinforcers from the MSWO preference assessment (e.g., “Say car”) in the absence of the item. After 3 s if the participant did not vocalize, the primary researcher repeated the statement, “Say car,” and waited an additional 3 s.

Experiment 1

General Procedures

For each modality, the primary researcher implemented the PECS protocol as outlined by Frost and Bondy (2002). Steps, instructional strategies, and mastery criterion was applied to PECS and Proloquo2Go responding for Phases I-III. All sessions for baseline and PECS phases consisted of at least 5 trials and up to 10 trials. Mastery criterion was met for each phase when the participant independently completed the AAC communicative response 80% of the session across three consecutive sessions. Intervention criteria was dependent on each PECS phase as each phase teaches new and different skills. If at any point in the session, the EO for the item originally chosen was gone (e.g., the participant no longer attempted to get access to the item, tried to leave the table), the researcher represented 2 to 3 items to see if another item gained the participant's attention.

Baseline

For all baseline sessions during AAC acquisition, the primary researcher gathered all materials (e.g., preferred items, PECS communication book, Proloquo2Go device, data sheets) prior to bringing the participant to the table. The researcher placed two to three items in front of the participant and told the participant to "pick one" to determine the EO. If an edible was selected, the participant received one bite of the edible. If a tangible item was selected, the participant received access to the item for 30 s. Depending on the item selected, corresponding pictures were presented on each modality with the modalities placed at equal distances in front of the participant. The researcher restricted and silently enticed the participant to reach for the item. The researcher did not name the item but kept the item in sight yet out of reach of the participant. Prompting of each modality did not occur and all problem behavior was ignored or followed

classroom specific behavior protocols. The separate baseline conditions are described below to depict the specific skills taught in each PECS phase.

Baseline Phase I. Data was taken on the participant's response and included the participant grabbing or reaching for the item, engaging in problem behavior (aggression, disruption), picking up the PECS picture, reaching the PECS picture, and exchanging the PECS picture, selecting the corresponding button in Proloquo2Go, or vocalizing the name or an approximation of the item. Regardless of how the participant attempted to gain access to the item, the researcher delivered the item after the attempt. The participant received one bite or access for 30 s. The session continued for 10 trials.

Baseline Phase II. A communication book was introduced during this phase with the corresponding PECS picture placed on the front cover of the book. The communication partner began 5 ft away from the participant and restricted access to the item. Both modalities were available and at an equal distance in front of the participant. Data were collected on which modality (if any) the participant chose, the steps of the AAC sequences completed, if the participant traveled to the communication partner (with or without an AAC modality), or if a vocalization occurred. If the participant grabbed the item, completed an AAC sequence, or vocally requested, the researcher delivered the item by providing one bite or 30 s of access to the item.

Baseline Phase IIIA. A preferred item selected by the participant, a non-preferred item, and a tray was used for Phase IIIA. The preferred and non-preferred items were placed on each end of the tray with access restricted. The primary researcher was an arm's length away from the participant and both modalities were equally distanced in front of the participant. Data was collected on the modality the participant selected (if any), if an AAC communication sequence

occurred, any grabbing or reaching for an item and for which item (preferred v non preferred) and any vocalizations. If the participant attempted to gain access to either item in any way (e.g., grabbing, AAC response, vocalized), the participant received access to that item (either one bite or 30 s access). If the participant selected the non-preferred item and showed disinterest, the researcher then delivered the preferred item. If the participant selected the non-preferred item and showed interest, a new non-preferred item was selected for the next trial.

Baseline Phase IIIB. For this phase, 5 preferred items were used. Depending on the items selected by the participant, the researcher placed the corresponding PECS pictures of the preferred items and the SGD at an equal distance apart in front of the participant. The preferred items were equally spaced on a tray and restricted. Data was collected on the modality the participant selected (if any), if an AAC communication sequence occurred, any grabbing or reaching for an item and for which item and any vocalizations. Only one item at a time could be chosen. If any AAC communicative sequence or vocalization occurred, the researcher stated, "Take it," presented the tray to the participant and recorded which item the participant selected to assess correspondence between the item requested and the item selected from the tray.

Intervention

Once intervention began, the primary researcher presented one modality at a time, alternating between PECS and Proloquo2Go, until the participant reached mastery criterion for that modality. At the beginning of each new phase, the modality offered first was alternated as well. For example, in Phase I, the PECS modality was first presented in trial 1 and on trial 2, Proloquo2Go was presented, alternating for 10 total trials. In Phase II, Proloquo2Go was presented on the first trial and PECS presented on trial 2. This alternating continued through all phases.

If at any point in the phases, mastery occurred for one modality (i.e., 80% across three consecutive sessions) and twice as many trials was reached for the second modality, alternating modalities ceased and the modality that did not reach independence was presented for 5 trials in a row to determine if mastery criterion could be reached. If mastery was achieved, the participant continued on to the simultaneous presentation of modalities. If the participant did not reach mastery for that modality training continued with the successful modality.

Procedures that remained consistent across intervention phases are listed here and phase-specific intervention procedures are listed under the appropriate headings. All problem behavior was ignored or followed classroom specific behavior protocols if it occurred during a session. Prior to the session, the researcher flipped a coin to determine which modality was presented first. The researcher gathered necessary materials including the participant's preferred items, PECS pictures of corresponding items, the iPad set to Proloquo2Go, a secondary prompter and data sheets. The researcher presented two to three items for the participant to select from and the participant received either one bite of an edible or 30 s access to the item. The corresponding PECS picture was placed in front of the participant during the PECS trials and Proloquo2Go was presented during SGD designated trials. For all phases except Phase II, the primary researcher sat directly in front of the participant, within an arm's reach away. The prompter stayed behind the participant, remained silent, and waited for the participant to initiate responses prior to prompting.

Phase I. The primary researcher restricted access to the item and enticed but did not name the item. If the participant reached for the item, the prompter used physical prompting to guide the participant to complete the sequence applicable for each AAC modality. For the PECS response, the prompter guided the participant to pick up the picture, reach it out to the primary

researcher, and exchange it into their hand. The Proloquo2Go sequence included the prompter guiding the participant to the correct page with the corresponding item button and selecting the button. Data was collected for the participant's initial behavior (e.g., reaches for the item, picks up the picture), the level of prompting needed for each step, and any vocalization. Once the participant completed the AAC response (i.e., picture exchanged, button selected, vocally requested), the primary researcher named the item and provided one bite or 30 s access to the item. The researcher presented the alternate modality on the next trial and continued alternating for the duration of the session. If at any point in the session the participant lost interest in the item being requested, the researcher re-presented new items for the participant to select.

Phase II. The communication book was introduced during this phase with the corresponding PECS picture placed on the front cover of the book. The researcher alternated the AAC modalities on each trial. Once the participant selected an item to request, the primary researcher placed the predetermined modality in front of the participant and moved 1 ft away while restricting the item. If the participant reached for the item without attempting to communicate via the AAC, the secondary prompter physically guided the participant toward the AAC modality providing necessary support for each step until the participant completed the AAC sequence taught in Phase I. The primary researcher named the item and provided one bite of an edible or 30 s access to the item. After 3 consecutive trials of independent AAC responding, the primary researcher moved back 1 ft at a time until over several sessions the researcher was 5 ft away. As the researcher moves further away, the prompter will guide the participant to carry their communication book or the SGD to the researcher then completing the AAC response.

Once the participant successfully traveled to the primary researcher 5 ft away, the secondary prompter started moving the communication book 1 ft away from the participant over several sessions until the modality was 5 ft away. At the start of each trial, the prompter guided the participant first to the AAC modality, then provided necessary support to guide the participant to the primary researcher to complete the AAC sequence. Because of the voice output component of Proloquo2Go, the participant was not required to travel to the communication partner but could make the AAC communicative response after traveling to the device.

Phase IIIA. In this phase, the participant was taught to begin discriminating between pictures, beginning with a preferred item and non-preferred item with corresponding pictures and a secondary prompter was not needed. Each item was placed on either end of the tray with the selected modality in front of the participant. The PECS communication book had pictures of each item on the front cover and the Proloquo2Go had both pictures available. If the participant reached to select the preferred item picture, the researcher said, “Ooh,” to reinforce the correct choice, then labeled and delivered the preferred item after the AAC communicative sequence. If the participant requested the non-preferred item, the researcher labeled and gave the non-preferred item. If the participant accepted the non-preferred item, the session ended, and the researcher assessed for a new non-preferred item for the next session. If the participant rejected the item, the researcher used a 4-Step Error Correction procedure as outlined by Frost and Bondy (2002).

Phase IIIB. The participant requested from a tray of 2-5 preferred items. Items were of similar preference. The primary researcher restricted access to the tray and waited for the participant to complete an AAC communicative sequence. Once the participant requested for an item, the researcher presented the tray and said, “Take it,” “Here,” or, “Go ahead.” If the

participant reached for the item that corresponded with the item requested via AAC, the researcher allowed access and named the item. If the participant reached for a different item than requested, the researcher blocked access to the items, used the "teach to the reach" rationale and used the 4-Step Error Correction procedures (Frost & Bondy, 2002). The beginning of Phase IIIB focused on corresponding pictures between two items, then after two consecutive sessions of success (80% or higher), an additional item was added until the participant corresponded between 5 items and pictures or icons. Before moving to Phase IV, the primary researcher placed the PECS pictures inside the communication book and taught the participant to look inside the book.

Concurrent Operant

Materials used in the intervention phase remained the same for this condition. To assess for preference of modality, the primary researcher sat across the table with the PECS and Proloquo2Go modalities next to each other in front of the participant. The primary researcher restricted access to the item and waited for the participant to initiate. If the participant reached for the item instead of using an AAC modality to request, the researcher tapped the table in front of the modalities and continued restricting access to the item. If the participant made a request using an AAC modality, the primary researcher stated the name of the item and delivered it to the participant. Five sessions were conducted and consisted of 5 trials with no mastery criterion required.

Maintenance

After the conclusion of acquisition, post-intervention sessions continued to evaluate the lasting effects on the use of each modality, PECS and Proloquo2Go, and the use of vocalizations. Maintenance sessions occurred once a week for four weeks. Each session consisted of 5 trials

and took place at the same location as the baseline and intervention conditions. Two to three items were placed in front of the participant with each AAC modality available. If the participant attempted to access the item by reaching for it, the researcher delivered a prompt by tapping the table near the AAC modalities and waited for an AAC communicative response before delivering the item. The primary researcher collected data on the modality selected (e.g., PECS, Proloquo2Go, independent vocalizations) and if prompting was needed.

Experiment 2

Treatment Challenge (Lag 1 Schedule)

Prior to the beginning of the session, the primary researcher presented the participant an opportunity to request for a preferred item with either PECS, Proloquo2Go, or an independent vocalization. After the participant completed the request, the timer for the 5 min session started. The participant received reinforcement on a Lag 1 schedule of reinforcement for any novel response from the last previous response they used to request for an item. For example, if the participant first used a PECS exchange to request, on the next trial, the participant no longer received reinforcement for any PECS exchanges but needed to use a Proloquo2Go or vocal response to receive access to the requested item.

After the participant used a novel response, either Proloquo2Go or vocalization, the next response needed to be a new response. For example, if the participant used PECS for the first response, and Proloquo2Go for the second response, the participant could use PECS for the third response. The participant received either one bite of an edible item contingent on novel responses that differed from the previously emitted response. The primary researcher ignored and safely blocked any challenging behavior and ignored repeated requests with the same

modality. This process repeated for the duration of the 5 min session. Only varied responses from the prior response used received reinforcement during the Lag 1 schedule.

Lag 0 Schedule

During this condition, the participant received reinforcement on a Lag 0 schedule. The participant used either PECS, Proloquo2Go, or an independent vocalization to make the initial request for the item that started the 5 min session. Any AAC response or independent vocalization accessed reinforcement and the participant received either one bite of an edible. Sessions lasted for 5 min and the primary researcher ignored and safely blocked all occurrences of challenging behavior.

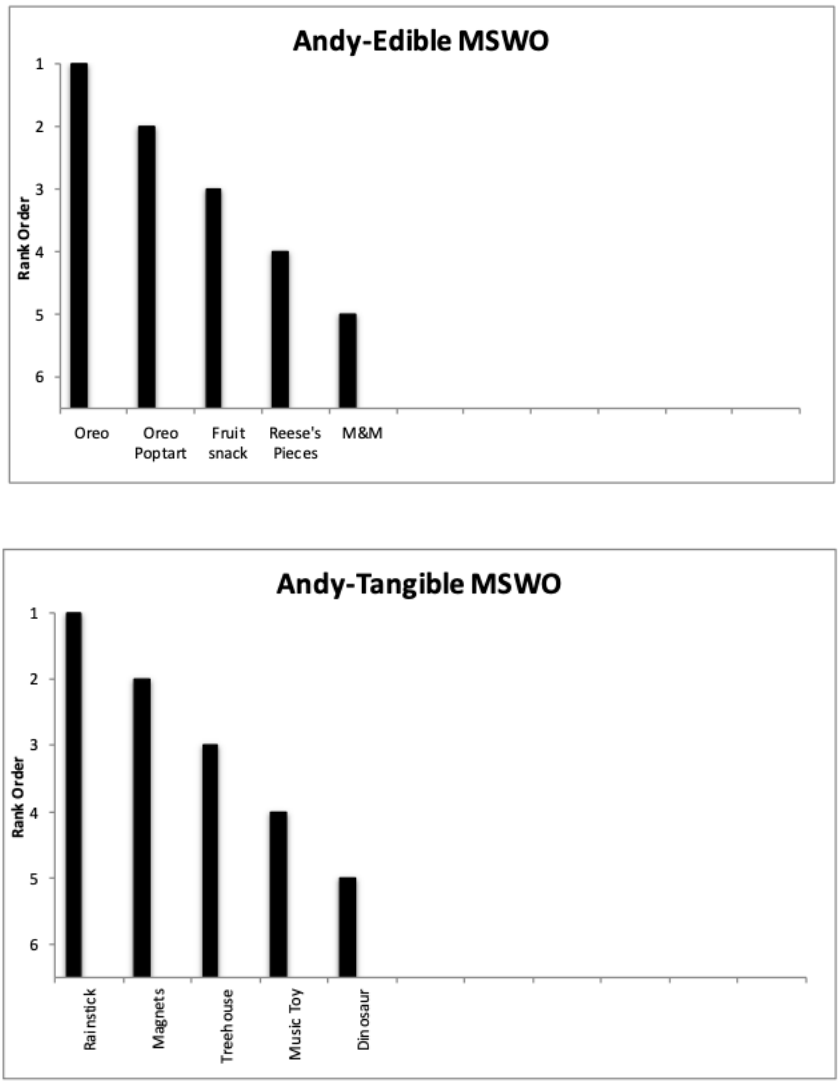
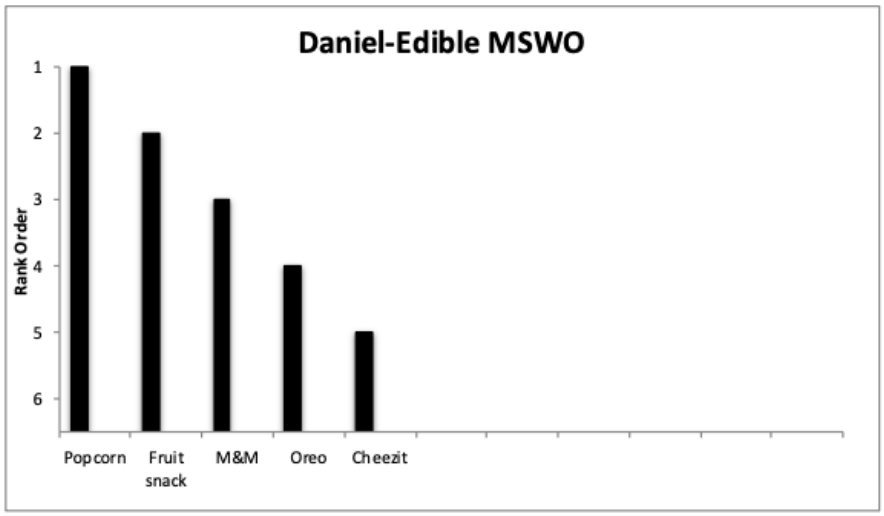


Figure 3

Results from Andy's Preference Assessment of Edible and Tangible Items

MSWO = Multiple stimulus without replacement.



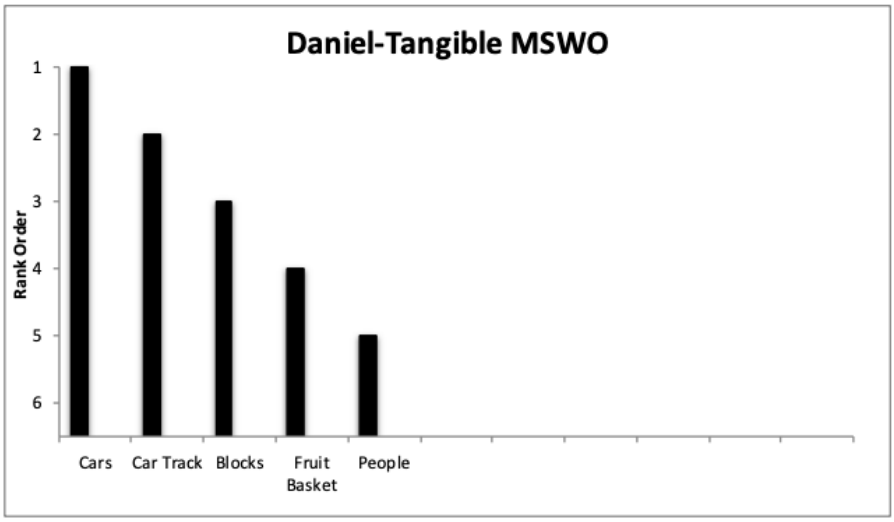


Figure 4

Results from Daniel's Preference Assessment of Edible and Tangible Items

MSWO = Multiple stimulus without replacement.

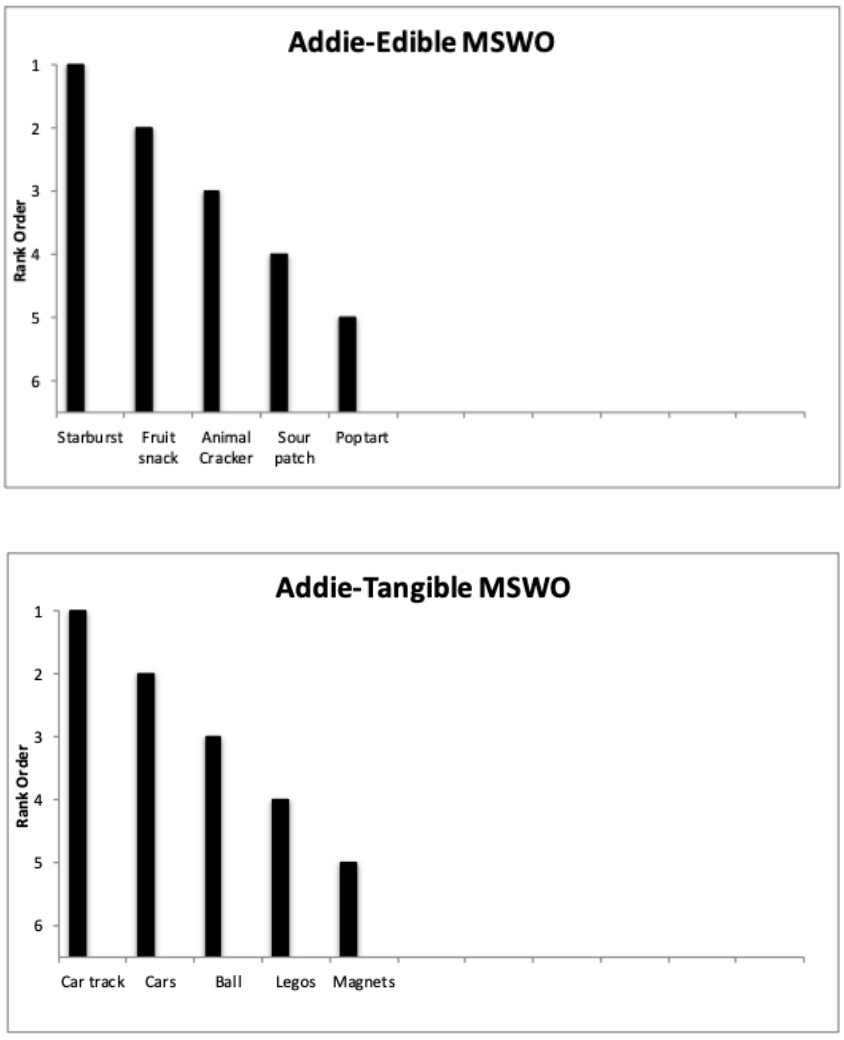
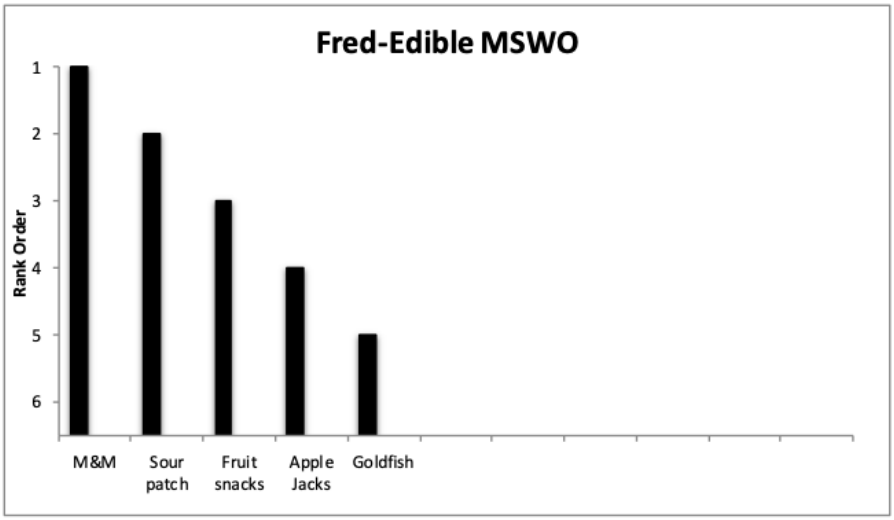


Figure 5

Results from Addie's Preference Assessment of Edible and Tangible Item

MSWO = Multiple stimulus without replacement.



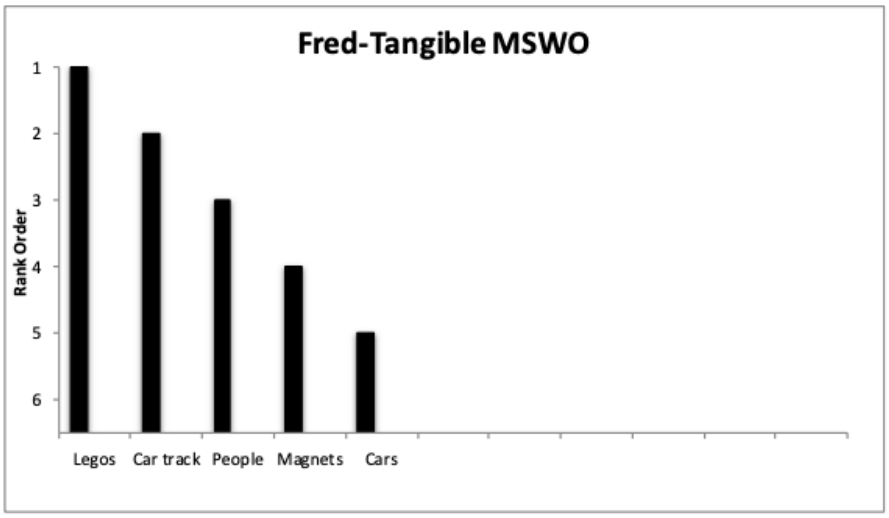


Figure 6

Results from Fred's Preference Assessment of Edible and Tangible Items

MSWO = Multiple stimulus without replacement.

CHAPTER 4

RESULTS

The purpose of this study was to evaluate the effects of teaching multiple AAC modalities and the impact on acquisition, preference, and persistence of communication with preschoolers with ASD and SI. Experiment 1 addressed the primary research question: What are the effects of simultaneously teaching two AAC modalities in regard to acquisition and preference to preschoolers with ASD? Additional secondary questions were also addressed in Experiment 1 including: (1) How does the rate of acquisition compare across modalities and across participants? (2) When teaching multiple modalities, does the participant exhibit a preference for one modality and at which PECS phase does it become apparent? (3) When taught multiple modalities, do both modalities maintain over time and at what level of independence? Experiment 2 addressed the following primary research question: When modalities are taught simultaneously, and a treatment challenge is embedded into the end of each training phase of PECS to mimic natural challenges found in the environment (e.g., one modality is not immediately reinforced), what are the effects on response persistence regarding each modality when placed on a lag schedule of reinforcement (i.e., PECS, SGD, or vocalization)? Table 5 provides a summary of findings related to each research question.

Experiment 1: Rate of Acquisition and Preference

The purpose of Experiment 1 was to evaluate simultaneously training two AAC modalities using the PECS protocol and assess acquisition, preference, and maintenance. Figure 7 depicts the number of sessions each participant took to reach mastery criteria across phases and

AAC modalities. Andy only mastered the PECS modality, and Daniel, Addie, and Fred mastered PECS and Proloquo2Go through Phase III of the PECS protocol. In intervention, Andy acquired PECS in a total of 25 sessions, Daniel acquired PECS in 27 sessions and Proloquo2Go in 29 sessions, Addie acquired PECS in 33 sessions and Proloquo2Go in 41 sessions, and Fred acquired PECS in 25 sessions and Proloquo2Go in 30 sessions.

Phase I

Figure 8 depicts acquisition and preference of PECS and Proloquo2Go across all participants in Phase I of training Percentage of responding was reported for PECS, Proloquo2Go, and independent vocalizations. The goal of Phase I was to teach participants to exchange a single PECS picture or follow a sequence on Proloquo2Go to select an icon to request a preferred item. All four participants acquired PECS at a faster rate. Only two participants mastered PECS and Proloquo2Go at Phase I of training. For the two participants that did not meet mastery criteria, the primary researcher consulted with the classroom teacher and determined Andy and Addie showed no progress on IEP goals related to discrimination. Before moving forward in training, the primary researcher simplified the full-grid display on Proloquo2Go to a single button response. Results related to acquisition of each modality and preference for each participant are described below.

Andy. During baseline, Andy did not use any modality (i.e., AAC, speech) to request. Once training began, Andy mastered PECS in five sessions. The Proloquo2Go response required physical prompting in all eight sessions with no sessions having an independent response. Andy did not independently vocalize during any session. By session nine of PECS Phase I, Andy completed the steps in the PECS trials with 100% of independent responding, but no change in

Proloquo2Go responding occurred during this phase. In the concurrent operant condition, Andy allocated responding to PECS 100% of trials in all five sessions.

Daniel. Daniel did not use any modality (i.e., AAC, speech) during baseline. Following the introduction of Phase I training, Daniel showed similar rates of acquisition for PECS and Proloquo2Go with a stable increase in responding. He mastered both PECS and Proloquo2Go in six sessions. During session 17 and 19, independent vocalizations increased above baseline levels. In the concurrent operant condition, Daniel allocated responding to both AAC modalities but had a higher level of Proloquo2Go responding.

Addie. Addie did not use any modality (i.e., AAC, speech) during baseline. She mastered PECS in five sessions with a stable increase in responding. With Proloquo2Go, she increased levels in independent responding in four sessions but never exceeded 40% and did not meet mastery criteria after 10 sessions. Addie did not independently vocalize across all sessions. In the concurrent operant condition, she allocated responding to PECS 100% of trials in all five sessions.

Fred. Fred did not use any modality (i.e., AAC, speech) during baseline. He mastered PECS in four sessions with a steady increase in responding. He mastered Proloquo2Go in eight sessions with a slightly slower increase but both modalities became stable. He did not independently vocalize in any session. In the concurrent operant condition, Fred allocated responding to both AAC modalities to communicate but at a higher level for Proloquo2Go in all sessions.

Phase II

Figure 9 depicts acquisition and preference of PECS and Proloquo2Go across all participants in Phase II of training. Percentage of responding is reported for PECS, Proloquo2Go,

and independent vocalizations. In Phase II, participants traveled to the communication book and to the communication partner. Results related to acquisition of each modality and preference for each participant are described below.

Andy. In baseline, Andy did not use AAC or speech to request. In Phase II training, Andy demonstrated an immediate change in responding for PECS and mastered traveling to the communication partner in seven sessions. He mastered traveling to the communication book and then to the communication partner in five sessions for a total of 12 sessions for PECS. After the modification to Proloquo2Go, Andy demonstrated some independent responding (20-40%) with Proloquo2Go in five sessions but never reached mastery criterion. He did not independently vocalize in any session. In the concurrent operant, he allocated responding to PECS for 100% of trials in four of the five sessions. In the second session, he selected PECS for 80% of trials and Proloquo2Go for 20% of trials.

Daniel. In the first three sessions of baseline, Daniel used PECS and Proloquo2Go to request in some trials but did not exceed 20% for independent responding, and independent vocalizations remained at 0%. In Phase II training, there was an immediate change in responding for PECS and Proloquo2Go. Daniel mastered Phase II for PECS in 10 total sessions and in 12 total sessions for Proloquo2Go. Daniel mastered traveling to the communication partner in five sessions for PECS and in seven sessions for Proloquo2Go. He mastered traveling to the communication book and the communication partner in five sessions for PECS and Proloquo2Go. Daniel's independent vocalizations increased above baseline levels in session 25 (10%), 27 (30%), 28 (30%), and 29 (10%). In the concurrent operant condition, he allocated responding to Proloquo2Go 100% of trials in three of the five sessions. In session two and three, he selected both AAC modalities. In the last session he independently vocalized 10% of trials.

Addie. Following the Proloquo2Go grid-display modification, Addie demonstrated elevated levels for PECS in all sessions during baseline but at no higher than 20% of trials. For Proloquo2Go and independent vocalizations, responding remained at 0%. There was an immediate increase in responding for PECS and Proloquo2Go with the introduction of intervention. Addie mastered Phase II in 11 total sessions for PECS and 13 total sessions for Proloquo2Go. During Phase II training, Addie mastered traveling to the communication partner in six sessions for PECS and eight sessions for Proloquo2Go. She mastered traveling to the communication book and the communication partner in five sessions for PECS and Proloquo2Go. With the modified Proloquo2Go, she mastered the Proloquo2Go response in six sessions. Across all sessions, Addie did not independently vocalize. In the concurrent operant condition, Addie allocated responding to PECS 100% for four of the five sessions. In the third session, she allocated responding to PECS for 40% of trials and to Proloquo2Go for 60% of trials.

Fred. In baseline, Fred's independent responding with PECS and Proloquo2Go ranged from 10-30% of trials for seven sessions. There was an immediate change in responding for Fred with PECS and Proloquo2Go. Fred mastered Phase II for PECS in 10 total sessions and in 11 total sessions for Proloquo2Go. During Phase II training, Fred mastered traveling to the communication partner in five sessions for PECS and six sessions for Proloquo2Go. He mastered traveling to the communication book and the communication partner in five sessions for PECS and Proloquo2Go. Fred did not independently vocalize in any session. In the concurrent operant condition, he allocated responding to PECS 100% of trials for four out of five sessions. In session one, he selected PECS for 40% of trials and Proloquo2Go for 60% of trials.

Phase IIIA

Figure 10 depicts acquisition and preference of PECS and Proloquo2Go across all participants in Phase IIIA training. Percentage of responding is reported for PECS, Proloquo2Go, and independent vocalizations. In Phase IIIA, participants were required to discriminate between a non-preferred and preferred PECS picture of Proloquo2Go icon when requesting a preferred item. At the onset of training for each participant, an immediate change in responding occurred. Results related to each participant's acquisition and preference are further described.

Andy. Phase IIIA sessions for Andy only included training PECS responses. His sessions included five trials with the PECS communication book presented in front of him. Andy did not use PECS or independent vocalizations during baseline. Andy mastered PECS in seven sessions with a slight increase in independent vocalizations in session nine for 20% of trials. The primary researcher did not conduct the concurrent operant in this or subsequent phases due to Andy only training with one AAC modality.

Daniel. In baseline, Daniel's responding remained between 10-30% for PECS and Proloquo2Go with no increase in the data level or trend. He mastered Phase IIIA in three sessions for PECS and Proloquo2Go with an immediate change and stability in responding. Daniel did not independently vocalize in any session across conditions. In the first, second, and last session of the concurrent operant, he allocated responding to Proloquo2Go 100% of trials. In session three and four, he selected PECS and Proloquo2Go between 40-60% of trials.

Addie. In two baseline sessions, Addie requested with PECS 70% (session one) and 60% (session 13) of trials; however, data for PECS remained variable throughout baseline with most sessions occurring at or below 30% of independent responding. Also in three baseline sessions, she responded with Proloquo2Go but responded for 20% of trials or less. Addie's responding

immediately changed with the start of intervention and she mastered PECS and Proloquo2Go in three sessions. She did not independently vocalize across all sessions. In the second, third, and fifth sessions of the concurrent operant, Addie allocated responding to PECS 100% of trials. In session one, she selected PECS for 40% and Proloquo2Go 60% of trials, and in session four she selected PECS for 80% of trials and Proloquo2Go at 20%.

Fred. In baseline, Fred independently responded with PECS 70% (session 11) and 50% (session 12) of trials. He demonstrated low but stable responding for Proloquo2Go that did not exceed 20% of trials. At the introduction of intervention, there was an immediate change in level and stability, and he mastered Phase IIIA in three sessions for PECS and Proloquo2Go. He did not independently vocalize in any session. Fred allocated responding to both AAC modalities across all five sessions. In the first three sessions, he selected PECS at a higher level than Proloquo2Go. In sessions four and five, he selected PECS and Proloquo2Go interchangeably between 40-60% of trials.

Phase IIIB

Figure 11 depicts acquisition and preference of PECS and Proloquo2Go across all participants in Phase IIIB of training. In Phase IIIB, all participants mastered corresponding between five pictures and items. A minimum of eight sessions was needed for participants to reach mastery criteria. Individual results related to acquisition and preference are described.

Andy. During baseline, Andy demonstrated a variable pattern of responding. In four non-concurrent sessions, he independently responded at 80% or higher. For all other sessions, responding was between zero and 40% and did not exceed 60%. Andy completed 10 baseline sessions and never reached mastery criteria with three concurrent sessions at 80% or higher. After a decrease in responding and a decreasing trend in the data, the primary researcher

implemented intervention and Andy's responding immediately changed and became stable. The variability decreased to zero and only two baseline sessions had overlapping data points with intervention. He mastered Phase IIIB for PECS in eight sessions. He had no increase in independent vocalizations across conditions.

Daniel. In baseline, Daniel independently responded with PECS or Proloquo2Go in each session but never exceeded 10% of trials for PECS and ranged between zero and 60% of trials for Proloquo2Go. Also in baseline, there was an increase in Daniel's independent vocalizations during session three and session 16 at 10% of trials. With the introduction of intervention, Daniel's responding immediately changed in level and variability. He met mastery criteria in eight sessions for PECS and Proloquo2Go. In intervention, Daniel engaged in independent vocalizations in all sessions except session 22. His independent vocalizations ranged between 10-40%, a substantial increase in vocalizations across phases. In the first session of the concurrent operant condition, Daniel allocated responding to Proloquo2Go for 80% of trials and PECS for 20% of trials. In the remaining four sessions, he selected Proloquo2Go 100% of trials.

Addie. Baseline sessions for Addie demonstrated low independent responding that did not exceed 20% of trials for PECS and Proloquo2Go. Most sessions remained at 0% of responding. There was an immediate change in responding with the start of intervention for PECS and Proloquo2Go. During intervention, data varied between 40-100%. During Phase IIIB as the primary researcher added items and pictures, Addie's responding initially decreased. Addie mastered corresponding between five items and pictures in 15 sessions for both AAC modalities. Addie did not independently vocalize across all sessions. During the first two concurrent operant sessions, Addie allocated responding to both AAC modalities. In the last three sessions, she selected PECS 100% of trials.

Fred. In baseline, Fred did not use any modality (i.e., AAC, speech). At the onset of intervention, his level of responding immediately increased and he mastered PECS and Proloquo2Go in eight sessions. He did not increase independent vocalizations during intervention. In session one and three of the concurrent operant, he allocated responding to both AAC modalities. In sessions two, four, and five, he selected PECS for 100% of trials.

Maintenance

Maintenance sessions began two weeks after the last participant (Addie) mastered Phase IIIB and data are depicted on Figure 11 along with the Phase IIIB data. Sessions occurred once a week for four weeks to evaluate the lasting independent responding of each modality. Andy's PECS and independent vocalization responding in maintenance demonstrated similar levels to intervention. Daniel, Addie, and Fred maintained a similar level of responding to intervention for PECS and Proloquo2Go. During Daniel's first two maintenance sessions, independent vocalizations increased to a higher level than baseline and intervention (occurred at 50% responding), but then decreased in the next two sessions to 40% and 20% responding. Independent vocalizations for Addie and Fred remained at zero levels.

Experiment 2: Persistence

Treatment Challenge

Once each participant mastered PECS and Proloquo2Go for each phase of PECS, the lag schedule sessions began. Daniel and Fred were the only participants to master Phase I of training for both modalities. Figures 12-14 display data for mands of each modality, PECS, Proloquo2Go, and independent vocalizations parsed out. Each of these figures displayed three sessions of a concurrent operant in the setting of the lag sessions to evaluate preference prior to the start of lag. Concurrent operant data was reported as a percentage of responding. Responding

during lag conditions were reported as rate per minute (rpm) for modality. Figure 12 depicts data for Daniel and Fred's Phase I Lag. Sessions for Phase I Lag ran concurrently to Phase II acquisition training and Phase II Lag ran concurrently to Phase III acquisition training. After Phase II acquisition, Daniel, Fred, and Addie started lag sessions. Figure 13 depicts data for Daniel, Fred, and Addie's Phase II Lag. Phase III Lag began after each individual participant mastered Phase IIIB acquisition training and continued until all conditions were complete. Figure 14 depicts data for Daniel, Fred, and Addie's Phase III Lag. Figures 15-17 displays data for each participant related to varied mands versus total mands with data points including combined responding for PECS, Proloquo2Go, and independent vocalizations.

Daniel. Referencing the top panel in Figure 12, in Phase I Lag Daniel selected PECS and Proloquo2Go in each session of the concurrent operant. In the last two sessions, Proloquo2Go was selected at a higher level of responding. Based on the concurrent operant, a preference for one singular could not be determined but indicated Daniel preferred and used both modalities. In the third session, Daniel had an increase in vocalizations to 20%. During Lag 1 conditions, PECS (M = 1.2 rpm) and Proloquo2Go (M = 1.5 rpm) responding occurred at similar elevated levels, and vocalizations emerged and occurred at near zero levels (M = 0.5 rpm). In both Lag 0 condition, PECS responding occurred at elevated levels (M = 2.5 rpm), Proloquo2Go responding occurred at a lower level (M = 1.3 rpm), and vocalizations remained at near zero levels (M = 0.2 rpm).

In Phase II Lag (refer to the top panel in Figure 13), Daniel selected Proloquo2Go at a higher percentage of responding for two of the three sessions in the concurrent operant condition, demonstrating a greater preference for Proloquo2Go. In one session, Proloquo2Go and vocalizations were selected the same amount. During Lag 1 conditions, Daniel had slightly

elevated responding with PECS (*M* = 1.2 rpm) and vocalizations (*M* = 0.1 rpm). There was greater elevated responding at a higher level with Proloquo2Go (*M* = 9.2 rpm), although in the first Lag 1 condition, data paths for PECS and Proloquo2Go overlap. It is in the second Lag 1 condition that great differentiation in level between the two modalities occurred. In Lag 0 conditions, PECS and vocalization responding was at near zero levels (*M* = 0.1 rpm). Proloquo2Go responding continued to occur at elevated levels (*M* = 6.8 rpm).

Daniel's data for Phase III Lag is depicted in the top panel of Figure 14. In the concurrent operant condition, Daniel never selected PECS, selected vocalizations once during one session, and selected Proloquo2Go most trials across sessions with two sessions occurring at 100%. During Lag 1 conditions, PECS occurred at zero levels. Proloquo2oGo (*M* = 5.1 rpm) and vocalizations (*M* = 3.1 rpm) occurred at closely similar elevated levels with overlapping data paths in the first Lag 1 condition. In the Lag 0 conditions, PECS responding remained at zero levels. Proloquo2Go remained at elevated levels (*M* = 4.8) and vocalizations decreased but were still slightly elevated (*M* = 1.3 rpm).

The top panel of Figure 15 reflects the varied versus total mand data for Daniel's Phase I Lag. During Lag 1 conditions, varied mands occurred at elevated levels (*M* = 1.9 rpm) and total mands occurred at elevated levels (*M* = 3.2 rpm). In Lag 0 conditions, varied mands decreased in level (*M* = 1.2 rpm) and total mands increased (*M* = 4.1 rpm). Phase II Lag is depicted in the top panel of Figure 16 and shows that for Lag 1 conditions, Daniel's varied mands occurred at elevated levels (*M* = 4.6 rpm) and total mands occurred at greater levels (*M* = 7.5 rpm). Lag 0 data show varied mands occurred at decreased near zero levels (*M* = 0.3 rpm) and total mands occurred at elevated levels (*M* = 7.0 rpm) indicating Daniel manded using the same modality during the majority of the sessions. In Phase III Lag as depicted in Figure 17, both Lag 1

conditions had varied mands occurring at elevated levels (*M* = 5.4 rpm) and total mands increasing and occurring at elevated levels (*M* = 8.3 rpm). In both Lag 0 conditions, varied mands decreased to near zero levels (*M* = 0.9 rpm) and total mands occurred at elevated levels (*M* = 6.1 rpm).

Fred. In Phase I, depicted in the bottom panel of Figure 12, Fred selected both AAC modalities, but selected PECS at a higher level than Proloquo2Go for two of the three sessions. During the Lag 1 conditions, PECS (*M* = 1.7 rpm) and Proloquo2Go (*M* = 2.7 rpm) occurred at elevated levels and vocalizations occurred at zero levels. In the Lag 0 conditions, PECS (*M* = 3.2 rpm) and Proloquo2Go (*M* = 2.0 rpm) responding continued to occur at elevated levels. It is noteworthy to differentiate that in the first Lag 0 condition, Proloquo2Go occurred at a higher level (*M* = 4 rpm) and in the second Lag 0 condition, PECS (*M* = 4 rpm) occurred at a higher level of responding but both occurred at the same mean level of responding.

The middle panel of Figure 13 shows data for Fred's Phase II Lag. In the concurrent operant, he selected PECS more than Proloquo2Go in all three sessions with two sessions at 100%. Lag 1 conditions reflect PECS (*M* = 2.5 rpm) and Proloquo2Go (*M* = 2.3 rpm) occurring at similarly elevated levels with vocalizations occurring at zero levels. Lag 0 conditions demonstrated Fred selected PECS for most of the sessions (*M* = 3.5 rpm), Proloquo2Go responding occurred at near zero levels (*M* = 0.6 rpm), and vocalizations occurred at zero levels.

Fred's Phase III Lag is depicted in Figure 14. During the concurrent operant, he selected PECS most in all three sessions with two sessions at 100%. Lag 1 conditions demonstrated both modalities occurring at similarly elevated levels (PECS, *M* = 2.5 rpm; Proloquo2Go, *M* = 2.2 rpm) and vocalizations occurring at zero levels. In Lag 0 conditions, PECS occurred at elevated

levels (*M* = 2.9 rpm), Proloquo2Go occurred at near zero levels (*M* = 0.4 rpm), and vocalizations occurred at zero levels.

The bottom panel of Figure 15 reflects the varied versus total mand data for Fred's Phase I Lag. In Lag 1 conditions, varied mands occurred at elevated levels (*M* = 1.7 rpm) and total mands occurred at elevated levels (*M* = 4.4 rpm). During Lag 0 conditions, varied mands decreased to near zero levels (0.1 rpm) and total mands remained at elevated levels (*M* = 3.6 rpm). Fred's Phase II varied data is depicted in the middle panel of Figure 16. Varied mands and occurred at elevated levels (*M* = 2.8. rpm) and total mands occurred at elevated levels (*M* = 4.9 rpm) during Lag 1 conditions. In Lag 0 conditions, varied mands decreased to near zero levels (*M* = 0.5 rpm) and total mands remained at elevated levels (*M* = 4.1 rpm). The middle panel of Figure 17 shows data for Fred's Phase III Lag for varied and total mands. In Lag 1 conditions, varied mands occurred at elevated levels (*M* = 2.9 rpm) and total mands occurred at an increased level (*M* = 4.7 rpm). Varied mands decreased to near zero levels (*M* = 0.4 rpm) and total mands continued to occur at elevated levels (*M* = 3.3 rpm) during Lag 0 conditions.

Addie. Addie participated in Phase II and Phase III Lag sessions. The bottom panel of Figure 13 contains data related to Addie's Phase II Lag. In the concurrent operant condition, Addie selected PECS and Proloquo2Go equally for one session, and selected PECS at 100% for two of the three sessions. During Lag 1 conditions, PECS (*M* = 4.2 rpm) and Proloquo2Go (*M* = 2.4 rpm) occurred at elevated levels and vocalizations occurred at zero levels. In Lag 0 conditions, PECS occurred at elevated levels (*M* = 4.3 rpm), Proloquo2Go decreased to near zero levels (*M* = 0.4 rpm), and vocalizations occurred at zero levels.

In Phase III Lag, depicted in the bottom panel of Figure 14, Addie selected PECS at a greater rate than Proloquo2Go for two sessions and chose PECS and Proloquo2Go equally for

one session in the concurrent operant. During Lag 1 conditions, PECS (*M* = 2.6 rpm) and Proloquo2Go (*M* = 1.9 rpm) occurred at elevated levels, and vocalizations occurred at zero levels. In Lag 0 conditions, PECS responding increased (*M* = 3.2 rpm), Proloquo2Go remained near the same level with a slight decrease (*M* = 1.2 rpm), and vocalizations remained at zero levels.

Addie's varied and total mand data are depicted in the bottom panel of Figure 16 and Figure 17. In Phase II, varied mands occurred at elevated levels (*M* = 3.5 rpm) and total mands occurred at almost twice the rate at (*M* = 6.7 rpm) during Lag 1 conditions. For Lag 0 conditions, varied mands decreased to near zero levels (*M* = 0.5 rpm) and total mands remained at elevated levels (*M* = 4.8 rpm). In Phase III Lag, during the Lag 1 conditions, varied mands (*M* = 2.8 rpm) and total mands (*M* = 4.6 rpm) occurred at elevated levels. In Lag 0 conditions, varied mands decreased level (*M* = 1.2 rpm) and total mands continued to occur at elevated levels (*M* = 4.5 rpm).

Table 5

Summary of Findings

Experiment	Research Question	Summary of Findings	Figure
1	1. What are the effects of simultaneously teaching two AAC modalities in regard to acquisition and preference to preschoolers with ASD?	Three of the four participants (Daniel, Addie, and Fred) simultaneously mastered PECS and Proloquo2Go	7-10
2	2. When modalities are taught simultaneously, and a treatment challenge is embedded into the end of each training phase of PECS to mimic natural challenges found in the environment (e.g., one modality is not immediately reinforced), what are the effects on response persistence in regard to each modality when placed on a lag schedule of reinforcement (i.e., PECS, SGD, or vocalization)?	Daniel, Addie, and Fred participated in Experiment 2. When exposed to a temporary extinction during Lag 1 conditions, participants maintained responding with both modalities and the brief exposure led to variations in the modality used to mand.	11-16
1	3. How does the rate of acquisition compare across modalities and across participants?	Researchers found similar rates of acquisition for PECS and Proloquo2Go for Daniel, Addie, and Fred. All four participants had similar rates of acquisition regardless of acquiring one modality or two.	7-10
-	4. How does the response effort across modalities differ and impact acquisition?	A limitation of the study resulted from not utilizing appropriate equipment to gather data around distance, force, or number of behaviors to analyze response effort differences.	-

Experiment	Research Question	Summary of Findings	Figure
1	5. When teaching multiple modalities, does the participant exhibit a preference for one modality and at which point in training does it become apparent?	The rate of acquisition did not seem to influence participant preference of modality and preferences differed across participants. Daniel preferred Proloquo2Go, Addie preferred PECS, and Fred preferred and used both PECS and Proloquo2Go. Preferences became apparent at the end of Phase I for each participant.	7-10
1	6. When taught multiple modalities, do both modalities maintain over time and at what level of independence?	The three participants who mastered both modalities (Danie, Addie, Fred) maintained each modality at comparable levels to intervention. Andy who only mastered PECS maintained responding at intervention levels.	7-10

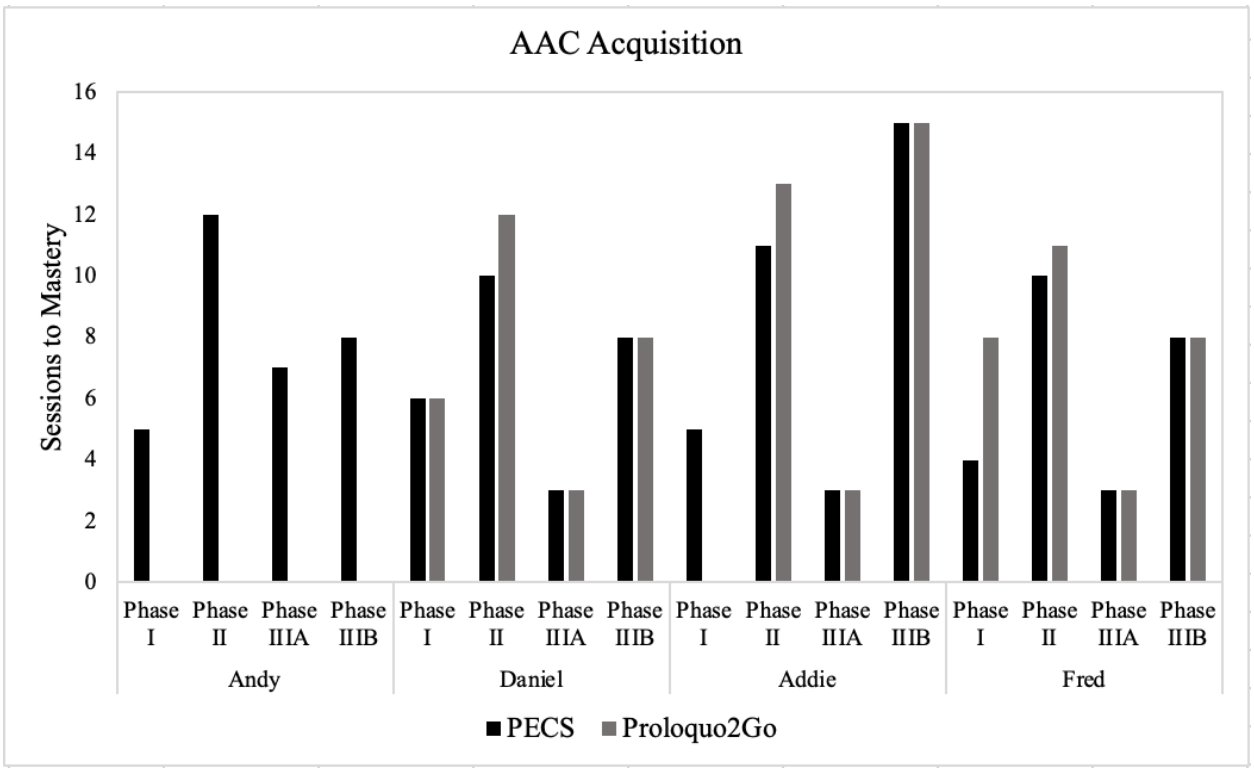


Figure 7

Trials to Mastery for PECS and Proloquo2Go Across Phases and Participants

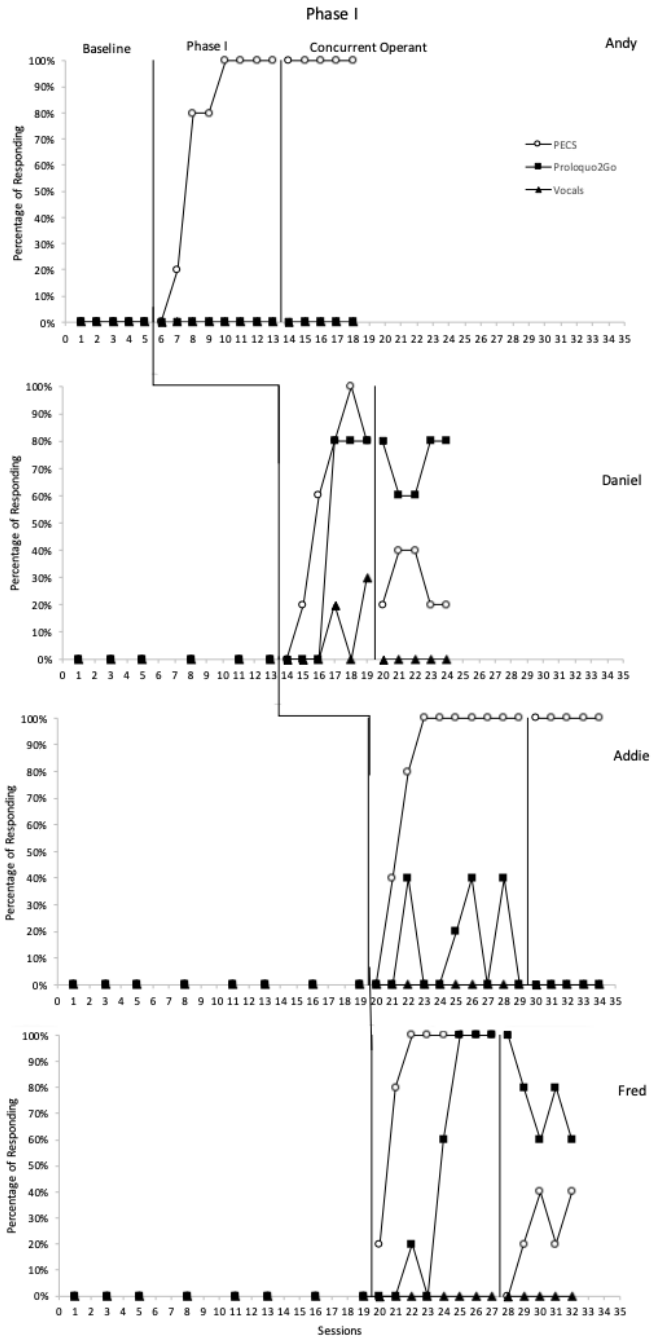


Figure 8

Phase I Acquisition of PECS and Proloquo2Go

Vocals = Independent vocalizations.

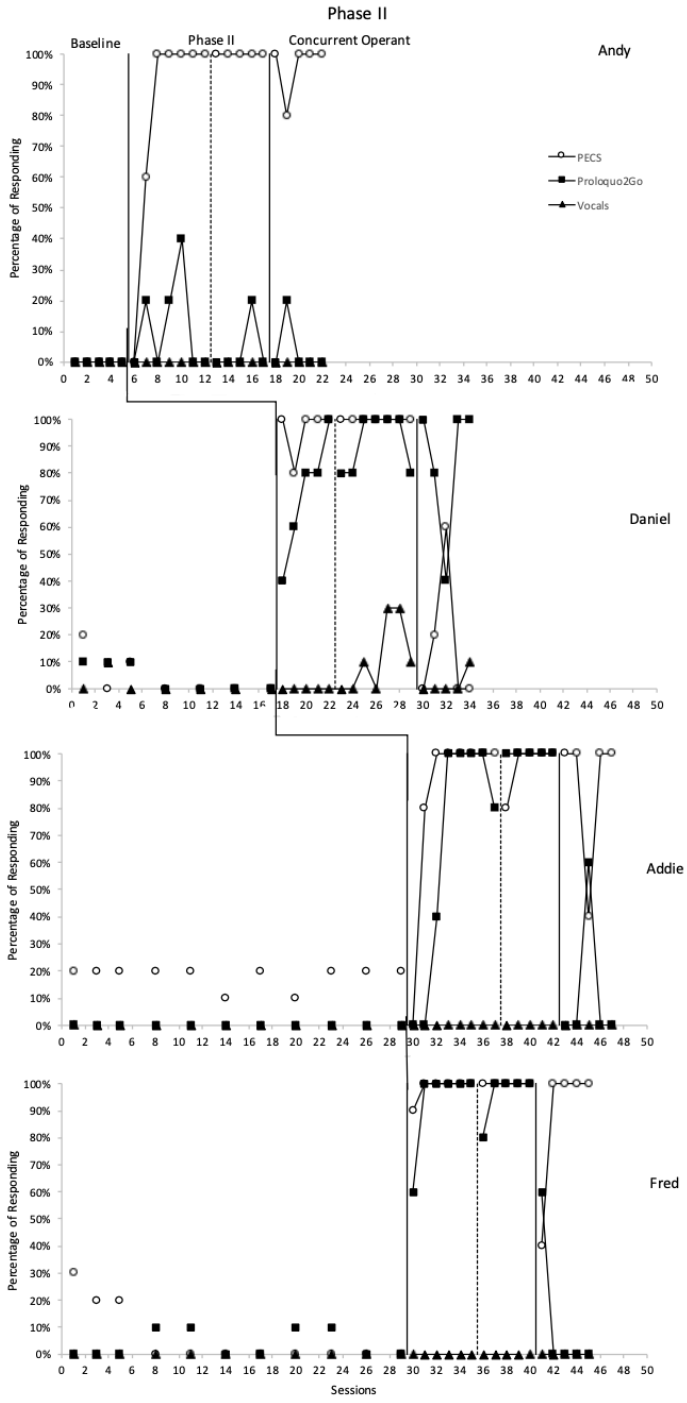


Figure 9

Phase II Acquisition of PECS and Proloquo2Go

Vocals = Independent vocalizations.

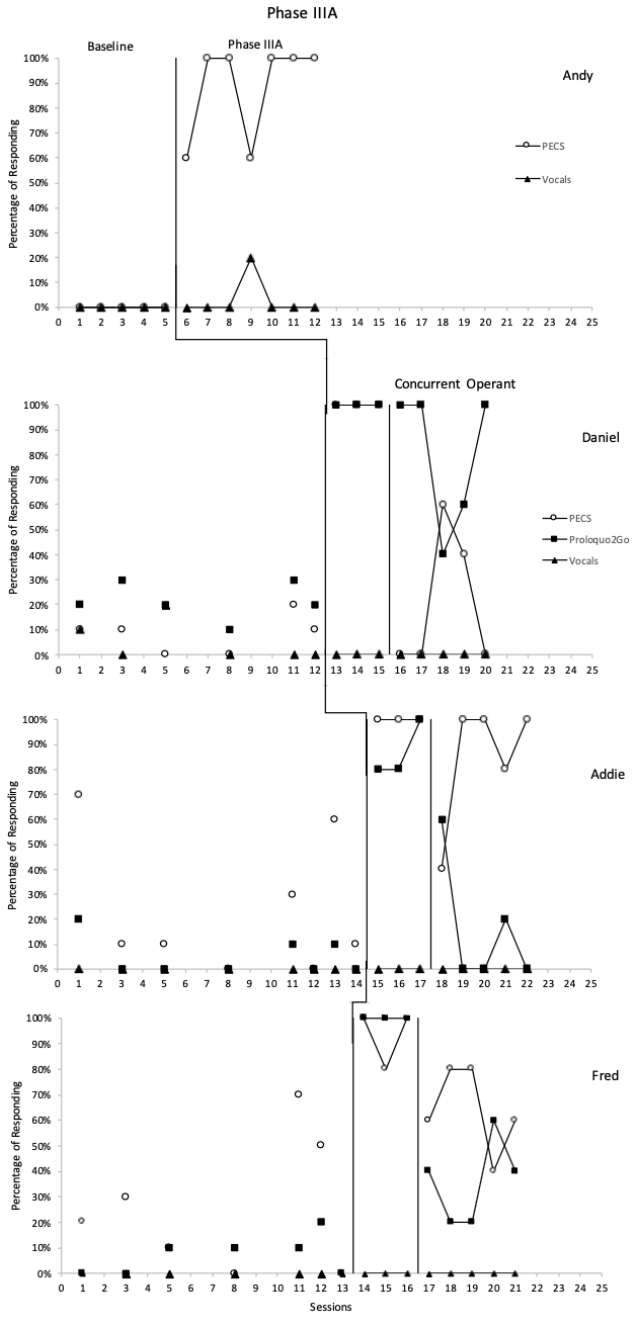


Figure 10

Phase IIIA Acquisition of PECS and Proloquo2Go

Vocals = Independent vocalizations.

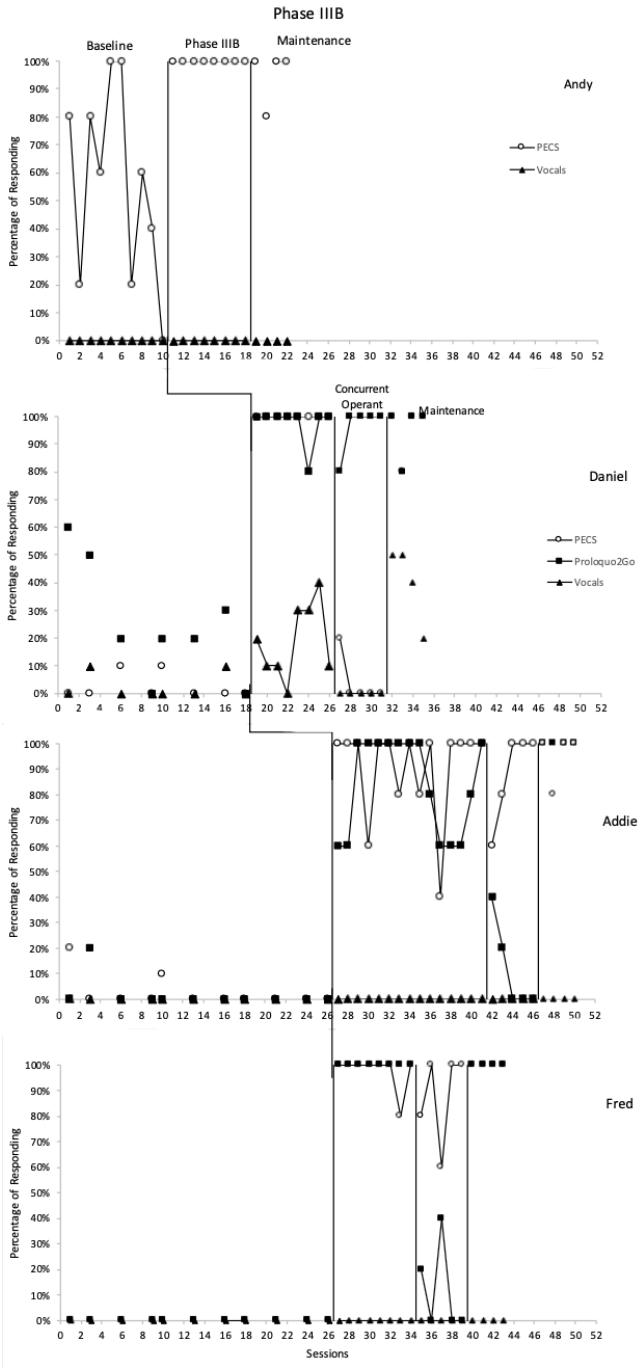


Figure 11

Phase IIIB Acquisition of PECS and Proloquo2Go

Vocals = Independent vocalizations.

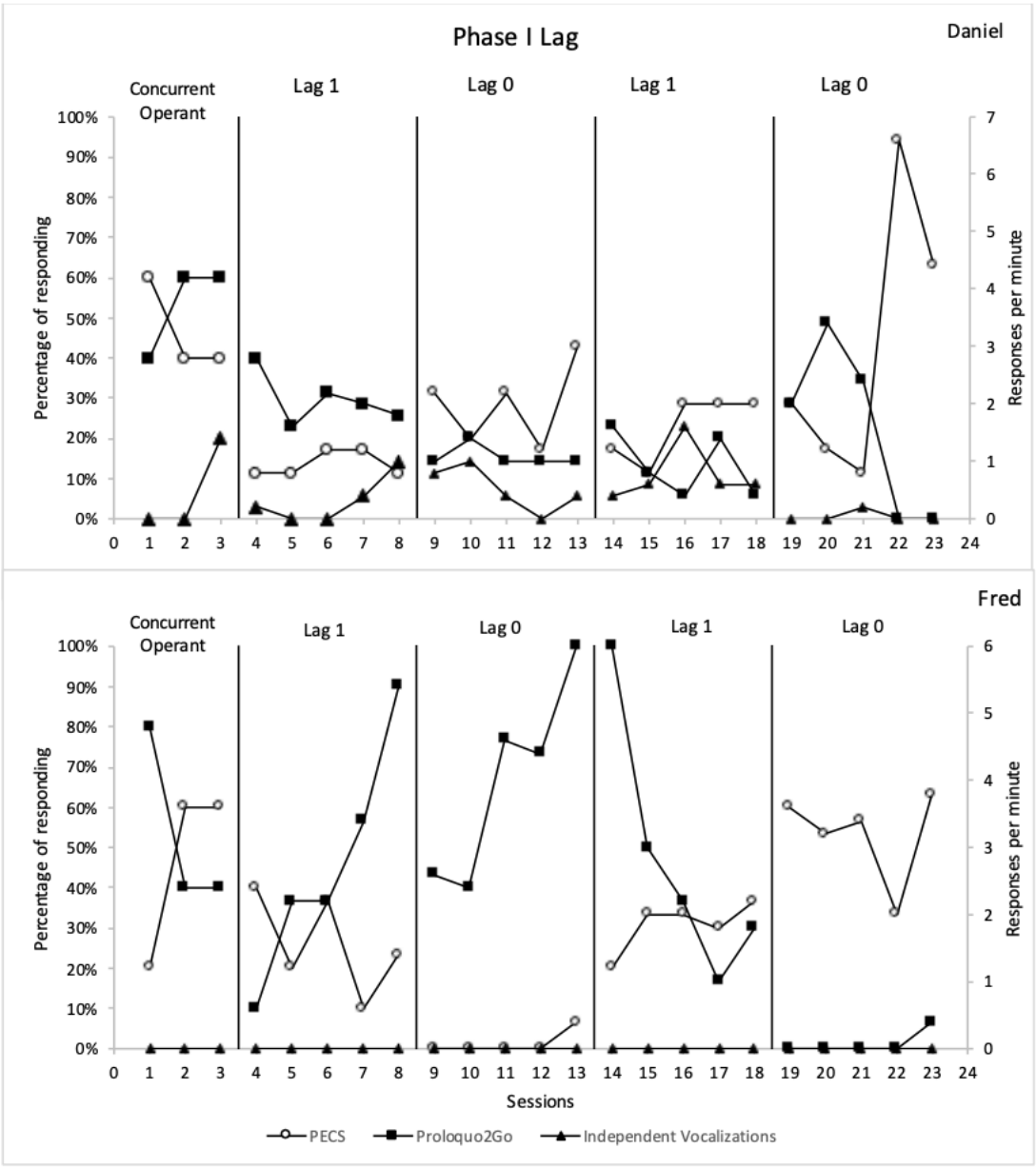


Figure 12

Phase I Lag Results

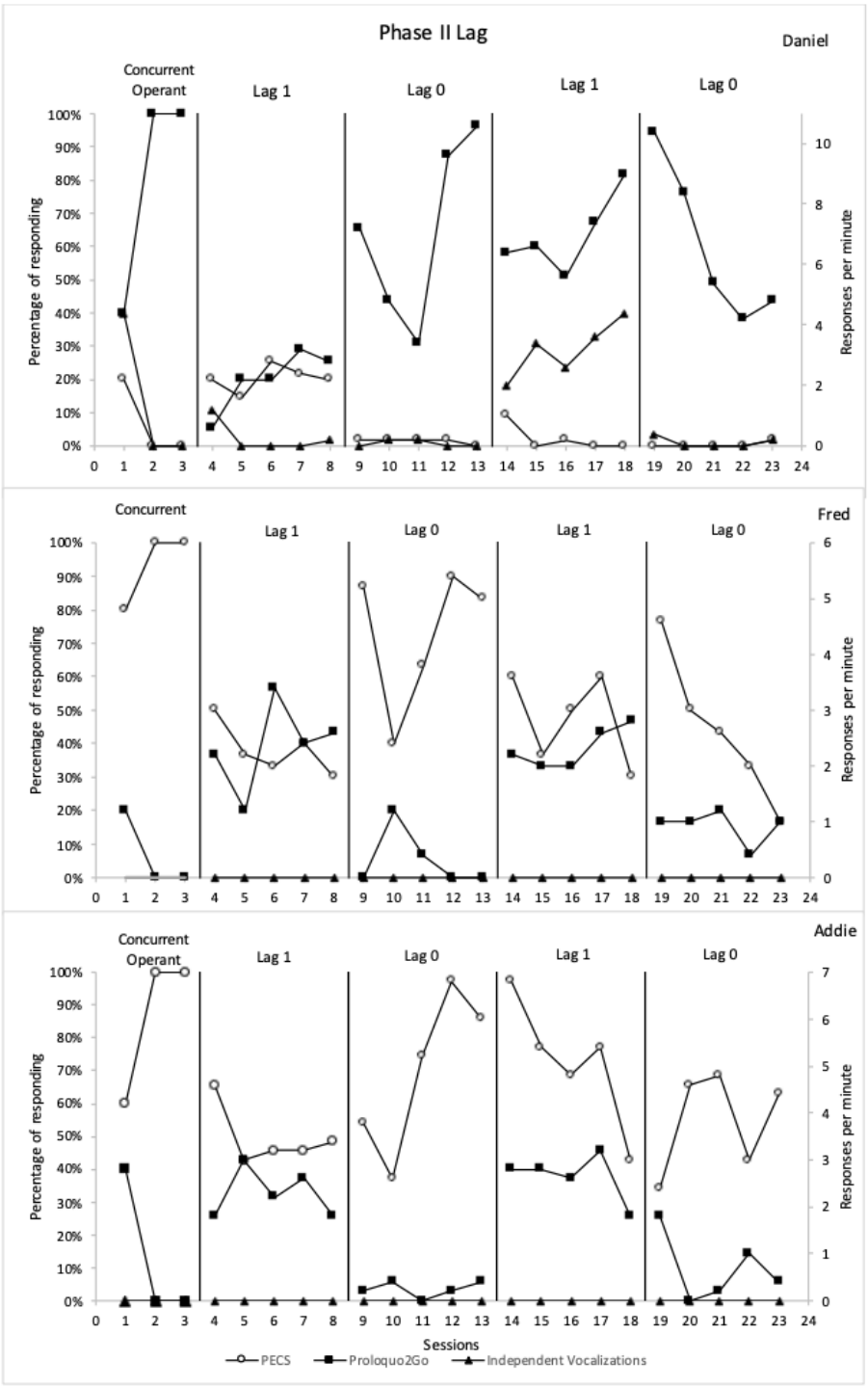


Figure 13

Phase II Lag Results

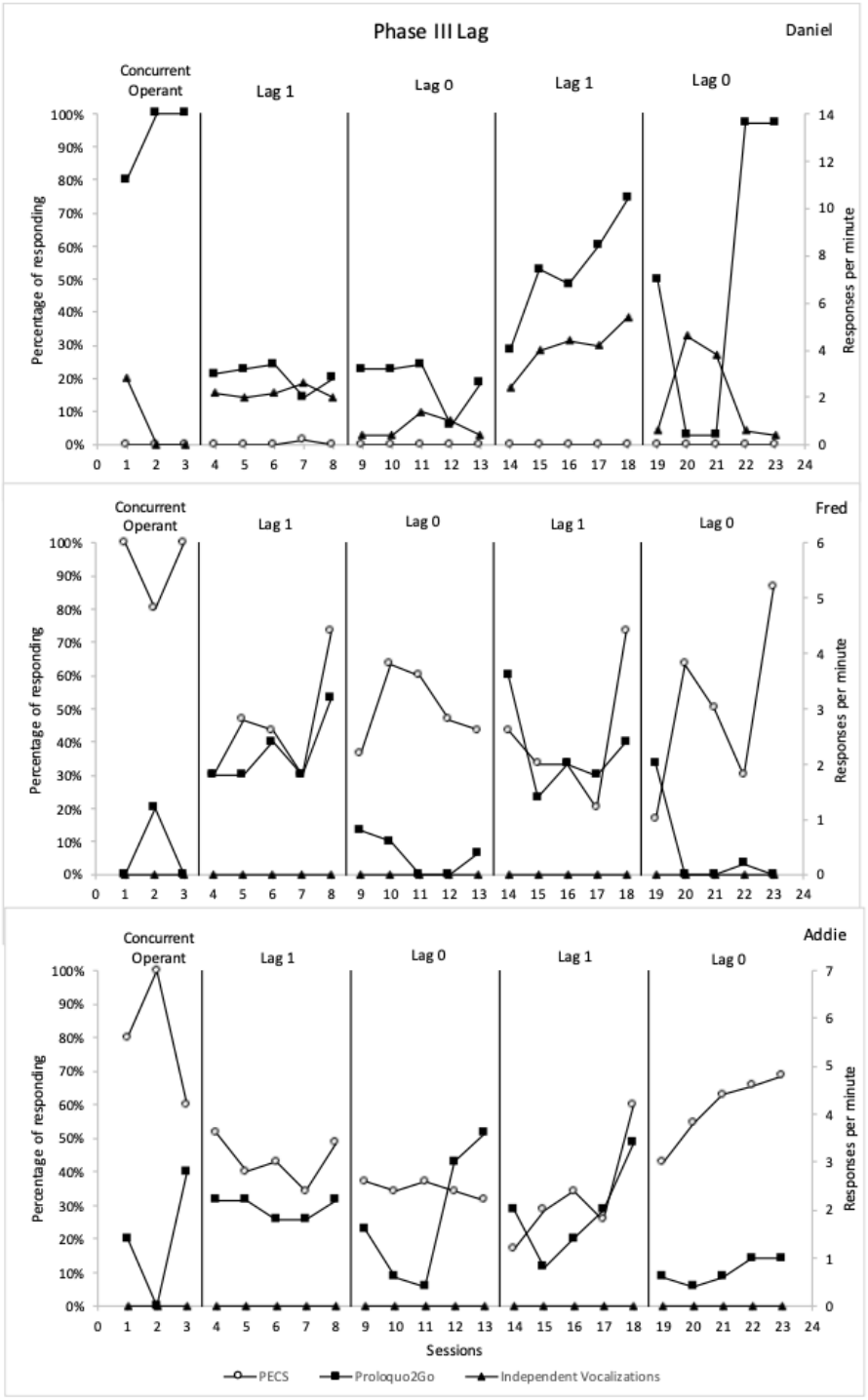


Figure 14

Phase III Lag Results

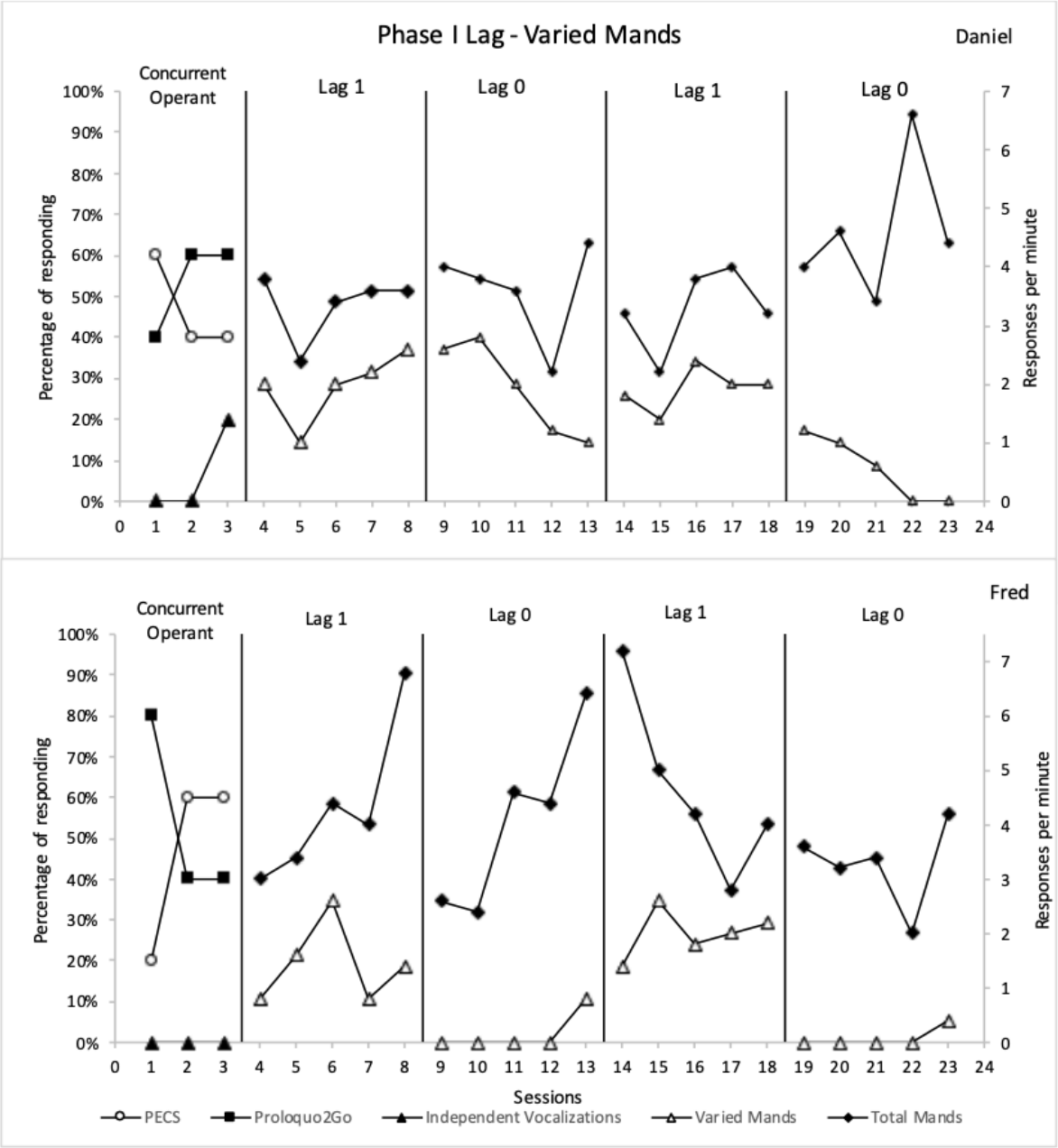


Figure 15

Phase I Lag Results with Varied and Total Mands

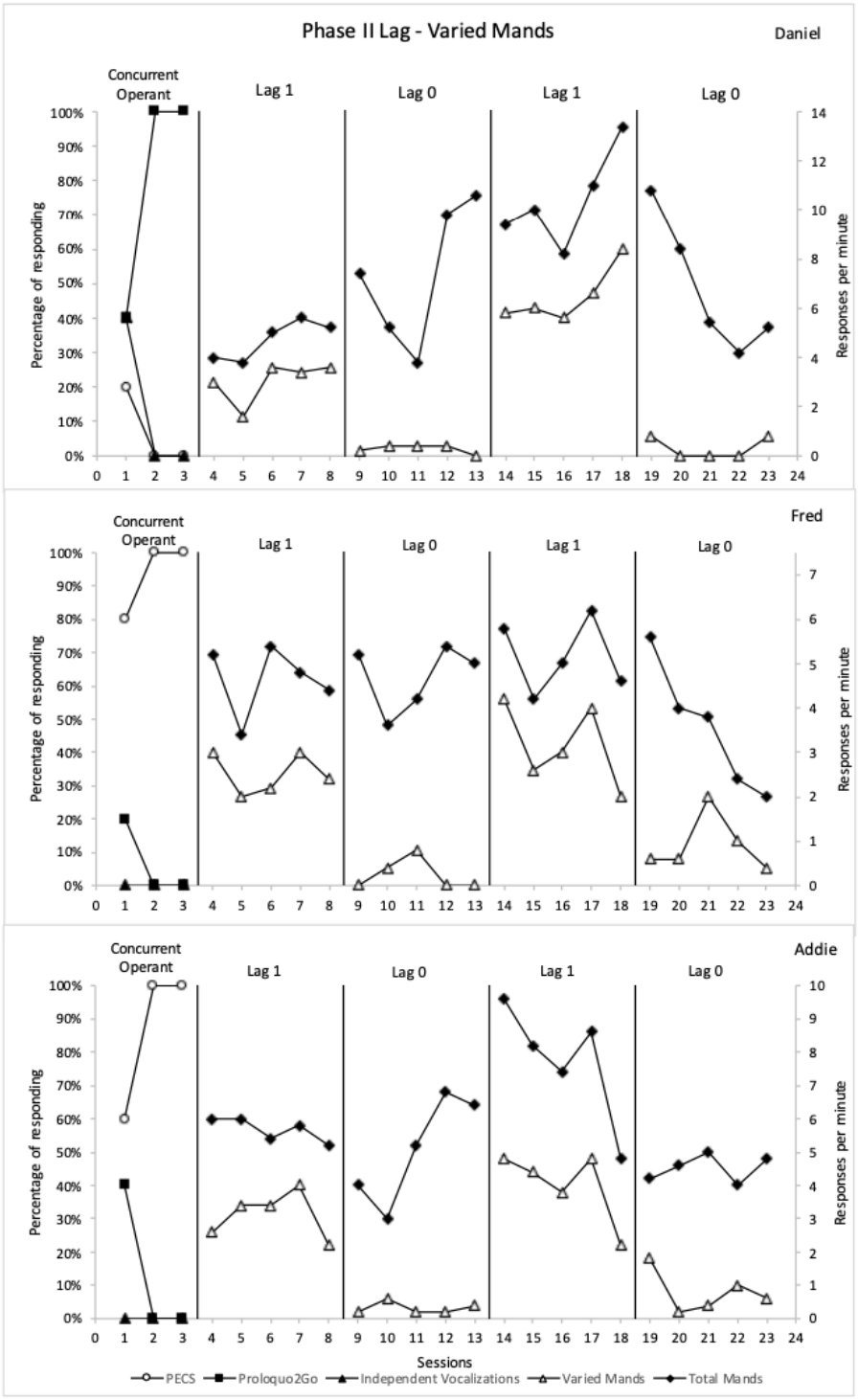


Figure 16

Phase II Lag Results with Varied and Total Mands

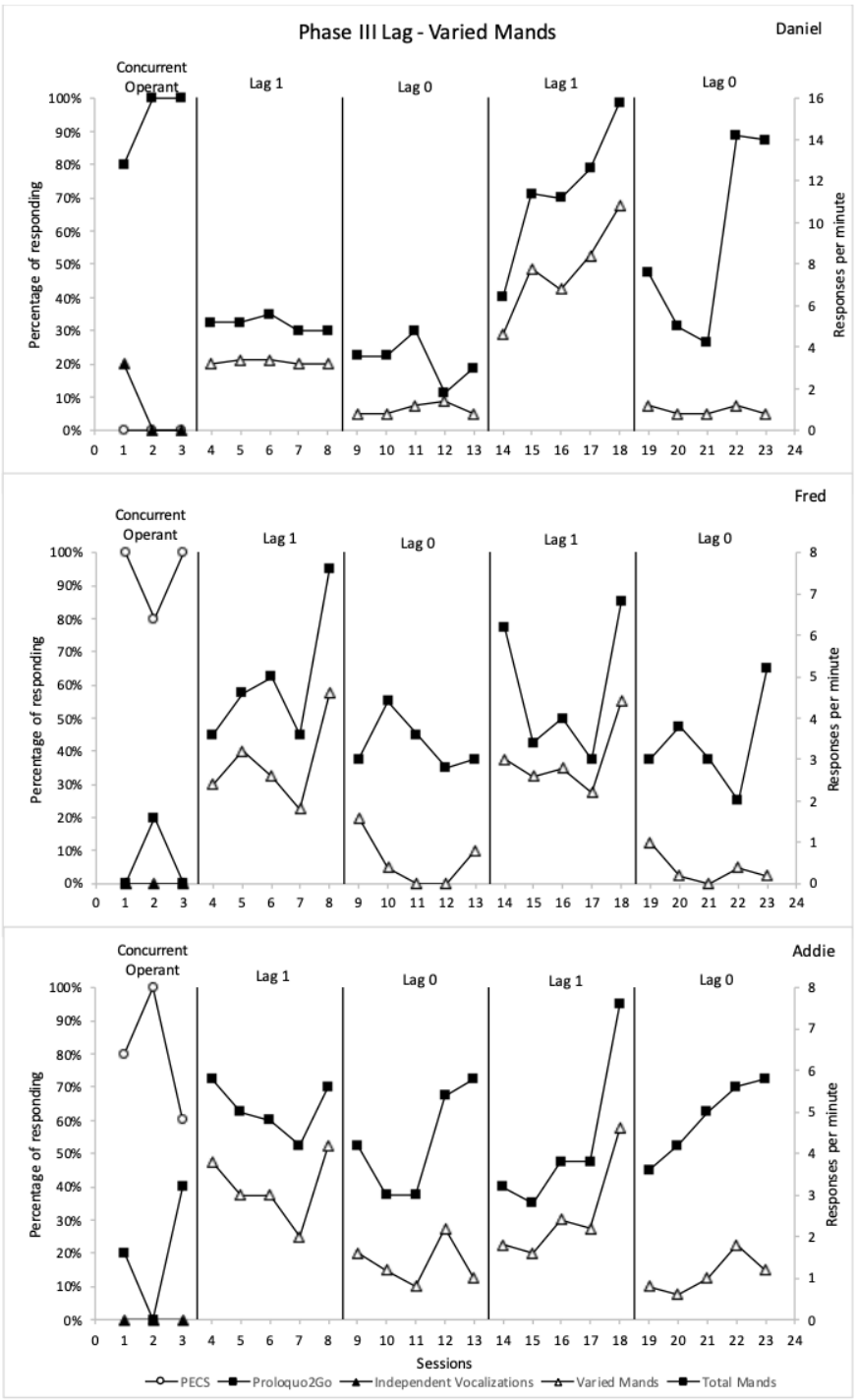


Figure 17

Phase III Lag Results with Varied and Total Mands

CHAPTER 5

DISCUSSION

Experiment 1 evaluated acquisition and preference of PECS and Proloquo2Go and addressed research questions 1, 3, 4, and 5, evaluating rate of acquisition, modality preference, and maintenance. Experiment 2 evaluated the effects of a contrived treatment challenge, or communication breakdown, using a Lag 1 schedule of reinforcement on response persistence for multiple modalities.

Three of the four participants with ASD and SI acquired two commonly used AAC modalities (i.e., PECS and SGD) during simultaneous training, maintained each modality at comparable levels to intervention, and interchanged modalities when faced with a contrived communication breakdown. One participant, Andy, only mastered PECS, and Daniel, Addie, and Fred mastered PECS and SGD. Both AAC modalities provided Daniel, Addie, and Fred with a functional multi-modal communication repertoire and when exposed to a temporary extinction, participants maintained both modalities. The brief exposure to extinction led to variations in the modality used to mand. Weekly maintenance probes, collected for four weeks following intervention, demonstrated all participants maintained responding of mastered modalities. Results, limitations, and implications for future practice are further discussed as applicable for each experiment.

Experiment 1

This experiment evaluated the use of the PECS protocol to teach requesting using PECS and Proloquo2Go and found the protocol to be adequate for training these modalities

simultaneously. These findings are consistent with existent literature when teaching an SGD using the PECS protocol (e.g., King et al., 2014) and other similar behavioral principles (e.g., prompting, shaping) used in the PECS protocol (e.g., Alzrayer et al., 2019; Lorah & Parnell, 2017). Currently there is not an identified evidence-based singular approach to teach SGD, but with few modifications the PECS protocol did increase SGD use for three of the four participants. Specific modifications to the PECS protocol in this study included adding additional steps in Phase I to teach the three-step sequence required to identify a target picture on the device and removing the requirement to travel to the communication partner in Phase II.

Researchers found similar rates of acquisition for PECS and Proloquo2Go for three of the four participants. During Phase I of training, Andy did not independently respond after 40 trials (eight sessions). He completed an additional 60 trials in Phase II and independent responding did not exceed 40%. Daniel showed similar rates of responding across all phases in training, but in Phases I and II, there was more of an immediate response with PECS, and in Phase II he mastered PECS in two less sessions than Proloquo2Go. Addie mastered PECS faster in Phases I and II and demonstrated similar responding in Phases IIIA and IIIB. Acquisition during Phase IIIB was variable for both modalities, but PECS had a faster response and greater stability at the end of training than Proloquo2Go. In Phase I, Fred acquired twice as many sessions to master Proloquo2Go, but in all subsequent phases, he showed similar rates of responding for both AAC modalities. These findings support the rationale for training multiple modalities simultaneously. The data denotes that there were not large differences in the number of sessions it took for participants to reach mastery for either modality. When comparing acquisition data from Andy, who acquired PECS, to Daniel, Addie, and Fred, who acquired PECS and Proloquo2Go, the data also suggest the acquisition phase of two modalities may be similar to acquiring one modality.

Even with longer acquisition periods in Phase I for Addie and Fred, the rate of acquisition for both modalities became similar in subsequent phases. The SGD acquisition may be slightly slower in the initial phases but then can match the rate of picture exchange.

To assess preference of modality, the primary researcher conducted a concurrent operant after the end of each acquisition phase. In Phase I, the concurrent operant reflected the level of mastery for Andy and Addie as PECS was the only mastered modality at that time and the only modality selected during the concurrent operant. Preferences differed across participants with no single modality being more preferred and preferences became apparent at the end of Phase I for each participant. As determined by multiple concurrent operant conditions, Daniel preferred Proloquo2Go, Addie preferred PECS, and Fred preferred and chose to use both PECS and Proloquo2Go across phases. Critically, even with clear preferences, participants still selected both modalities in at least one session in each phase with no singular usage in the concurrent operant for all sessions. The rate of acquisition did not seem to influence preference of modality for participants. For example, in Phase I Fred mastered PECS in half the number of sessions as Proloquo2Go yet chose to communicate with Proloquo2Go more often in all five sessions of the concurrent operant.

Most previous studies have lacked maintenance data when more than one modality was initially trained. This study demonstrated multiple modalities maintained at near intervention levels for participants that acquired more than one modality five weeks post intervention. The goal of AAC and the reasoning behind this study was to provide individuals with an adaptable functional communication repertoire that would increase access and participation in life and provide the users options in communication breakdowns. Adding the maintenance measure to this study confirmed that multiple modalities could be simultaneously acquired and maintained at

mastery levels. With several communicative options, individuals have a broader flexibility towards communication and can transfer between modalities if needed. Longer range maintenance data might reveal interesting patterns around the lasting effects of each modality, especially if the participant goes for a period of time without using one modality.

Limitations

In Experiment 1, to determine if a functional relation existed between using the PECS protocol to simultaneously teach two AAC modalities, researchers used a multiple probe across participants design across three phases of the PECS protocol. Limitations with the use of the multiple probe across participants design included an extended amount of time in baseline and participants were reliant on the rate of acquisition of others during intervention before proceeding to the next phase. This could have impacted internal validity marginally if participants ceased responding or serendipitously acquired the response, but they did not. The greater concern is one related to social validity of constructing a study focused on communication training for young children and delaying onset of that training because of lengthy baselines.

Baseline procedures allowed participants to either use an AAC modality, vocalize, or grab the item from the tray. This became a limitation after Phase I when the initial communicative response had been taught. In subsequent phases, participants should have been required to at least exchange the PECS picture or use Proloquo2Go to request. In Andy's baseline during acquisition Phase IIIB, his data became variable when he would alternate responding between using AAC or grabbing the item from the tray. The lower data points on his baseline indicated sessions where he was grabbing the item and the higher data points reflect the sessions he exchanged a PECS picture and correctly corresponded the picture to the item

selected. The procedural limitations created data variability that could only be stabilized by introducing intervention as demonstrated in Figure 11.

During acquisition phases, researchers counted vocalizations as a single variable and only counted if it occurred independently before the communication partner named the item. Imitative occurrences were not scored and therefore the study did not assess if echoics increased. Future studies evaluating the impact of AAC on vocalizations may choose to parse these variables out to gather additional information if vocalizations change and at what capacity (e.g., spontaneous or imitative vocalizations). Furthermore, the study did not progress past requesting as is not uncommon in the literature despite that progression to Phases IV-VI might reveal other differences in responding. This is supported by the PECS manual through incorporating a delay to reinforcement at the end of training in Phase IV to encourage vocalizations (Frost & Bondy, 2022). Other communicative variables addressed in Phases IV and VI (e.g., tacting, commenting) need to be evaluated within the context of multimodal communication.

A large component of AAC introduction and successful AAC use relies on practitioners to consider individual preferences and effectively teach individuals to use that modality, rather than the preference of the practitioner for specific modalities. In an attempt to equate comparison conditions across participants and availability of the app allowing for immediate intervention, the primary researcher selected a singular SGD (i.e., Proloquo2Go) to teach without first trialing multiple SGDs, or considering device feature-matching idiosyncrasies across participants. Daniel and Fred mastered three-step sequences on Proloquo2Go to find icons from the start of Phase I. Andy and Addie did not master the three-step sequence and required a simplified display that contained one page with one icon, and this created a limitation as the device became different across participants. Also, while the simplification of the grid-display was effective for Addie and

she mastered the simplified version of Proloquo2Go, additional teaching steps became necessary to teach sequences as more icons and vocabulary were added. Lastly, Andy did not master Proloquo2Go within the scope of this study, but a different SGD may better consider his needs and future studies should further assess device appropriateness around type and number of symbols, iconicity, display set up, and organizational structure.

History threats were apparent during the course of the study but ethically could not be eradicated; nevertheless, stable baseline data suggests outside factors did not impact experimental variables. Because the study took place in a public school, researchers had obligations to restrict study sessions around the rest of the student's schedule. Teachers and staff in the classroom emphasized communication throughout the day and utilized resources such as picture choices which had similar behavioral responding as exchanging a PECS picture. Participants also participated in 1:1 speech sessions with the school SLP which largely focused on requesting items using different AAC modalities including picture exchange and SGD. However, if these factors influenced responding, data would likely have increased during baseline.

Another history threat occurred during Phase II when Daniel received access through insurance to an SGD device that used the LAMP Words for Life ® program. He used this SGD throughout the day in the classroom and became fluent with LAMP and Proloquo2Go. While a history threat for Daniel, this is also a limitation for Fred and Addie who did not also have access to a device during or after the study. Once they mastered Phase I, Fred and Addie had a PECS communication book they used in the classroom that remained at the current phase they were learning through this study. The modalities available to each participant could have influenced

responding during the maintenance phase because of the modality being most frequently used post intervention; however, data reflected comparable levels to intervention for each modality.

Generalization data were not collected. Sessions occurred in the participants' classroom at a table or in the front of the room and did not extend into more of their natural classroom schedule. Once each participant mastered a phase, the classroom teacher mimicked instructional sessions for that phase in other settings (e.g., classroom, the school, and with other teachers) but those data were not included in this study. Also, in relation to external validity, four participants limit generality of results and therefore when replicating, future researchers should consider participant characteristics, AAC modality, and training environment as each will extend the findings to a greater population of individuals if successful.

Implications for Practice

When introducing AAC to young children without typical speech, practitioners should consider personal strengths, preference, and specific training of each modality as explicit training reduces AAC abandonment (ASHA, 2022). For two of the participants, the use of Proloquo2Go as an SGD was found to be effective with a grid-display of 4x8 and multi-step sequences required to select icons (e.g., food>snack>popcorn). The other two participants did require simplification of the grid-display and a decrease in the sequencing steps and only one participant was successful. As further outlined in The Participation Model (Beukelman & Mirenda, 2013), practitioners need to make several considerations when selecting AAC. As relevant to SGDs, practitioners should evaluate several different types of SGD (e.g., scene display, grid-display) and other skills related to usage (e.g., scanning, discrimination, pointing) to identify the best fit for an individual prior to teaching. Although each participant's VB-MAPP scores showed limited abilities in scanning and discrimination, Daniel and Fred mastered the three-step sequence on the

4x8 grid-display during Phase I. If a larger grid-display type is chosen, practitioners should consider teaching the full sequence on the device when beginning with an SGD and then simplifying if needed.

As demonstrated by the literature, PECS and SGD are the two most used modalities for young children with ASD (Ganz, 2015); however, practitioners should not immediately assume one or either of these modalities will be effective for all individuals but should remain dedicated to finding the modality that is the best fit for the individual by trialing and introducing multiple. Both AACs had advantages and disadvantages and practitioners should consider these relative to users before introducing. Overall, participants contacted reinforcement with the PECS exchange faster, better establishing the communicative response; whereas when prompted to request with Proloquo2Go in initial sessions, participants received a delay to reinforcement when on many trials the participant selected the icon repetitively and ignored the communication partner. These observations provide support for increasing the discrete teaching of an SGD and focusing on emphasizing the social interaction component of communication that PECS has embedded within its system. Additionally, in the beginning phases, the purpose of PECS is to teach a singular response (e.g., exchange the picture), but the SGD required a chain of responses (e.g., scan, discriminate, point) so practitioners should consider the physical responding needed to complete a communicative response.

One weakness of PECS involved the use of a single item to request in the early phases. This required the communication partner to infer the establishing operation of the participant. To combat this, prior to each session the primary researcher provided two to three items for the participants to choose from; however, in some Proloquo2Go trials, the participant would select different items for different trials because those differing icons were available, something not

possible in the beginning phases of PECS when concentration is around asking for one item at a time (prior to discrimination and correspondent training). During training sessions, the communication partner should have multiple preferred options readily available to follow the child's establishing operation (EO). Differing from PECS, the larger vocabulary immediately available to users with Proloquo2Go might serve as an advantage thus relying less on the communication partner to identify changing EOs. Other advantages of Proloquo2Go practitioners should contemplate include the voice output component and the app is easy to modify or simply as needed for the individual user.

A challenge related to using Proloquo2Go follows from participant history of using iPads for entertainment rather than communication. The primary researcher enabled an iOS feature to prevent participants from leaving the app, but this may have contributed to frustration for participants as they tried to navigate away from Proloquo2Go and access entertainment options. After the participant's attempts to leave the app contacted extinction and communicative responding came under stimulus control of this specific iPad, participant frustrations decreased. Practitioners should be aware of this though if choosing to use an iPad as an SGD and be able to dedicate the device for communication only. Additionally, practitioners should allow the participant time to explore the device prior to explicit communication training or trials, as all participants spent initial sessions pressing decontextualized icons repetitively.

Future studies and practitioners implementing AAC should consider the benefits of training multiple modalities simultaneously. Following The Participation Model (Beukelman & Mirenda, 2013) and recommendations from Pyramid Educational Consultants and Horton (2021), multiple modalities should be evaluated and assessed for best fit prior to training as well as continuing progress monitoring to ensure the modality remains a best fit for the individual.

AAC teams need to ensure the AAC supports provided do not restrict an individual's ability to communicate but can expand as the individual needs. Initial AAC training should incorporate plans for generalization across environments and consider communication partner and communities to ensure the individual has access to communication in all aspects of their life. Furthermore, in the event one modality becomes unavailable, each modality should be integrated into the individual's repertoire periodically to maintain each response and sustain flexibility around communication. The study included participants from diverse ethnicities expanding the research to underrepresented groups and demonstrated success with AAC training for two modalities. Practitioners serving individuals with diverse backgrounds should continue advocating for AAC resources within the community and schools as needed and should consider the additional benefits of multimodal AAC communication if resources are not consistently available.

Experiment 2

In Experiment 2, researchers embedded a contrived communication breakdown using a Lag 1 schedule of reinforcement to examine the effects of response persistence and variability when multiple AAC modalities were taught. To examine how participant responses varied across AAC modalities, data were graphed to reflect responding per modality of communication and as varied and total responding. In this experiment, researchers included a concurrent operant condition prior to the initial Lag 1 condition to assess preference of modality. For all three participants, the modality selected at a higher level was the modality used at a higher rate during Lag 1 and Lag 0 conditions. The data also showed that some participants may change preference of modality or selection of modality across training. By Phase III Lag for Daniel, he shifted responding to include Proloquo2Go and vocalizations and no longer used PECS as a response.

Extending previous findings that the localized extinction found in lag schedules produced response variation (Adami et al., 2017; Falcomata et al., 2018), the results demonstrated participants produced higher variation of responding during Lag 1 conditions in comparison to no extinction during the Lag 0 conditions where participants mostly relied on a singular modality to request. In Lag 1 sessions, the primary researcher observed that participants often immediately selected the last previously reinforced modality. Once the participant contacted a brief extinction of that modality, the participant then alternated to the other modality. However, in some instances, as can be seen in sharp increases in the total mands data path during Lag 1 conditions (refer to Fig. 12-14), participant responding experienced a short extinction burst where they continued selecting a modality repeatedly without contacting reinforcement. The most attempts at one modality to complete the request occurred with Fred who selected Proloquo2Go 11 times before alternating responding (refer to the bottom panel of Fig. 12, session 14).

Adami et al. (2017) and Falcomata et al. (2018) embedded lag schedules of reinforcement during FCT to encourage varied responding across trained mands and to decrease challenging behavior. In this study, challenging behavior was not a variable of interest, but anecdotally, findings are comparable with each participant increasing varied responding across multiple communicative responses. Similar to Falcomata et al., following training and reinforcement of multiple mands, participants often used another mand topography before engaging in challenging behavior. This should influence communication research because the training of secondary responses reduces occurrence of challenging behavior when an individual encounters a communication breakdown.

Findings from the current study extend the literature on response persistence and variability in the context of extinction, variable reinforcement, and lag schedules with multiple

modalities of communication. As demonstrated in the Lag 1 conditions, communicative requesting persisted and varied even when contacting extinction. By strengthening the communicative repertoire and encouraging multimodal communication, responding is more likely to be resistant to temporary extinctions when using AAC and can vary responding to recover during a communication breakdown.

The purpose of the Lag 1 schedule of reinforcement was to mimic a communication breakdown that may occur when an individual uses AAC and a communication partner fails to respond in a reinforcing manner. In this instance, during the Lag 1 conditions the participant responded with an AAC modality to complete a request, the item requested was not delivered, and the participant had to alternate responding to another modality. These findings preliminarily suggest that introducing a contrived communication breakdown into training can help increase response persistence and response variability for individuals with multimodal communication repertoires. Further studies should evaluate and include different components of communication breakdowns and integrate each into initial AAC training.

Limitations

In Experiment 2, limitations arose around number of sessions conducted too closely together as motivating operations often decreased after the initial session. To combat this, the primary researcher offered multiple options to request, although for individuals with limited preferences, this could impact the rate of responding and the stability of the data. Additionally, during acquisition sessions in Experiment 1, the primary researcher alternated presenting each modality which could have influenced participant's responding during Experiment 2 conditions. The data do not suggest this happened within this study; however, participants were previously exposed to alternating modalities and using each modality to request a single item.

Initially, researchers inquired about the individual response effort of each modality and how that would impact acquisition, preference, as well as persistence. However, this study did not include the appropriate variables (e.g., distance, force, number of behaviors) or utilize equipment to gather these data that would have appropriately reflect differences in response effort (Wilder et al., 2020). Additionally, idiosyncratic characteristics could involve strengths and weaknesses around isolating and pointing with one finger, discriminating a large array of icons on a grid display, or picking up and manipulating PECS pictures.

Implications for Practice

As demonstrated by this study, the implementation of lag schedules of reinforcement was an effective means of encouraging multimodal communication and further supported that brief extinction of one modality increased response persistence and variability. Additional studies should evaluate lag schedules of reinforcement when teaching multiple AAC modalities to increase the external validity and provide evidence either supporting or refuting these claims. Researchers may also evaluate different parameters of reinforcement such as magnitude or quality to assess the impact on response variability and persistence. As indicated within this study, preference did seem to influence the modality most used in the Lag 1 and Lag 0 schedules and evaluating the effects of altering parameters is warranted. Finally, Experiment 2 demonstrated the benefits of integrating contrived communication breakdowns within initial AAC training. After an AAC response has been acquired, practitioners should embed possible communication breakdowns that could occur and discretely teach individuals strategies to identify and repair such breakdowns.

The study implemented a Lag 1 schedule of reinforcement in a contrived setting for 5 min per session. In practice, implementation of lag schedules should occur more naturally within

a treatment session with practitioners ensuring the individual ends with accessing reinforcement of any appropriate mand (e.g., AAC, vocalization). For example, if the practitioner provides an opportunity to mand or a spontaneous mand from the individual occurs, the practitioner can choose to implement either a Lag 0 or Lag 1 schedule of reinforcement. On the Lag 0 schedule, whichever mand used would access reinforcement. For the next mand that occurred, the practitioner could implement a Lag 1 schedule of reinforcement and the individual would only access reinforcement if a varied mand occurred. Again, prior to ending a session, the individual should remain in a Lag 0 schedule of reinforcement to not leave any appropriate communication on extinction as the goal is only a brief extinction to encourage varied manding.

In Experiments 1 and 2, we measured vocalizations as a secondary dependent variable to evaluate the potential impact of AAC on speech. Frequently parents and caregivers will raise concern that introduction of AAC may hamper development of speech (AssistiveWare, 2020; Millar et al., 2006; Seattle Children's Hospital Speech and Language Services, 2018). Several researchers and ASHA as well have refuted this concern as the literature has shown current speech will not decrease if AAC is used (Beukelman & Light, 2020; White et al., 2021). Considering each participant scored a zero for echoic skills on the VB-MAPP assessment, and did not vocally respond during the vocal screening, researchers in future studies may consider determining a priori accepted approximations of each target vocalization for data collection purposes on the chance vocalizations emerge during the study. For one participant, Daniel, vocalizations did emerge in acquisition Phase I, and increased considerably across phases and even passed and replaced the use of PECS in Lag Phase II and III in Experiment 2. Vocalizations did not emerge for Andy, Addie, or Fred, despite all participants scoring a zero on the EESA at the start of the study. If not directly evaluating the impact between AAC and vocalizations,

future studies should include vocalizations as a secondary variable when introducing AAC so assessment between this relationship can continue to be explored.

Practitioners and parents should remain aware that an individual's communication needs can change over time. Modalities should either be flexible and adaptable to meet changing needs, or an individual may need to transition to a different modality, including speech. Pyramid Educational Consultants and Horton (2021), recommend assessing at least three modalities over at least three points in time before deciding on which modality to proceed with, especially if considering a singular AAC approach. Following the decision-making process of The Participation Model (Beukelman & Light, 2020), trial periods and ongoing progress monitoring of the success of the AAC are crucial in determining effective modalities.

Transitions within AAC should be individual-led and should not decrease an individual's communication repertoire. If switching from PECS to an SGD or vice versa, each modality should contain the same level and complexity of vocabulary and allow further communicative growth and expansion (Frost & McGowan, 2012). Additional criteria to consider is independence, efficiency, intelligibility, and individual preference (Frost & McGowan, 2012). Similar to initial AAC introduction, any change in modality should involve an adequate training period for the individual and relevant communication partners (e.g., caregivers, educators) and the previously used modality continue to be available until the individual is as successful with the new AAC. If removing an AAC modality would decrease an individual's communication level, practitioners should explore additional supports (e.g., multimodal communication, that would maintain the highest communicative ability for the individual.

In conclusion, the current study demonstrated the effects of training two AAC modalities to preschoolers with ASD as related to acquisition, preference, and vocalizations, as well as

embedded a contrived communication breakdown using a lag schedule of reinforcement to increase response persistence and variability. For individuals with ASD and SI, multimodal communication encompasses the goal of expanding communicative repertoires to provide them with the greatest opportunity to participate in life. By initially training multiple AAC modalities at the preschool age, individuals receive a more robust functional communication system earlier, decreasing the likelihood of challenging behavior and difficulties in skill acquisition, and increasing participation in life and social interactions with peers.

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**Also included in Schlosser and Wendt (2008) review (Chapter 2)

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Appendix A: Phase I Acquisition Baseline Data Sheet

Date: Data Collector: Primary/IOA
Session #

Trials	Modality	Grab/ Reach +/-	Pick Up +/-	Reach +/-	Release +/-	Icon selected +/-	Vocal full/approx.	PBX +/-	Item
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Any session notes:

Appendix B: Phase I Acquisition Intervention Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

*The primary researcher will alternate presenting each modality for 5 total PECS trials and 5 total Proloquo2Go trials for a total of 10 trials.

PECS Responses

Trials	Pick-Up	Reach	Release	Vocalization FW or WA	Challenging Behavior	Item selected
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			

Proloquo2Go Responses

Trials	Page 1	Page 2	Icon	Vocalization FW or WA	Challenging Behavior	Item selected
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			
	FP PP +	FP PP +	FP PP +			

Appendix C: Phase II Acquisition Baseline Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

Communication partner = 5 feet away

Trials	Modality Selected	Pick Up +/-	Reach +/-	Travel to CP +/-	Release +/-	Icon Selected	Vocal full/approx.	PBX +/-	Item	Grab/ reach +/-
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Any session notes:

Appendix D: Phase II Acquisition Intervention Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

*The primary researcher will alternate presenting each modality for 5 total PECS trials and 5 total Proloquo2Go trials for a total of 10 trials.
*After 3 independent responses with traveling, PR will move back 1 ft at a time up to 5 ft.
*The participant is not required to travel to the PR when using Proloquo2Go.

PECS Responses

Trials	Distance to book	Traveled	Pick-Up	Reach	Distance to PR	Traveled	Release	Vocalization FW or WA	Challenging Behavior	Item selected
		+ -	FP PP +	FP PP +		+ -	FP PP +			
		+ -	FP PP +	FP PP +		+ -	FP PP +			
		+ -	FP PP +	FP PP +		+ -	FP PP +			
		+ -	FP PP +	FP PP +		+ -	FP PP +			
		+ -	FP PP +	FP PP +		+ -	FP PP +			

Proloquo2Go Responses

Trials	Distance to device	Traveled	Page 1	Page 2	Icon	Distance to PR	Traveled	Vocalization FW or WA	Challenging Behavior	Item selected
		+ -	FP PP +	FP PP +	FP PP +		+ -			
		+ -	FP PP +	FP PP +	FP PP +		+ -			
		+ -	FP PP +	FP PP +	FP PP +		+ -			
		+ -	FP PP +	FP PP +	FP PP +		+ -			
		+ -	FP PP +	FP PP +	FP PP +		+ -			

Appendix E: Phase IIIA Acquisition Baseline Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

Preferred item: Non-preferred item:

Trials	Modality Selected	Pick Up +/-	Reach +/-	Release +/-	Icon Selected	Vocal full/approx.	PBX +/-	Grab/ reach +/-	Item
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Any session notes:

Appendix F: Phase IIIA Acquisition Intervention Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

*The primary researcher will alternate presenting each modality for 5 total PECS trials and 5 total Proloquo2Go trials for a total of 10 trials.

PECS Responses

Trials	Non-preferred Item	Preferred Item	Discrimination	Vocalization FW or WA	Challenging Behavior	Error Correction
			+ -			
			+ -			
			+ -			
			+ -			
			+ -			

Proloquo2Go Responses

Trials	Non-preferred Item	Preferred Item	Discrimination	Vocalization FW or WA	Challenging Behavior	Error Correction
			+ -			
			+ -			
			+ -			
			+ -			
			+ -			

Appendix G: Phase IIIB Acquisition Baseline Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

Items used:

Trials	Modality Selected	Pick Up +/-	Reach +/-	Release +/-	Icon Selected	Correspondence +/-	Vocal full/approx.	Grab/ reach +/-	Item
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Any session notes:

Appendix H: Phase IIIB Acquisition Intervention Data Sheet

Date: Participant: Data Collector: Primary/IOA
Session #

*The primary researcher will alternate presenting each modality for 5 total PECS trials and 5 total Proloquo2Go trials for a total of 10 trials.

PECS Responses

Trials	Array Size	Correspondence	Vocalization FW or WA	Challenging Behavior	Item selected	Items used
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				

Proloquo2Go Responses

Trials	Array Size	Correspondence	Vocalization FW or WA	Challenging Behavior	Item selected	Items used
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				
	2 3 4 5	+ -				

Appendix I: Concurrent Operant Data Sheet

Concurrent Operant Participant: Session#
Date Data Collector: Primary/IOA

Trial	Modality Selected	Item Requested	Vocalization	Problem Behavior	Prompting needed? *
1					
2					
3					
4					
5					

*includes the researcher tapping on the table

Appendix J: Maintenance Data Sheet

Date: **Participant:** **Session:**

Steps:

1. Offer two items for the participant to choose from.
2. Place one modality in front of the participant. After 5 trials, switch modality
3. Block access to the item.
4. Provide item after communicative attempt.

Trial	Modality-PECS	Vocalization	Item	PBX or Prompting
1				
2				
3				
4				
5				

Trial	Modality-Proloquo2Go	Vocalization	Item	PBX or Prompting
1				
2				
3				
4				
5				

Appendix K: Lag Schedule Data Sheet

Date: Participant: Data collector: Session #

Lag 1 or 0 Schedule Condition 1 or 2

Session Notes:

AAC Response Used (PECS, Proloquo2Go, Vocalization)	Reinforcement received (for novel response only for Lag 1)

Appendix L: Phase I Baseline Procedural Fidelity Checklist

Date: Participant: Data Collector: Researcher: Emily
Session #

Overall:	+/-/NA
Placed 2 to 3 items available to determine EO	
Allowed one bite, 30 s access	
Modalities at equal distance apart	
Corresponding item pictures available	
Did not name item	
Item restricted, silently enticed	
Item in sight, out of reach	
Did not prompt	
PBX safely ignored	
Item delivered after attempt to access	

Appendix M: Phase I Intervention Procedural Fidelity Checklist

Procedural Fidelity Phase I | Participant: Date: | Data Collector: Session#

	+ / - / NA
Placed 2 to 3 items available to determine EO	
Allowed one bite, 30 s access	
Modalities alternated, presented one at a time	
Corresponding item pictures available	
Did not name item before request	
Item restricted, silently enticed	
Item in sight, out of reach	
Pbx ignored	
Reinforces within ½ second	
No insistence on speech	

Appendix N: Phase II Baseline Procedural Fidelity Checklist

Date: Participant: Data Collector: Researcher: Emily
Session #

Overall:	+/-/NA
Placed 2 to 3 items available to determine EO	
Allowed one bite, 30 s access	
Modalities at equal distance apart	
Corresponding item pictures available	
Did not name item	
Communication Partner 5 feet away	
Item restricted, silently enticed	
Item in sight, out of reach	
Did not prompt	
PBX safely ignored	
Item delivered after attempt to access	

Appendix O: Phase II Intervention Procedural Fidelity Checklist

Date: Data Collector: Researcher:
Session #

Overall:	+/-/NA
Placed 2-3 items available to determine EO	
Allowed one bite, 30 s access for SR+	
Modalities alternated	
Corresponding item pictures available	
Did not name item before request	
Communication partner appropriate feet away	
Item restricted, silently enticed	
Item in sight but out of reach	
Communication partner does not prompt	
Pbx ignored and safely blocked	
Item delivered after communication request	

Appendix P: Phase IIIA Baseline Procedural Fidelity Checklist

Date: Participant: Data Collector: Researcher: Emily
Session #

Overall:	+/-/NA
Placed 2 to 3 items available to determine EO	
Allowed one bite, 30 s access	
Modalities at equal distance apart	
Corresponding item pictures available	
Did not name item	
Items restricted on tray, silently enticed	
Item in sight, out of reach	
Did not prompt	
PBX safely ignored	
Item delivered after attempt to access	

Appendix Q: Phase IIIA Intervention Procedural Fidelity Checklist

Date: Participant: Data Collector: Researcher:
Session #

Overall:	+/-/NA
Placed 2-3 items available to determine EO	
Allowed one bite, 30 s access for SR+	
Modalities alternated	
Corresponding item pictures available	
Did not name item before request	
Provided praise at selection of correct picture	
Followed Error Correction as needed	
Item restricted, silently enticed	
Item in sight but out of reach	
Communication partner does not prompt	
Pbx ignored and safely blocked	
Item delivered after communication request	
Ended after three Error Correction in a row	

Appendix R: Phase IIIB Baseline Procedural Fidelity Checklist

Date: Participant: Data Collector: Researcher: Emily
Session #

Overall:	+/-/NA
Placed 2 to 3 items available to determine EO	
Allowed one bite, 30 s access	
Modalities at equal distance apart	
Corresponding item pictures available	
Did not name item	
Five items available	
Items restricted on tray, silently enticed	
Items in sight, out of reach	
Did not prompt	
PBX safely ignored	
Item reached for delivered after attempt to access	

Appendix S: Phase IIIB Intervention Procedural Fidelity Checklist

Date: Data Collector: Participant:
Session #

	+ / - / NA
Allowed one bite, 30 s access for SR+	
Modalities alternated	
Corresponding item pictures available	
Did not name item before request	
Items in sight but out of reach	
Error Correction followed	
Session ended after 3 error correction	

Appendix T: Lag 1 Schedule Procedural Fidelity Checklist

Date: Participant: Data collector: Session #
Condition 1 or 2

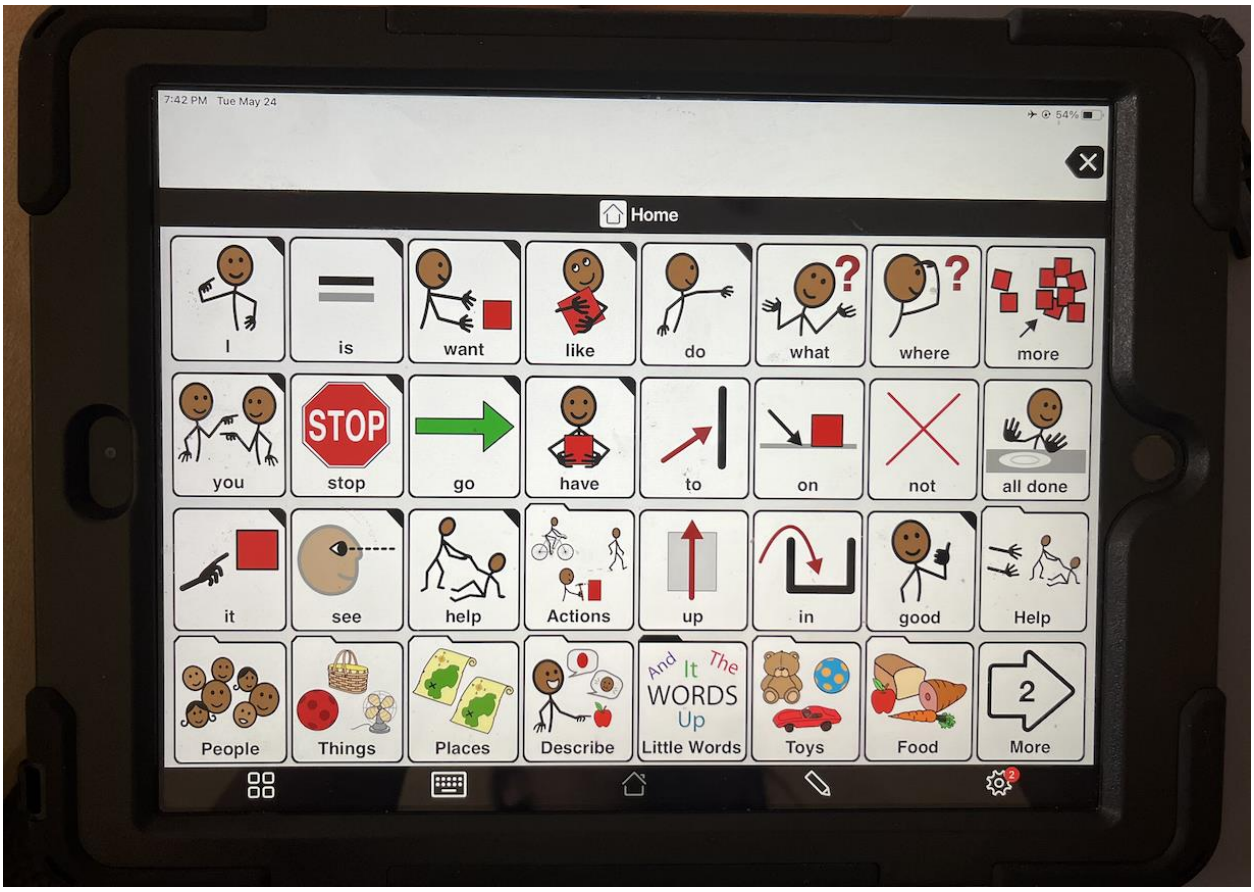
	+ / - / NA
Session conducted in novel context in pk room	
Both modalities available	
Opportunity to request prior to timer beginning	
Sessions lasted 5 min	
Participant received reinforcement on a Lag 1 schedule for any novel response from the last previous response used	
Reinforcement for 1 bite or 30 s access	
Ignored repeated responses (e.g., repeated PECS requests in a row	

Appendix U: Lag 0 Schedule Procedural Fidelity Checklist

Date: Participant: Data collector: Session #
Condition 1 or 2

	+ / - / NA
Session conducted in novel context	
Any communication modality reinforced (PECS, Proloquo2Go, vocal)	
Sessions lasted 5 min	

Appendix V: Image of Proloquo2Go Grid-Display for Daniel and Fred



Appendix W: Image of Proloquo2Go Grid-Display for Andy and Addie