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ORIGINAL ARTICLE

The Effect of Delay to Reinforcement and Response Effort on Response Variability for Individuals with Autism Spectrum Disorder

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Abstract

Augmentative and alternative communication (AAC) is a tool used by individuals unable to communicate or experience difficulty communicating vocally. Previous research has demonstrated that individuals will vary their communicative responding when reinforcement is delayed and when the response effort to communicate is increased. This study evaluated the effect of adjusting these variables to alter responding of three elementary age individuals with autism spectrum disorder who used AAC. A reversal design allowed for an evaluation of a functional relation between delay to reinforcement, response effort, and communication response allocation. When these parameters were changed, two participants shifted their responding while the third participant maintained his response allocation. This research provides further evidence that altering delay to reinforcement and response effort may aid in moving an individual from an AAC to spoken language. The researchers discuss outcomes in terms of how these variables can be manipulated in practice and the potential for altering other parameters of reinforcement in context of communication training.

Keywords Augmentative and alternative communication · Autism spectrum disorder · Response effort · Delay to reinforcement · Response variability

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About four million Americans experience difficulty with spoken language and rely on alternative forms of communication to meet their daily needs (Beukelman and Mirenda 2013). Augmentative and alternative communication (AAC) provides individuals with the support they need to communicate. Beukelman and Mirenda (2013) found that despite the evidence base for AAC, families and practitioners might hesitate to implement interventions involving AAC for individuals with a narrow vocalization repertoire out of fear that AAC will lead to a decline in or hindrance of vocalizations. However, existing research suggests that AAC may further improve vocal repertoires for individuals with complex communication needs, such as autism spectrum disorder (ASD). For example, Schlosser and Wendt (2008) reviewed nine single-case design studies that included 27 participants to determine the effect of AAC on vocalizations of children with ASD. They found no evidence suggesting that AAC inhibited speech production. In fact, according to the review, most of the nine studies showed increases in speech production following introduction of AAC. However, the researchers did not identify an empirically supported means for determining when and how to transition individuals from AAC to vocalizations.

Producing response variability represents one potential strategy that might allow for transition from AAC to vocalizations. Studies have shown that increases in delays to reinforcement and response effort can result in response variability (Cagliani et al. 2017). Thus, altering these variables associated with individuals' AAC-based manding (i.e., request for reinforcers) may increase response variability across communication modalities. Neuringer and Jensen described variability as "an operant dimension of behavior" (2013, p. 513) that would be sensitive to manipulations of reinforcement. Carr and Kologinsky (1983) evaluated communication modality response variability exhibited by six individuals with ASD. In the two-part study, they first taught the participants how to make spontaneous requests using sign language. Then, to evaluate generalization of the signs, the researchers conducted a second study that consisted of a series of conditions during which researchers manipulated reinforcement for spontaneous signing. Each participant signed frequently to request preferred items. During the first condition, researchers reinforced sign A and sign B contacted extinction. During the following condition researchers reinforced sign A and sign B contacted extinction. Finally, the third condition involved reinforcing both signs to promote spontaneity of both signs. The results showed that when researchers temporarily discontinued reinforcement for one behavior, the individual began engaging in another previously reinforced behavior. After this temporary exposure to extinction, the participants varied (i.e., switched from one sign to another spontaneously) their behavior more frequently. This study demonstrated that manipulating reinforcement parameters could produce shifts in responding within one modality (i.e. signs) of communication.

Researchers have conducted additional work to evaluate this shift in responding across modalities of communication (e.g., across various forms of AAC, or from AAC to vocalizations) during broad based communication training. Several studies have further investigated the effect of response variability by demonstrating that altering parameters of reinforcement, specifically delay to reinforcement, may result in individuals shifting their responding from AAC to vocalizations (Tincani 2004; Tincani et al. 2006; Carbone et al. 2010; Gevarter et al. 2014). Delay to reinforcement is a temporary exposure to extinction; therefore, the individual engages in a behavior and the therapist waits a pre-determined amount of time before delivering the reinforcer.

Response effort is another variable that can affect the efficiency of a response and can be conceptualized as the level of energy required to obtain reinforcement. Manipulating response effort can result in the reduction of the behavior whose effort was increased, and the potential increase of an alternative behavior (Friman & Poling, 1995). Several researchers have invesitageted the effect of response effort on functional communication training (FCT) outcomes. Horner and Day (1991) found that problem behavior continued to occur at higher levels when FCT included a more effortful response (singing an entire sentence) relative to when FCT included a less effortful response (singing one word) to request for a break. Richman et al. (2001) reported similar results when comparing the response effort of two different AAC-based mands and problem behavior. Specifically, results of their study showed better outcomes with one-word sign compared to picture exchange. Buckley and Newchok (2005) spcifically investigated the various levels of response effort assoicated with picture exchange. They noted higher levels of problem behavior associated with FCT that required the individual to move locations to engage in picture exchange relative to FCT with the picture placed within arm's reach. Collectively, these studies suggested that the level of response effort required to communicate impacted response allocation either across AAC strategy (Richman et al. 2001) or across appropriate and inappropriate behavior (Buckley and Newchok 2005; Horner and Day 1991).

Cagliani et al. (2017) evaluated effects of incorporating both of the aforementioned variables, delay to reinforcement and increased response effort, on target word vocalization production during Picture Exchange Communication Systems (PECS; Bondy and Frost 1994) exchanges. All participants communicated with PECS on the Phase IIIb level. During intervention, the researcher implemented a delay to reinforcement following exchanges. The delay began at 1 s and increased by 1 s each day of intervention until the individual independently vocalized target words during the delay for at least 80% of the session's trials. The researchers also evaluated the impact of increased response effort required to communicate with PECS by moving the book away from the participant. The delay to reinforcement led to an increase in independent target word vocalizations during the delay for three of four participants, and the increase in response effort led to two of four participants altering their response allocation to solely independent target word vocalizations. While this study demonstrated the effect of delay to reinforcement on vocalizations, the authors did not evaluate the independent effects of response effort. Additionally, the authors only included participants who were communicating at Phase IIIb of PECS. While these results suggest some strategies for transitioning individuals with ASD from PECS Phase IIIb to vocalizations, individuals with ASD may be ready to transition during earlier PECS phases. An additional limitation of this study was the demonstration across lack of variability in AAC modality – all four participants al-used the same form of AAC. In order to keep up with the enhanced technology in AAC, more research is necessary to determine when and how to alter response allocation with individuals whom utilize high-tech AAC, such as speech generating devices (SGDs). While SGDs demonstrate substantial growth within AAC, loss, damage, misplacement, and availability hinder their effectiveness. Individuals may leave their SGD at home or forget to charge it, which requires them to rely on other modalities of communication. Therefore, it is imperative that SGD users can alter their responding from one modality to another given the necessary circumstances to do so. Finally, the previous study did not provide information on the participants' ability to

vocalize besides anecdotal report from teachers and clinicians. By incorporating an assessment to provide a basis for each participant's ability to vocalize under specific conditions, practitioners may be able to develop a better understanding of which individuals who utilize AAC may continue to benefit from instruction related to vocalizations. The purpose of the current study was to replicate the findings of Cagliani et al. (2017) across PECS and other AAC devices, such as SGDs. In addition, the purpose of the current study was to evaluate the effect of increased response effort only on vocalizations in the context of PECS and SGD based AAC.

Method

Participants

Three individuals between 8 and 9 years old participated in this study. We selected individuals based on their Individual Education Plan (IEP) objectives and parent priorities related to increasing functional communication. Two individuals attended a university-operated special education classroom, while the other attended a university-based behavioral clinic. Legal guardians provided informed consent for all individual participants. To qualify for the study, all participants had to demonstrate the ability to communicate with aided AAC (based on data collection) and to vocally imitate based on a score greater than 0 on the Early Echoic Skills Assessment Group 1: Simple and reduplicated syllables portion (ESSA; Esch 2007). The EESA is a component of the Behavior Milestones and Placement Program (VB-MAPP; Sundberg 2008). Teachers and caregivers reported that all participants infrequently requested items with independent word vocalizations. Specific information pertaining to the participants can be found in Tables 1 and 2.

Jamal Jamal was a 9-year old, African-American male enrolled in public school. He received special education services in a self-contained classroom overseen by certified teachers and operated by university graduate level students and faculty. Jamal's

Table 1 Participant information

Participant	Age*	Educational eligibility	Intellectual functioning	Target vocalizations	Adaptive behavior scale
Jamal	9*	ASD, MOID, SLI	40[d]	intelligible word vocalizations	<60[c]
Nelson	8*	ASD, SLI	<50[a]	word approximation vocalizations (e.g. graupay, gubbie)	<60[b]
Adam	8*	ASD, SLI	<50[a]	intelligible word vocalizations	61[b]

[a] Developmental a Profile-3rd Edition

[b] Adaptive Behavior Assessment-2nd Edition

[c] Adaptive Behavior Assessment-3rd Edition

[d] Stanford-Binet Intelligence Scales-5th Edition

*At the start of the study; ASD = autism spectrum disorder; MOID = moderate intellectual disability; SLI = speech language impairment

Table 2 Early Echoic Skills Assessment (EESA) results

	Jamal	Nelson	Adam		Jamal	Nelson	Adam
ah	1	1	0	no no	1	.5	0
wow	1	.5	0	oh	1	.5	0
bee	1	1	0	moo	1	1	0
knee	1	.5	0	up	1	.5	0
oo	1	.5	0	may	1	.5	.5
bye bye	1	.5	0	pop	1	.5	0
hop	1	1	0	too	1	1	1
mama	1	.5	0	we	1	1	.5
papa	1	1	0	boy	1	.5	0
me	1	.5	0	wa wa	1	1	0
one	1	1	0	toy	1	.5	.5
my	1	.5	0	baa	1	1	1
boo	1	.5	0				
	Jamal		Nelson		Adam		
Total Points	25		17.5		3.5		

Scores come from the Verbal Behavior Milestones and Placement Program Early Echoic Skills Assessment, Group 1: Simple and reduplicated syllables

teachers reported that he could vocally imitate whole words, but did not consistently vocally mand for preferred items. Prior to the start of the study, Jamal received a SGD through his school but threw the device and damaged it, leaving him with no appropriate form of communication. Jamal's teachers presented him with an array of picture options to allow him to make choices. The pictures were available each time he exchanged tokens from his token economy. Jamal's teachers did not implement any form of communication training prior to the start of the study. Jamal enjoyed playing with a hula-hoop, balls, and racing games on an iPad.

Nelson Nelson was an 8-year old, African-American male in the same classroom as Jamal. He communicated primarily using a SGD, but had previously learned to communicate using sign language and PECS. The school speech-language pathologist (SLP) and classroom teachers trained Nelson to use his SGD. Nelson was a student in the same classroom as Jamal. He had experience using the SGD across settings and was able to spontaneously request more than 20 items. A year prior to this study, Nelson participated in another study that manipulated delay to reinforcement and response effort with PECS (Cagliani et al. 2017). While Nelson had experience with delay to reinforcement and response effort during the previous school year with PECS, Nelson did not experience these same conditions while utilizing his SGD prior to this study. Nelson occasionally emitted vocal approximations when AAC was not available, but most frequently required prompting for vocalizations. Specifically, he vocalized for hugs, tickles, and to be pushed on the swing. Nelson enjoyed swinging, watching videos on an iPad, and playing with toy cars, and could complete self-care skills such as using the restroom and feeding himself.

Adam Adam was an 8-year old, Caucasian male who received applied behavior analysis services to address his communication deficits at a university clinic. He received approximately 1 to 2 h of behavioral services weekly for 7 months prior to the start of the study. During that time Adam mastered PECS through Phase IIIb, demonstrating the ability to exchange a picture, travel, correspond pictures, and discriminate pictures. In addition to the clinical services, Adam was enrolled in a public school where he received special education services in a self-contained special education classroom. Adam enjoyed playing with magnets, toy cars, and playing chase. Based on a review of Adam's IEP, he received a SGD through his school, but his classroom teachers and school SLP reported he required continuous prompting to navigate the device. At home Adam relied on pictures and gestures to communicate his wants and needs.

Settings and Materials

The study took place in three settings: a self-contained special education classroom (Jamal and Nelson), a therapy room at an elementary school (Nelson), and a university-based behavioral clinic (Adam). All settings included a table sized appropriately for the participant along with two chairs. Two participants, Adam and Jamal had PECS books made from a 14 cm by 21.6 cm two-ring binder containing laminated color photographs of items which measured approximately 5.08 cm × 5.08 cm. Each image had a printed label at the bottom. Jamal's notebook always had one picture on the front of it that corresponded with the available item, and Adam's notebooks always had at least five pictures of preferred items on it. Nelson used an SGD, specifically a Prentke Romich Company Accent 800-D device (23 cm × 14.7 cm × 3.5 cm) with Words for Life software. While the Words for Life software is typically used to teach individuals to communicate through Language Acquisition and Motor Planning (LAMP), Nelson was taught to discriminate pictures rather than using motor planning. Nelson's device had a 17 cm by 11 cm screen with six rows of picture symbols and 12 columns of picture symbols. The pictures were not actual photographs but 1.25 cm by 1.5 cm symbols of familiar objects and actions. Researchers obtained participant preferences from their teachers and parents. Prior to the start of each session the researcher conducted a multiple stimulus without replacement preference assessment to determine a hierarchy of items that would be used for the session. As preferences changed and other choices became available throughout the study, the researchers added pictures as appropriate. In addition to the various forms of AAC, each setting included reinforcers matching pictures in the PECS book and SGD. Table 2 depicts these relative to each participant's preferences.

Dependent Variables, Response Definitions, and Measurement

The primary dependent variable was independent, intelligible word vocalizations (Cagliani et al. 2017). This variable was recorded on a trial-by-trial basis using a dichotomous (i.e., yes/no) recording procedure and was reported as percentage of trials. Each session consisted of five trials. An independent, intelligible word vocalization was an audible, oral response that matched with at least one of the available reinforcers. For some participants (i.e. Nelson), word approximation vocalizations of the snack items

were accepted after communication partners and data collectors agreed upon a target vocalization. Examples of the accepted approximations are included in Table 1. To arrive at this agreement, the researchers completed a screening process that is discussed in a later section. Data were also collected on the percentage of trials with independent picture exchanges or independent complete SGD requests (as opposed to vocal responses). An independent picture exchange involved the participant handing a corresponding picture from his PECS book to the therapist without prompting (Cagliani et al. 2017). An independent SGD request involved the participant independently navigating the device and touching a picture of an available reinforcer on the SGD.

Experimental Design

A reversal design replicated across participants was used to evaluate effects of implementing a delay to reinforcement during PECS or SGD mands to increase target vocalizations as mands for preferred items. Baseline conditions included at least three PECS or SGD sessions without manipulations. Considering reinforcer delay as "B" and increased response effort as "C," the condition order was A-B-A-B-A-C-A-C for Nelson and Adam, and for Jamal the sequence was A-C-A-C-A-B-A-B. The researchers counterbalanced the conditions in an attempt to control for sequence threats to internal validity (Ledford and Gast 2018). Participants entered into intervention after three sessions of manding independently with AAC for preferred items for 80% of trials in the session. Participants returned to baseline after engaging in target word vocalizations or vocalization approximations with 80% independence of trials in the session across at least three sessions. Conditions were not replicated if the participant did not engage in independent vocalizations during the delay for at least one trial across three sessions.

Vocal Imitation Assessment

Each participant's vocal imitation abilities were assessed using the Verbal Behavior-Milestones Assessment Placement Program - Early Echoic Skills Assessment (ESSA; Esch 2007). Each participant was asked to repeat up to 25 sounds from Group 1: Simple and reduplicated syllables. The person administering the assessment said to the participant, "Say" and then provided the target sound. Targets included vowels, diphthongs, and the following consonants: p, b, m, n, h, and w. Participants scored one point for each sound if they emitted the correct sounds and correct number of syllables. Participants scored half of a point if they partially emitted the target vocalizations and used an incorrect consonant, left out a consonant, or included extra syllables. Participants earned zero points if they did not respond after three trials, used incorrect vowels, or left out syllables. Each participant's assessment results are included in Table 2.

Screening

Prior to implementation of baseline, each participant took part in a formal screening to determine what their individualized target vocalizations sounded like and to ensure that multiple communication partners and observers had a reference point for vocalizations to reinforce. Screening involved a therapist asking the participant to say the name of the specific item (e.g., "Say gummy bear") in the absence of the actual item. The therapist

waited 3 s, or until the individual vocalized. If the participant did not vocalize, the therapist repeated the vocal model and waited an additional 3 s unless the individual vocalized before the 3 s was over. The screening sessions were recorded on an iPhone using the *Voice Memo* application. After the screening, the therapist and other data collectors reviewed the recording and wrote the vocalization phonetically. All therapists and data collectors agreed on the target vocalization for each participant including examples and non-examples. For Adam, because the expected vocalization did not occur during the screening, caregivers and teachers described phonetically what the target vocalization sounded like. Table 3 provides additional information related to each participant's form of communication.

General Procedures

Sessions lasted between 10 and 60 min and took place during instructional time, regular school snack time, or during a clinic visit. Each session consisted of five trials. The number of sessions conducted during any given day varied based on the allotted time and the participant's establishing operation for the items available. Sessions ended when the participant moved on to another activity within the school day (e.g., from snack to recess), or after 5 min of the participant not requesting for preferred items. If five trials were not completed the session data were not included. At the beginning of the session, the therapist sat across from the individual with containers of reinforcers (food and/or toys) and signaled to the individual that they could request their preferred items by saying, "If you want something, you can ask." The therapist then waited while looking at the individual. Regardless of phase, any unprompted vocal mand resulted in immediate access to the corresponding item. Vocalizations were never prompted; only AAC requests were prompted if they did not occur independently. The therapist provided a small, bite-size portion if the individual manded for a piece of food. If the individual manded for a toy, the therapist provided 1 min of access to the toy, and then retrieved the toy to begin the next trial.

Baseline

During baseline, any mand (vocal, picture exchange, or SGD) resulted in immediate access to reinforcement. After any mand, the therapist vocally modeled the label for the

Table 3 Communication information

Participant	EESA score	AAC	Items requested
Jamal	25/25[a]	PECS Phase I	pop-tart, chicken sandwich, chips Ext: popcorn
Nelson	17.5/25[a]	SGD	pop-tart, grapes, hot takis, gummies, skittles Ext: strawberries
Adam	3.5/25[a]	PECS Phase IIIb	skittles, cars, starbursts, magnets, sprite, juice, french fries

[a] Verbal Behavior Milestone and Placement Program Early Echoic Skills Assessment Group 1: Simple and reduplicated syllables portion; PECS=Picture Exchange Communication Systems; SGD = speech generating device; Ext = extension

item and provided it to the individual. The therapist then provided behavior specific praise for the mand for the item. For example, the therapist might have said, "Cookie, great job saying cookie."

Delay to Reinforcement

During this condition all AAC mands resulted in a gradually increasing delay to reinforcement. Any vocal mand avoided the delay, and resulted in immediate reinforcement. While Cagliani et al. (2017) increased the delay by 1 s each day of intervention, we systematically increased the delay in the current study using a parametric manipulation. The delay began at 1 s and doubled until the participant independently vocalized for at least 80% of trials in the session across two sessions. If the participant dropped below 80% more than once during any subsequent sessions the delay was increased. The gradually increasing delay utilized for the parametric manipulation involved the following durations: 1 s, 2 s, 4 s, 8 s, 16 s, 32 s, and 64 s. If the participant did not vocalize for 80% of trials in a session with the final 64 s delay, subsequent conditions with a delay did not progress past 64 s. Once the participant requested for the item with AAC the therapist held the item in her hand and did not provide prompts. If a vocal mand did not occur during the delay, the procedures after the delay were identical to what occurred during baseline.

Response Effort

The second experimental condition was a proximity fading procedure designed to increase the response effort for picture exchange or SGD request. This phase was similar to the response effort condition of Cagliani et al. (2017) in that the AAC device was moved out of reach from the participant initially and then brought back within arms reach based on independent responding. Researchers placed the PECS book or SGD just past the communication partner, 1 m away, who was holding the preferred item. This placement ensured the AAC was in sight but required the participant to move from the chair in which they were sitting to communicate. Identical to the other conditions, if the individual vocalized using the target vocalization at any time during the trials, they were immediately provided with the reinforcer. Additionally, all picture exchanges and SGD requests resulted in immediate reinforcement during this condition.

Extension

Participants who vocalized during at least 80% of session trials across three sessions for at least one of the conditions participated in an extension. During the extension the participant did not have access to their device in order to determine if they would engage in vocalizations when presented with the preferred stimuli. The extension consisted of three different conditions with varying environmental manipulations. One environmental manipulation was the location of implementation. During the environmental manipulation condition the individual was brought to a new setting in the school the participant had previously worked but not for the purpose of the study. A reinforcer used during intervention in the study was made available by the familiar therapist. Another condition consisted of a change in available reinforcers. During this

condition, none of the previously used reinforcers were available for request, and the familiar therapist presented an equally preferred item. While the communication partner (familiar therapist) was held constant throughout the course of previous conditions, the communication partner was changed to another adult who was not previously associated with the study. Each of these variables was altered separately from one another.

Interobserver Agreement and Procedural Fidelity

For at least 30% of all sessions across all conditions and independent variables a second, independent observer collected participant response data and procedural fidelity data. The data collector was an undergrad, masters, or doctoral student in special education. All data collectors received specific training on the data collection procedures prior to assisting. Researchers scored procedural fidelity based on the implementation procedures including whether the PECS book or SGD was available, the communication partner's behavior on each trial, and the prompter's behavior on each trial. Procedural fidelity was collected for 48.9% of Jamal's sessions across all conditions and was 100% for all sessions. Procedural fidelity was collected for 55.6% of Nelson's sessions across all conditions and was 100% for all sessions. Procedural fidelity was collected for 75% of Adam's sessions across all conditions and was 100% for all sessions.

Interobserver agreement (IOA) was calculated using trial-by-trial IOA (dividing the number of agreed upon trials by the total number of trials and multiplying that number by 100; Cooper et al. 2007). Each session consisted of five trials. IOA was collected for 47.5% of Jamal's sessions. The mean IOA for Jamal across all conditions was 95.2% (range 80–100%). IOA was collected for 91.7% of Nelson's sessions. The mean IOA for Nelson across all conditions was 95.8% (range 80–100%). IOA was collected for 100% of Adam's sessions. The mean IOA for Adam across all conditions was 98.7% (range 80–100%).

Results

Figures 1, 2 and 3 show the percent of trials with AAC mands and the percent of trials in which independent intelligible word vocalizations or independent word approximation vocalizations occurred for each participant. Session numbers are noted on the x-axis of each graph and the percent of trials with independent responding (AAC and vocalizations) is represented on the y-axis. During baseline all participants engaged in stable responding involving minimal vocalizations and frequent AAC mands.

Delay to Reinforcement

Jamal and Nelson both engaged in independent vocalizations during the delay to reinforcement condition. Additionally, both participants utilized their AAC prior to the delay to reinforcement. The delay to reinforcement varied across participants following the parametric manipulation. Despite the increase in delay to reinforcement, Adam did not engage in independent vocalizations during this condition.

Jamal Jamal used picture exchange and independent vocalizations to mand for preferred items during the delay to reinforcement condition. During the first baseline condition

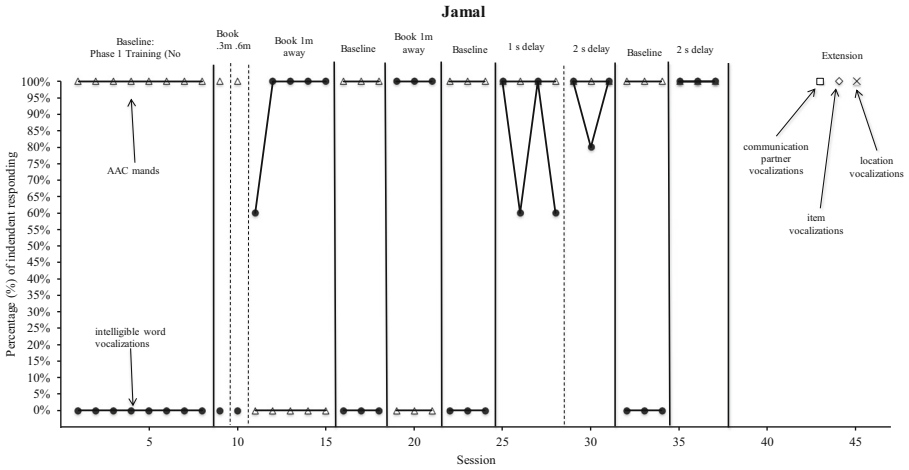

Fig. 1 Performance data on Jamal. Percentage of independent AAC responding and target word vocalizations

Jamal began using independent word vocalizations at the initial delay of 1 s. Researchers found that the frequency of independent vocalizations were variable at a 1-s delay (i.e. alternating between 60 and 100% of trials) and therefore increased the delay to 2 s. Once researchers increased the delay to 2 s, Jamal exchanged pictures and vocalized during the delay period for at least 80% of the sessions across three sessions. Upon returning to baseline, 0-s delay, Jamal did not engage in independent vocalizations but continued manding for items using picture exchange. During the second implementation of the delay to reinforcement condition Jamal independently vocalized during the delay for 100% of the session across three sessions in addition to exchanging pictures.

Nelson Nelson was exposed to the delay to reinforcement condition immediately after his initial baseline. Nelson did not begin using word approximation vocalizations until

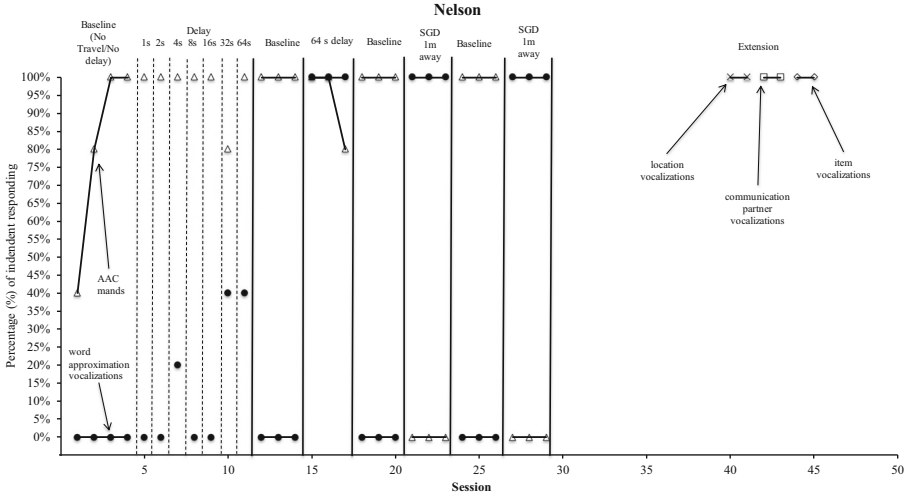

Fig. 2 Performance data on Nelson. Percentage of independent AAC responding and word approximation vocalizations

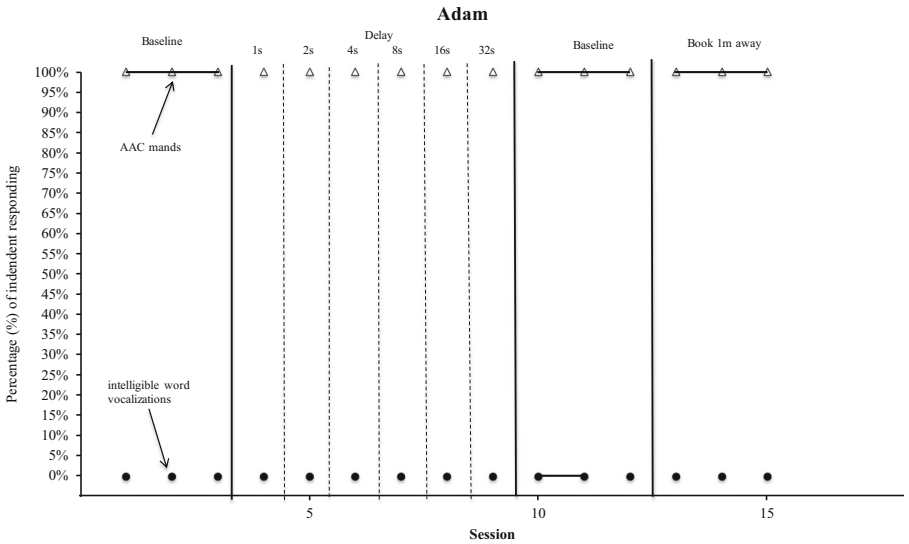

Fig. 3 Performance Data on Adam. Percentage of independent AAC responding and intelligible word vocalizations

researchers increased the delay to 4 s. Nelson vocalized on the third trial during this session. Researchers increased the delay to 32 s and 64 s for Nelson during which he vocalized 40% for both sessions. During the 32 s delay session, Nelson vocalized for the first and second trials. During the 64 s delay sessions, Nelson vocalized during the third and fifth session. The delay to reinforcement did result in an increase in level when compared to baseline. Nelson solely communicated with the SGD during the return to baseline. Researchers returned to the delay to reinforcement condition, keeping the delay at 64 s and Nelson vocalized 100% of the session across three sessions. Nelson often vocalized within the first 10 s of the delay thus terminating the delay long before 64 s had passed.

Adam Adam's responded similar to that in baseline in that he relied exclusively on PECS to communicate. The delay increased up to 32 s, regardless Adam did not resort to other modalities to access the preferred item faster. Researchers decided to discontinue the delay at 32 s due to some instances of problem behavior including disruption and aggression that they had witnessed previously.

Response Effort

Jamal and Nelson both began engaging in independent vocalizations during the response effort condition. Rather than getting up and moving to their device to mand for the preferred item, both participants independently vocalized to request the preferred item. Adam moved to his AAC to communicate and did not engage in vocalizations during this condition.

Jamal Jamal was exposed to response effort after the first baseline condition. During baseline, Jamal reliably used PECS Phase I to communicate without vocalizations.

Researchers gradually increase response effort Jamal by increasing the distance between him and the communication book in an effort to teach Jamal how to move to and from his PECS book. Researchers first moved the book 0.3 m away then 0.6 m and finally 1 m. Jamal switched from exchanging pictures to communicating with vocalizations when his communication book was 1 m away. Jamal responded solely using PECS during a return to baseline, and used vocalizations exclusively when researchers increase the response effort the second time.

Nelson Nelson was first exposed to response effort after the third exposure to baseline. During baseline Nelson reliably used a SGD to communicate without vocalizations. Nelson immediately switched from SGD to vocalizations when his device was moved. Upon returning to baseline Nelson switched back to using his SGD and back to vocalizations in his second exposure to the response effort condition.

Adam Adam was exposed to response effort in a similar sequence as Nelson. Adam's vocalizations did not increase as a result of the increased response effort. Adam traveled to his PECS book when the response effort was increased and exchanged a picture similarly to how he communicated in baseline.

Extension

The extension took place at least 1 week after the last session of the final condition. Jamal and Nelson participated in at least three sessions of the extension. The extension was made up of three conditions and the respective AACs were not present across the three conditions.

Jamal Jamal participated in three sessions of extension. During the first session, Jamal communicated with a familiar communication partner not included in previous conditions. In the second session researchers presented Jamal with popcorn, which was not used during any of the previous conditions. The final condition took place in a novel location, the hallway workspace. Researchers had not conducted sessions in the hallway during preceding sessions. Across all three sessions Jamal communicated with intelligible word vocalizations for 100% of trials during the session.

Nelson Nelson participated in six sessions of extension also including a new location, new item, and new communication partner without his SGD present. The variations included a communication partner not previously associated with the study, the cafeteria as a new setting, and strawberries as a new item to request. Across all three conditions Nelson communicated with vocalizations for 100% of trials during the session across all six sessions.

Discussion

Manipulating delay to reinforcement and response effort can produce shifts in response allocation (Cagliani et al. 2017). These two variables previously manipulated in

conjunction with various AAC mands, result in shifts in response allocation. The current study extended the findings of Cagliani et al. (2017) by replicating those findings with individuals utilizing PECS at earlier phases and individuals communicating with high-tech SGDs. Additionally, this study provided multiple demonstrations of effects across delay to reinforcement and response effort conditions and participants.

Nelson and Jamal both quickly switched mand modalities during the response effort condition when their AAC was moved 1 m away. Both participants also altered their responding during the delay to reinforcement condition, but determining the necessary delay time required additional sessions than the response effort conditions. Additionally, vocalizations were more variable during the delay to reinforcement condition. This information may suggest that by response effort manipulations lead to more immediate changes in communicative responding. Additionally, the delay to reinforcement condition may be more likely to elicit problem behavior given the temporary exposure to extinction. Practitioners should consider the risks associated with extinction when implementing a delay to reinforcement. While there is not an experimental design in place to compare the two independent variable, response effort and delay to reinforcement, the response effort condition lead to a more immediate change in responding which may lead practitioners to first attempting this manipulation.

Cagliani et al. (2017) did not provide background information related to the participants' vocal imitation abilities prior to the start of the study. By including this information in the current study, we began to lay the foundation for determining when individuals are capable of altering their responding from AAC to vocalizations and when practitioners should continue to provide instruction on vocalizations. The information gathered from the EESA may be preliminary data to support the relation between echoic ability and independent target word vocalization development. While practitioners determined that each of these participants would benefit from AAC instruction, the EESA scores may provide information on whether further instruction on vocalizations is warranted. Jamal and Nelson both scored greater than 17.5 on the assessment and were able to alter their responding from AAC to vocalizations. However, Adam did not vocally mand throughout the course of the study. Researchers should continue to investigate the relationship between vocal imitation and reliance on AAC. Additionally, this information may provide support for practitioners to continue working on vocal imitation and necessitate further research on how to improve vocal imitation in individuals with limited vocal ability.

Adam was the only participant to not use word approximation vocalizations or intelligible word vocalizations when the delay to reinforcement and response effort were altered. Adam's difficulty with vocal imitation was evident during his screening on the VB-MAPP EESA (3.5/25), which was lower than the other participants. According to the VB-MAPP, those scores are indicative that vocal imitation should specifically be targeted and an AAC should be considered. Adam's mother and teacher both described the occurrences of vocalizations in a way that suggested they were under faulty stimulus control. For instance, Adam would echo vocalizations after a therapist prompted him through a series of motor movements (e.g. touch your head, touch your nose, say "ball"). Researchers did witness Adam vocalize during the course of the study. While playing with a toy ramp and cars, Adam would occasionally vocalize "set, go" after a therapist held a car while saying "ready." During play, Adam produced non-word vocalizations at high frequency. Additionally, researchers were

unable to get Adam to emit the target word vocalizations during the screening and therefore relied on parent report of the vocalizations. While Adam vocalized in other settings, his vocalizations were not under stimulus control in the clinical setting.

There were several limitations of the current study that necessitate discussion. The response effort condition was very similar to PECS Phase II, requiring individuals to move from their seat to communicate. Adam's experience with PECS Phase II may have influenced his responding during the response effort condition. The setting for Adam was similar to the setting he received PECS training.

Other limitations were related to measurement and response definitions. While Nelsons vocalizations were considered approximations, the researcher determined these to be close enough in sound to consider a target vocalization and discriminable from other vocalizations. Researchers did not collect data to track the development of word approximation vocalizations across a session and the course of the study. For instance, Nelson went from approximating "berry" at the beginning of the extension sessions to approximating "strawberry" towards the end of the second session. Additionally, data were not collected during delay to reinforcement conditions on persistence of responding with AAC. Data on the number of times the individual utilized their AAC during the brief moment of extinction may have provided additional information on the use of delay to reinforcement in practice. Based on the results of Athens and Vollmer (2010) it is probable that researchers reinforced a chain of persistent responding during the delay to reinforcement condition.

A final limitation relates to the extension. The purpose of the extension was to investigate how the participants would respond under similar circumstances without the presence of their device given the history of reinforcement established with vocalizations during the course of the study. Participants were not probed prior to baseline on the various procedures (i.e. location, therapist, items) included in the extension condition. Prior to the onset of the study, participants were using AAC due to their lack of vocal communication. Therefore, it is highly unlikely that vocalizations would have occurred at the frequency they did with similar environmental arrangements prior to the study beginning. Had probes taken place prior to the start of the study, these sessions would have demonstrated generalization.

Despite the identified limitations, the findings of the current study have implications for practice. As previously noted, practitioners and caregivers of individuals with some vocal repertoire may express criticism or caution towards the use of AAC with their client or child in fear that AAC may limit their use of vocalizations or serve as an "ending point" in communication. Based on the findings of the current study, practitioners and parents may be more willing to consider AAC when speech is not developing typically. The study also provides a systematic way to transition individuals from using AAC to vocalizations when they are ready to do so.

While the current study demonstrated that adjusting the delay to reinforcement and response effort for AAC mands resulted in an increase in target word vocalizations it should be noted that the researchers do not suggest eliminating the availability of the participant's AAC. Vocalizations should always be considered and likely the end goal when training individuals with ASD to communicate, but multiple modalities should be available across settings. All three participants continued using their prescribed AAC outside of the study when the variables were not altered. This may suggest that the individuals prefer to use the AAC rather than vocalizations.

Researchers should consider investigating the effects of altering other parameters including magnitude, quality, and rate of reinforcement to increase response variability across modalities of communication. Researchers should also consider altering delay to reinforcement and response effort to increase response variability from one AAC modality from another (e.g. low-tech to high-tech). For instance, an individual may benefit from transitioning from a one-button switch, which potentially restricts his or her ability to communicate across environments, to a device with additional options. Additional research should also be conducted to determine the effect of altering delay to reinforcement and response effort during AAC teaching sessions on individual's communicative responding across environments outside of the specific session. Finally, the data presented on vocal imitation are preliminary but should be further investigated to determine the impact of vocal imitation ability on independent speech development in addition to researching best practices for vocal imitation training.

Compliance with Ethical Standards

Ethical Approval This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Conflict of Interest Rachel Cagliani declares that she has no conflict of interest. Kevin Ayres declares that she has no conflict of interest. Joel Ringdahl declares that she has no conflict of interest. Erinn Whiteside declares that she has no conflict of interest.

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