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RESEARCH ARTICLE

Naturalistic teaching approach to develop spontaneous vocalizations and augmented communication in children with autism spectrum disorder

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ABSTRACT

Naturalistic developmental behavioral interventions (NDBI) have been shown to facilitate the development of spontaneous language in individuals with speech and language impairment. Several meta-analyses have reported a small number of studies that utilized naturalistic teaching approaches combined with augmentative and alternative communication (AAC) interventions to develop requesting skills in individuals with autism spectrum disorder (ASD). Therefore, the main purpose of this study was to determine whether a natural language paradigm (NLP) and time delay is effective in expanding vocal and augmented requesting skills in three children with ASD between the ages of 4 and 6 years. A concurrent multiple baseline design across participants was used to evaluate the effectiveness of the intervention. The results of the study demonstrated that the participants were successful in emitting vocal requests when both modalities were available and NLP combined with time delay was effective in increasing spontaneous vocal requests in all participants.

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Autism spectrum disorder (ASD) is a type of developmental disorder that is characterized by deficits in specific skills. In the Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5; American Psychiatric Association, 2013), ASD is diagnosed by the presence of deficits in social-communication skills, accompanied by strong repetitive patterns of activities and interests. These symptoms are present from infancy and might seriously impair the individual's daily functioning. As a consequence of the deficits in social-communication skills and the emission of restrictive behaviors, children with ASD have delays in their natural language development or, in some cases, might never fully acquire speech (Klinger, Dawson, & Renner, 2002). Some studies suggested that about 30% of children with ASD will remain nonverbal or minimally verbal when they reach kindergarten age (Anderson et al., 2007; Tager-Flusberg & Kasari, 2013). Considering the impact that the lack of spontaneous language development can have on overall life quality, an effective way of teaching communication skills has a crucial role for improving the well-being of speech and language-impaired populations, such as children with ASD (Walker & Snell, 2013). One of the most successful methods in developing communication skills is augmentative and alternative communication (AAC; Baxter, Enderby, Evans, & Judge, 2012; Light & McNaughton, 2011; Light et al., 2019). However, few studies have focused on the use of naturalistic teaching procedures during the implementation of AAC interventions (Alzrayer, Banda, & Koul, 2014; Ganz et al., 2012; Gevarter & Zamora, 2018; Rispoli, Franco, van der Meer, Lang, & Camargo, 2010).

AAC interventions consist of a practice that aims to supplement, support, or replace the use of natural speech (Beukelman & Light, 2020) and such practices are recommended for use with children with ASD who have severe speech impediments such as unintelligible speech or highly limited vocal expression (Gevarter et al., 2016). The results of a systematic review, conducted by Schlosser and Wendt (2008), revealed that AAC interventions did not hinder speech production in children with ASD and modest gains in natural speech production were observed.

AAC can be applied in structured discrete trial training (DTT) or naturalistic teaching approaches. Although both methods rely on behavioral principles (LeBlanc, Esch, Sidener, & Firth, 2006) and were shown to be effective (Alzrayer et al., 2014; Alzrayer, 2020; Ganz et al., 2012; Muharib et al., 2019; van der Meer & Rispoli et al., 2010), there are some differences between them. In highly structured teaching approaches, like in DTT, a skill is broken into small components and trained separately in discrete trials until the individual acquires the targeted skill (Schreibman et al., 2015). In naturalistic teaching approaches, opportunities are given to the child to use language in natural contexts (i.e., normal routines) and be reinforced using natural consequences (e.g., giving access to preferred edibles during snack time upon the occurrence of requesting). Although DTT improves communication skills, the highly structured nature of DTT limits children to being conditioned to a specific and limited set of stimuli, and therefore generalization of learned communication skills to other situations, people, or tasks is very unlikely (Cowan & Allen, 2007). To improve upon DTT, researchers undertook more efforts to further engage young children

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with ASD and create a connection between their skills and the world around them, otherwise known as naturalistic developmental behavioral interventions (NDBIs; Schreibman et al., 2015). The existing literature on NDBIs has been growing since 1998 (Schepis, Reid, Behrmann, & Sutton, 1998). Researchers suggest that the use of NDBI strategies, when the therapist and the child work together using natural environments and inevitable actions, offers additional avenues to teach developmental skills compared to highly structured contexts (Schreibman et al., 2015).

With the various types of NDBIs (e.g., incidental teaching, pivotal response training, and the Early Start Denver Model), children with ASD are encouraged to take the initiative and engage in spontaneous behaviors, which, when rewarded, help children recognize that they are contributing to their own learning (Schreibman et al., 2015). Researchers also found that naturally occurring or child-led openings to improve communication are the most effective openings (Gevarter & Zamora, 2018). These interventions promote social development, are more effective, and lead to improvements in communication skills (Schreibman et al., 2015). Furthermore, Gevarter and Zamora (2018) pointed out that age-appropriate activities provide significant opportunities for children with ASD to imitate certain response patterns. However, practitioners should keep in mind that children with ASD face difficulties with initiating communication, which make it imperative to rely on strategies that target initiated communication opportunities. Further, it should be noted that both behavioral and naturalistic approaches could be integrated and the strength from both fields could be used to improve the social-communication skills in children with ASD (Schreibman et al., 2015).

For children with ASD who experience communicative issues, such as underdeveloped gesturing and imitation, reciprocal imitation training (RIT) is an intervention that parents of such children can use to improve their child's communication skills and language development within natural settings (Ingersoll & Gergans, 2007; Ingersoll, Lewis, & Kroman, 2007). RIT uses strategies to improve parent–child reciprocity and teach the child to imitate another person (Ingersoll & Gergans, 2007). When using RIT, interventionists apply techniques shown to work for teaching object imitation, including physical prompts, conditional imitation, linguistic mapping, letting the child lead, and contingent emphasis (Ingersoll et al., 2007).

Speech-generating devices (SGDs), a type of aided AAC, are dedicated electronic devices that help with social-communication difficulties by producing digitized or synthesized speech output (Schlosser, Sigafoos, & Koul, 2009). Still, Rehfeldt, Whelan, May, and Dymond (2014) found that SGDs have been largely successful in improving communication skills in children with ASD. Although some concerns arose regarding the use of SGDs as toys in previous studies, children with developmental disabilities used the devices as a means of functional communication (Sigafoos, Didden, & O'Reilly, 2003). Previous studies have shown that using tablets with AAC applications increases independent vocalizations in children with ASD between the ages of 3 and 9-years old (Gevarter et al., 2016; Roche et al., 2014). SGDs have shown promising results in previous studies, but aided AAC using new technology (e.g., tablets with AAC applications that produce speech output) requires further empirical study to determine their effectiveness in the autism population (Alzrayer et al., 2014; Schlosser & Koul, 2015; Still et al., 2014).

Two areas of research for communication skill improvement include the use of SGD and parents using enhanced milieu teaching (EMT), both of which involve utilizing naturalistic strategies (Schepis et al., 1998; Kaiser, Hancock, & Nietfeld, 2000). Schepis et al. (1998) examined the effectiveness of using SGDs in combination with NDBIs on the social interactions of young children with ASD. The results indicated that the children used SGDs readily to interact, and there was an increase in their communicative interactions as a result of pairing with NDBIs (Schepis et al., 1998).

Further, a study by Kaiser et al. (2000) showed that the EMT procedures could be used effectively by parents of children with ASD in multiple environments for any duration. The results also indicated a positive effect for the communication skills of children with ASD (Kaiser et al., 2000). Moreover, Olive et al. (2007) found that using EMT combined with an SGD resulted in improvements in the communication skills of children with ASD. The combination of SGD and EMT showed dramatic advances in the communication abilities of children with ASD. These findings provide support for utilizing AAC combined with NDBIs to improve the social interaction and communication skills of children with ASD (Olive et al., 2007; Schepis et al., 1998).

The natural language paradigm (NLP), another type of NDBI, prioritizes teaching in non-artificial settings (or at least as much as possible). There are four main components in NLP: (a) providing a vocal model and reinforcing any approximal vocalizations, (b) taking turns playing with the toy between the instructor and the child, (c) modeling different spoken words/phrases related to the toy and play context, and (d) sharing the control with the child by following his or her desire to change toys or activities (Koegel, O'Dell, & Koegel, 1987). With the NPL, multiple reinforcements and contexts are used in different trials to simulate the target performance environment in a more reliable manner (Gillett & LeBlanc, 2007). With NLP strategies, the child is the initiator, choosing the desired stimuli in a natural and mostly unscripted manner (Cowan & Allen, 2007; Koegel et al., 1987; Schreibman et al., 2015).

Previous studies using the NLP have shown that it may provide better results than the structured language teaching paradigms. When the NLP is compared to a structured teaching method, Koegel et al. (1987) found that children who were taught via the NLP exhibited more imitative utterances and were able to generalize their gains outside the clinic setting. A fast increase of the number of intervals in which children produced vocalizations was also related to the NLP, compared to a free play baseline (Gillett & LeBlanc, 2007). Furthermore, NLP strategies can be taught to parents, which ensures that the speech gains can be obtained or maintained in the child's own environment (Gillett & LeBlanc, 2007).

In previous studies, AAC and naturalistic teaching methods or NDBI were shown to be effective methods for dealing with speech impairment (Gevarter & Zamora, 2018; Schreibman et al., 2015) and, therefore, should assume a crucial role in interventions with populations with these problems. However, there seems to be a dearth of studies that test the efficacy of combining these methods. Therefore, the main objective of this study was to determine whether NLP and time delay increase the level of vocalizations and, if unsuccessful, subsequent augmented communication for spontaneous requests.

Method

Participants

Three participants were recruited from a special education school to participate in this study. The participants received individualized instruction and other related services, such as speech, occupational, and physical therapy. They met the following criteria and were included in the study: (a) age 4 to 6 years; (b) ASD diagnosis and no concomitant diagnoses (e.g., visual or hearing impairments) by medical professionals or licensed school psychologists; (c) absent or weak mand/requesting repertoire based on the barrier assessment in the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008), which indicate very few or effective requests at all; (d) limited echoic repertoire/vocal imitation as indicated by a total score of less than 20 in the Early Echoic Skills Assessment (EESA; Esch, 2008) from the VB-MAPP; and (e) no experience using the GoTalk Now™ [1] application. A child who scores an absent or weak mand/requesting repertoire on the barrier assessment in the VB-MAPP demonstrates very limited requesting abilities, depends on prompts, and exhibits challenging behavior due to their limited communication skills (Sundberg, 2008). The participants' scores in the VB-MAPP in the requesting and echoic skills domains were primarily in the 0–18 month range.

Erin, Joseph, and Mary (all names are pseudonyms) were able to emit simple single sounds to request a few preferred items and activities using echoic prompts. For example, when Erin wanted to play with the ball, he would say *ba* after the instructor provided him with the vocal model *ball*. Joseph was able to emit single sounds to request different preferred items independently, such as *baa* for bubbles and *oo* for Oreo. None of the participants had prior exposure to AAC interventions. Refer to Table 1 for information about the participants' demographics. Each participant's parent provided consent for their child to participate in the research.

Setting

The study took place in a special education school where the participants received educational and other services. The sessions were conducted in a play area in each participant's classroom. Each session followed a one-on-one format between the participant and the instructor. The independent observer was present during the sessions to collect interobserver agreement (IOA) and treatment integrity data. The play area contained child-sized chairs, tables, shelves with toys, and other materials. The sessions were conducted once or twice a day, five times per week, for 10 to 15 min each.

Research design

A multiple baseline design across participants (Baer, Wolf, & Risley, 1968) was used to evaluate the effects of the intervention. Baseline data were collected concurrently from all participants. When the augmented requesting and spontaneous vocalization data were stable during baseline (i.e., no more than 5% variability on the dependent measures) in the last three data points for one of the participants, the intervention was introduced to the selected participant. When the data for both dependent measures were stable for the intervention phase, the intervention was implemented for the next participant until all of the participants received the intervention. When the participants reached the acquisition criterion (i.e., at least one request per min across three consecutive sessions on either modality), maintenance data were collected from all participants. A multiple follow-up probe design was used to evaluate maintenance (Barrios & Hartmann, 1988; Schlosser & Lee, 2000). The study was approved by the appropriate ethics committee.

Dependent measures

The rate of spontaneous vocalization and augmented requesting per min were measured. Spontaneous vocalization was defined as independently vocalizing the same sounds and the number of syllables as the word of the selected item or vocally approximating at least one sound (e.g., *ba* for ball) within 5 s and without a previous vocal model. Augmented communication was defined as independently pressing the graphic symbol that corresponded to the desired item that was appropriate within a context (e.g., pressing the graphic symbol of a *BALL* while playing ball with the instructor). Since all the participants were able to approximate the vocalizations, the spontaneous vocalization reported focused only on approximations. Table 2 contains a sample of the most-frequently uttered spontaneous vocalizations across participants. The instructors used a data collection sheet, developed by the first author, to record data on spontaneous vocalization and augmented requesting for 100% of the sessions across all phases. The data on spontaneous vocalizations and augmented requesting were taken prior to providing verbal modeling for vocalizations or physical modeling for augmented requesting.

Experimenters

The instructors (who implemented the sessions) were special education teachers with an emphasis in autism and a background in applied behavior analysis. Each instructor had a

[1]GoTalk™ is a product of the Attainment Company of Verona, MI., https://www.attainmentcompany.com/gotalk-now

Table 1. Participants characteristics.

Demographic variables	Erin	Joseph	Mary
Age	5	6	4
Gender	Male	Male	Female
Mand/request repertoire[a]	1 (Level 1)	2 (Level 1)	1 (Level 1)
Echoic repertoire[a]	9	2	8
Receptive communication[b]	0:9	1:00	0:10
Expressive communication[b]	0:8	0:10	0:9
Vocalizations	*Pop, bye bye, mama*	*oo, eee, ah, baa*	*No, mama, me, papa, wow, bee*

[a]Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP), Early Echoic Skills Assessment (EESA).
[b]Age equivalent (year: month) on the Vineland Adaptive Behavior Scale-Second Edition (Vineland-II; Sparrow, Cicchetti, & Balla, 2005).

Table 2. Sample of the most uttered spontaneous vocalizations across participants.

Erin	Joseph	Mary
Baa (ball)	*Da da* (toy drum)	*Bu bu* (bubble)
Doh (play-dough)	*Ca* (car)	*Boo* (book)
Ke ke (slinky)	*Pop* (pop up toy)	*Tain* (train)
Poo (piano)	*Oo* (yo yo)	*Wa wa* (water toy)

least three years of teaching experience. Three instructors (each participant's regular classroom teacher) were trained to implement the intervention.

Materials

A 16GB Apple iPad II© [2] loaded with the GoTalk Now application was used as the AAC system. The iPad was placed inside a protective stand cover case and a BubCap™ [3] home button cover was used to prevent the child from exiting the application while using the device for communication. The iPad was configured to display six to nine graphic symbols of the preferred items (e.g., car, ball, children's book, musical toy, Play-Doh, blocks, and train) on the grid display screen. The graphic symbols were line drawings and were taken from the SymbolStix™ [4] library; the size of each symbol was $1^{3/4}" \times 1^{3/4}"$ (4.46 × 4.46 cm). The main reason behind selecting symbol type, size, and number was to allow the user to add a variety of preferred items or activities to ensure the participants' motivation or desire to request during the sessions. Upon activating a graphic symbol on the display screen, synthesized speech output was produced labeling the item corresponding to the graphic symbol (e.g., "*ball*" for *BALL*).

Procedures

Preference assessment

A stimulus preference assessment was conducted to select the most-preferred items for each participant. The experimenter (first author) conducted an indirect preference assessment by interviewing the instructors using the Indirect Preference Assessment Interview Protocol (Green et al., 2008) to select the potential preferred items. Additionally, 10 to 15 preferred items were selected based on the indirect assessment to identify the most-preferred toys and activities using a contrived free-operant preference assessment (Roane, Vollmer, Ringdahl, & Marcus, 1998). Before conducting the assessment, the experimenter gave each participant a chance to sample each toy for about 15–25 s. All the toys were then placed randomly on the floor and the participant was instructed to play. Preference assessment sessions were 5 min long and were conducted once a day for four consecutive days. In each session, the experimenter took data on three elements: approach (reaching), engagement (manipulating toys either appropriately or inappropriately), and duration (time spent interacting with the toy).

Experimenters training

Before conducting the baseline sessions, the experimenter trained each participant's instructor to implement the procedure for each phase. The training consisted of the following: (a) explaining the target behavior outcomes and procedures for each phase; (b) presenting correct and incorrect examples of target behavior and procedural steps using videos; and (c) role playing the procedures for each phase with each instructor. The training process continued with the instructors until they reached at least 90% or higher on correct implementation of the procedures across all phases on three consecutive role-play sessions. The experimenter used a treatment integrity checklist for the baseline and the intervention to measure the instructors' mastery level. The training sessions were conducted for 2–3 h per day for a total of five days and took place in a conference room in the special education school where the participants received educational and other related services. Only the experimenter and the instructors were present during the training. The time and the duration of the training were determined based on the instructors' schedule and availability. After the training, each participant's instructor implemented the procedures in each phase.

Baseline

The sessions started with the instructor setting up the environment during playtime by placing the most-preferred toys

[2]Apple iPod©, iPad©, and iPhone© are registered trademarks of the Apple Corporation, Cupertino, California, www.apple.com

[3]BubCap™ is a registered trademark of are trademarks of Paperclip Robot, Inc. http://bubcap.com/

[4]SymbolStix™ is a registered trademark of n2y, LLC. https://www.n2y.com/symbolstix-prime/

randomly on the floor in the play area. The format of the session was child-directed; therefore, the instructor followed the participant's lead by giving the child a chance to select the preferred toy. During play, the instructor gave multiple opportunities (between 10 to 15 trials) for the participant to request using either modality (iPad or vocalization). For example, when a participant played with a preferred toy for about 10–15 s, the instructor would either interrupt the participant's play or give the participant a toy with the switch turned off and wait for 3 to 5 s for the participant to use speech and/or the iPad to request. The instructors recorded the participant's ability to vocalize or activate a single icon on the iPad screen display to request access to preferred toys. The baseline sessions were conducted over two-to three-week periods.

Intervention

The instructors implemented a modified NLP procedure (Koegel et al., 1987) along with a constant time delay procedure. After the participant selected a toy, the instructor gently took the toy from the participant and modeled the appropriate play for 5 s while giving verbal models for the appropriate word/phrase up to three times. For example, if the participant selected a car to play with, the instructor took the car and rolled the car on the floor while repeatedly providing appropriate vocal models (e.g., *Look, I'm playing with the car. That's a car. Car*). That was done to pair the arbitrary auditory stimulus (e.g., *car*) and the visual stimulus (the car toy). The instructor then waited for 5 s for the participant to echo the verbal model as a request for access to the preferred toy. Enticing the participant with the toy and giving multiple verbal models were programmed to motivate or encourage the participant to echo the verbal model (the word car). When the participant echoed the verbal model within the 5-s timeframe, the instructor immediately gave the toy to the participant. The instructor gave the participant 35 s of playtime, interacted with the participant, and continued providing multiple vocal models of words and phrases that were appropriate during the play context (e.g., *Look [participant's name]. I'm pushing the car. Can we race? I have a red car, and you have a yellow car.*). If the participant did not emit vocalizations, the instructor provided a model prompt (pressing the symbol on the iPad) without the vocal model for the participant to activate the symbol that corresponded to the preferred toy within 5 s. When the participant imitated the modeled action, the instructor gave the participant the requested toy and 30 s of playtime and interacted with the participant during play. The reason behind the difference in playtime between the vocalizations and augmented requesting was to increase vocal responses by implementing differential reinforcement. The instructor repeated the model prompt once for the participant in case the participant did not respond to the previous prompt within 5 s. If the participant responded to the second model prompt, the instructor gave the participant 15 s to play with the preferred item.

In situations where the participant spontaneously vocalized before the verbal model, the instructor immediately gave access to the preferred item and recorded the response as correct. Similarly, the instructor gave the preferred toy if the participant chose to use the iPad to request before or after giving the verbal model. When the participant activated a symbol, the instructor presented all the toys to the participant and instructed him/her to pick the toy to assess the participant's symbol discrimination and correspondence between saying (activating the symbol) and doing (selecting the correct referent) (Schlosser & Sigafoos, 2002). If the participant selected the toy that corresponded to the chosen symbol, the instructor gave the participant 35 s of playtime and recorded the response as correct. If, however, the participant selected a toy that did not correspond to the activated symbol, the instructor provided a physical prompt (i.e., holding the participant's hand and guiding him/her to pick the toy that corresponded to the symbol). In addition, if the participants did not respond to the physical modeling of selecting the symbol, the instructors gave physical prompt to emit the target response. If the participant selected the iPad to request, the participant was not required to vocalize. The intervention sessions were conducted over a four- to five-week period.

The rationale for providing more models for the spontaneous vocalizations compared to the augmented requesting was to increase the likelihood of vocalizations to occur and only use the iPad in case of a failure in producing the vocalizations during requesting.

Maintenance

The instructor followed the same baseline procedure in this phase. The sessions were conducted after a 2-week gap between the last intervention session and the start of this phase. The sessions were conducted once a week over five-to six-week periods.

Interobserver agreement and treatment integrity

An independent observer (graduate student who specialized in ASD) attended 42% of the total baseline and intervention sessions for each participant to assess the interobserver agreement (IOA) of the dependent variables. The agreement was calculated using trial-by-trial method by dividing the number of agreements by the number of agreements plus disagreements multiplied by 100. The mean IOA values for spontaneous vocalization were 92%, 94%, and 92% for Erin, Joseph, and Mary, respectively. For augmented requests, the mean IOA values were 89%, 94%, and 96% for Erin, Joseph, and Mary, respectively. The observer also collected treatment integrity and procedural integrity data (Schlosser, 2002) using a checklist for all the sessions. The checklist contained the following steps: (a) placing preferred items randomly on the floor in the play area, (b) waiting for the participant to select a preferred item, (c) providing an appropriate play and vocal model, (d) waiting 5 s for the participant to imitate the vocal model, (e) immediately giving the participant the requested toy while playing with him/her, and (f) providing a physical model by using the iPad to request in case no vocal requests occurred. Treatment/procedural integrity, that is, the percentage of steps that were followed correctly, was calculated by dividing the number of procedural steps completed correctly by the total number of steps and multiplying the result by 100. The mean treatment integrity was 96% across the participants and ranged between 90% and 100% for the intervention phase. The mean procedural integrity during the baseline and maintenance phases was 100% for all the participants.

Social validity

After completing the study, the instructors were given a questionnaire (created by the first author) to rate 10 statements using a 4-point Likert scale that indicated whether they: 1 (*strongly disagree*), 2 (*disagree*), 3 (*agree*), and 4 (*strongly agree*). The questionnaire contained four main components to assess the social validity of the following social validation components of the AAC intervention (Schlosser, 1999) along with NLP and time delay, including intervention goals (appropriateness of the selected targets), methods (procedures and materials), and outcomes (perspectives of behavioral changes).

Data collection and analysis

The data were recorded live, and we applied visual analysis techniques to determine where there was a functional relation between the intervention and the dependent measures (Kratochwill et al., 2010). More specially, we examined the level, trend, variability, and latency/immediacy to determine the change of the dependent measures across phases. Further, Tau-U (Parker, Vannest, Davis, & Sauber, 2011), an effect size indicator, was used to assess the behavior change detected in the dependent variables after the implementation of the independent variable. Tau-U calculator by Single Case Research™ [5] was used to determine the effect size of the intervention. There are two main advantages of Tau: (a) it reports changes in level across phases and positive baseline trend; and (b) it is distribution free and well-matched with adjustments from visual analysis (Rakap, 2015). Despite these advantages, there are a few limitations to this effect measurement method, such as (a) estimations can be flatted and not bound between −1 and +1, (b) data cannot be visualized, and (c) discrepancies with the terminology (Brossart, Laird, & Armstrong, 2018; Tarlow, 2017). Parker et al. (2011) proposed guidelines to interpret Tau-U scores as follows: 0 to 0.65 (weak effects), 0.66 to 0.92 (moderate effects), and 0.93 to 1.0 (strong effects).

An independent rater (who had experience with effect size measurement methods) calculated Tau-U scores across six A-B comparisons for both independent variables and for all participants. IOA was calculated by dividing the number of agreements by the total number of Tau-U calculations and multiplied by 100. The overall IOA was 100% across all comparisons.

Results

Erin

As shown in Figure 1, augmented requesting did not occur and spontaneous vocalizations occurred in few trials during the baseline sessions. After the NLP procedure, Erin's average rate of use for the iPad to request was 0.51 and ranged from 0 to 1.2 augmented requests per min. The augmented requesting data showed an immediate change in the level with moderate variability and a gradual decreasing trend. For spontaneous vocalizations, the average rate was 1.4 and ranged from 0.4 to 2 vocalizations per min. The data for spontaneous vocalizations displayed a gradual change in level with a high variability and increasing trend. The Tau-U (Parker et al., 2011) value for augmented requesting was 0.78 with a 90% confidence interval (CI) (0.19, 1.00), which means that the intervention had a medium effect and statistical significance ($p = 0.01$). The Tau-U value for spontaneous vocalizations was 0.94 with a 90% CI (0.35, 1.00), which indicates that the intervention had a strong effect and statistical significance ($p = 0.01$).

During maintenance, Erin preferred to vocalize to request access to preferred items. The average rate of spontaneous vocalization was 0.8 and ranged from 0.7 to 0.9 requests per min. The data remained in the high-level range with a low variability and increasing trend. For augmented requesting, Erin used the iPad to request in one trial during maintenance sessions, and his performance averaged 0.2 and ranged from 0 to 0.1 requests per min.

Joseph

As illustrated in Figure 1, Joseph did not emit augmented requests or spontaneous vocalizations during the baseline phase. During the intervention, the average rate of augmented requests was 0.28 and ranged from 0 to 1.2 requests per min. The data showed an immediate change in level for the augmented requesting with moderate variability and a decreasing trend. For spontaneous vocalizations, Joseph's emission average was 1.3 with a range between 0.8 and 1.8 vocalizations per min. The data showed an immediate change in level with low variability and a gradual increase in the trend. The Tau-U value for the augmented requesting was 0.50 with a 90% CI (0.43, 0.96), which means that the intervention had a weak effect and statistical significance ($p = 0.01$). The Tau-U value for spontaneous vocalizations was 1.00 with a 90% CI (0.54, 1.00), which indicates that the intervention had a strong effect and statistical significance ($p = 0.01$).

During maintenance, Joseph chose to request through vocalization more often than using the iPad. The average rate for spontaneous vocalization was 1.2 with a range of 1

[5]Single Case Research™ is a registered treatment of http://www.singlecaseresearch.org

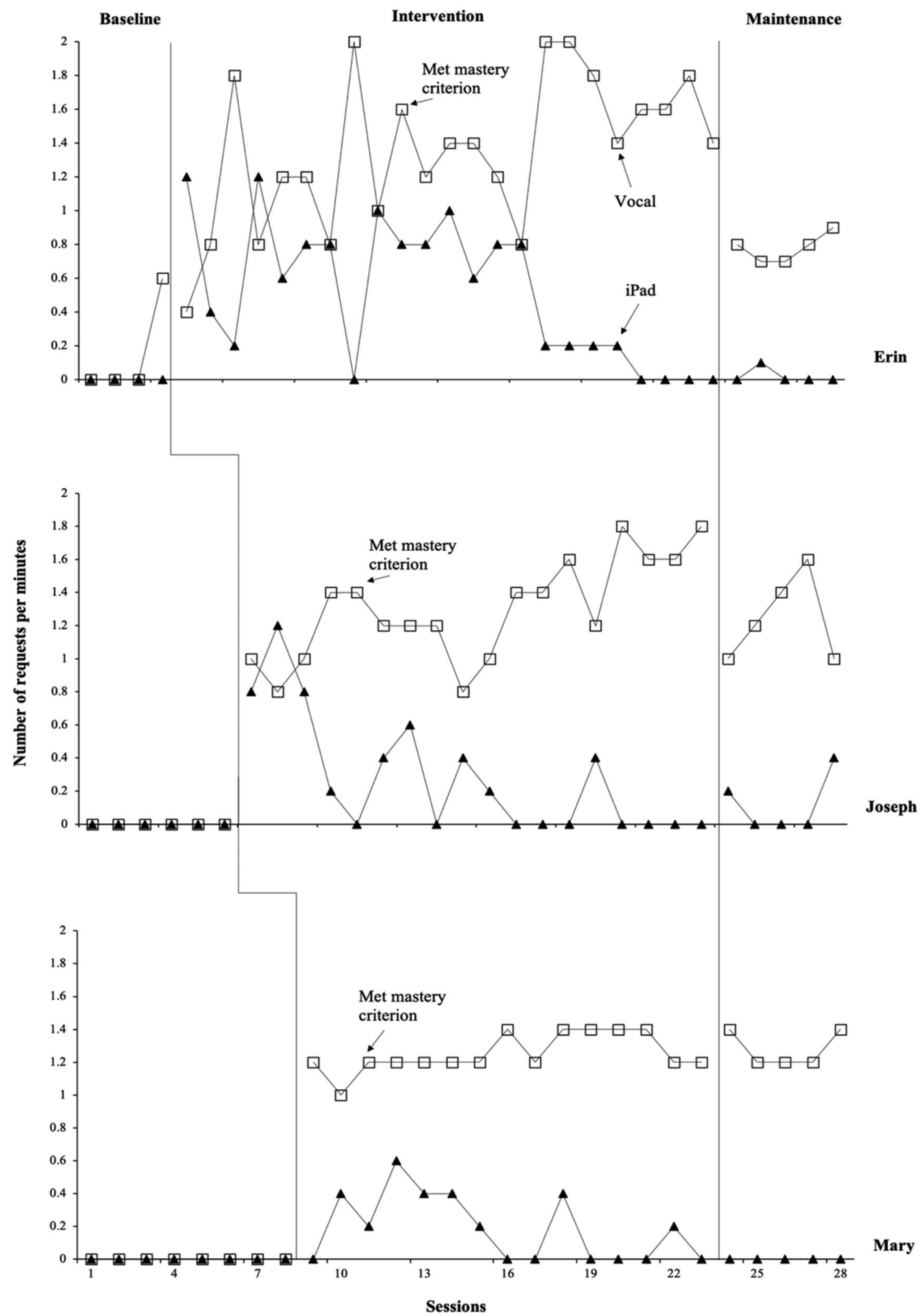

Figure 1. Number of requests per min for augmented communication and spontaneous vocalizations across participants.

to 1.6 requests per min. The data remained at a high level with an increasing trend. For augmented requests, the average rate for augmented request was 0.1, with a range from 0 to 0.4 requests per min. The data remained in the low-level range.

Mary

As shown in Figure 1, Mary did not emit augmented requesting or spontaneous vocalizations during the baseline phase. During the intervention, the average rate of augmented requesting was 0.2 and ranged from 0 to 0.6 requests per min. The data showed a slight change in the level, with a low variability and decreasing trend. For spontaneous vocalizations, the average rate was 1.3 and ranged from 1 to 1.4 requests per min. The data showed an immediate increase in the level after the intervention, with low variability and an increasing trend. The Tau-U value for augmented requesting was 0.70 with a 90% CI (0.11, 0.96), which means that the intervention had a medium effect and statistical significance ($p = 0.01$). The Tau-U value for spontaneous vocalizations was 1.00 with a 90% CI (0.58, 1.00), which indicates that the intervention had a strong effect and statistical significance ($p = 0.01$). During maintenance, Mary spontaneously vocalized to request access to preferred items. The average rate of vocalizations was 1.3 and ranged from 1.2 to 1.4 requests per min. The data remained at a high level with low variability and an increasing trend.

The level of the baseline data for spontaneous vocalizations and augmented requesting was low across all participants. After the intervention, there was a clear change to spontaneous vocalization and a minimum change to augmented requesting data for all participants. During maintenance, the data continued to cluster around high level for spontaneous vocalizations and low level for augmented requesting. The results of the visual analysis were consistent with the Tau-U scores, supporting the fact that the participants demonstrated improvement in their spontaneous vocalizations compared to their performance in augmented requesting.

Social validity

The social validity questionnaire revealed that all the instructors reported that deficits in requesting skills were apparent in the participants' repertoire; the rating was 4 (strongly agree). The instructors also reported that the participants showed improvements in their requesting skills after the implementation of the intervention and the changes in the dependent variables were socially significant; the mean rating was 4 (strongly agree). Further, all instructors agreed that the intervention was practical and cost-efficient. As for whether the instructors would continue implementing the intervention, the instructors reported that they were willing to use the NLP and time delay combined with AAC after the study (average rating: 3.9 [agree]).

Discussion

The study investigated the effectiveness of the NLP and time delay in the development of spontaneous vocalization and augmented requesting skills. The results indicated that the naturalistic teaching strategy was effective at increasing spontaneous vocalizations in all participants, which was consistent with the results of previous studies (Cowan & Allen, 2007; Gillett & LeBlanc, 2007; Koegel et al., 1987). The findings of the current study extend the literature by providing evidence that supports the efficacy of adapting the NLP and time delay to teach functional communication in children with ASD with minimal vocal skills.

There are certain factors that may have contributed to the positive outcomes of the study. Motivational variables are vital in communication intervention packages. A child has to be motivated to interact with others. Greer and Ross (2007) discussed three procedures that are used to establish motivation in functional communication training: brief deprivation, interrupted chain, and incidental or captured moments. Brief deprivation refers to delivering the preferred stimulus contingent on the occurrence of the verbal response. For example, a teacher gives a child a preferred toy only after they ask for the toy (e.g., *Can I have the toy, please?*). The second procedure, interrupted chain, requires the instructor to interrupt the child's activity to increase the child's motivation to emit a verbal response. A teacher might stop the DVD player to evoke a verbal response from the child, such as a request to continue watching the movie. In the incidental or captured procedure, the instructor has to manipulate variables in the environment to increase the child's motivation to communicate. For example, a teacher might put a desired toy in the child's view just out of reach to motivate the child to ask for the teacher's help to get the toy.

Moreover, time delay is another factor that may have facilitated the development of spontaneous vocalizations. In previous studies, time delay was implemented using either aided or unaided AAC interventions, such as manual signs (Carbone, Sweeney-Kerwin, Attanasio, & Kasper, 2010) and the Picture Exchange Communication System (PECS™ [6]; Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002; Ganz & Simpson, 2004). The results of these studies indicated that vocalizations increased after the implementation of a time delay. Consistent with the findings of previous studies, the results of this study provide further evidence of the effectiveness of implementing a time delay procedure on the development of spontaneous vocalization.

Having an echoic repertoire or vocal imitation and extensive exposure to non-augmented communication interventions for all participants facilitated acquisition of spontaneous vocalization. According to the systematic review by Schlosser and Wendt (2008), the emission of vocal imitation before the intervention stage is considered to be a strong sign for the development of speech at a later age. Although the participants had an echoic repertoire, it was limited according to EESA scores (Esch, 2008). After the intervention, spontaneous approximate vocalizations emerged for all three participants and continued to occur during the maintenance phase. More recent studies reported the impact of individual differences in vocal imitation skills in the acquisition of speech development (Gevarter & Horan, 2019; Gevarter et al., 2016; Wendt, Hsu, Simon, Dienhart, & Cain, 2019).

The finding of the current study is inconsistent with previous studies (Schlosser et al., 2007; Wendt et al., 2019), which showed that having limited speech-like skills might not be

[6]PECS™ is a a registered trademark and a product of the Pyramid Educational Consultants, Inc., Newark, DE. https://pecsusa.com/pecs/

associated with developing speech after the implementation of the AAC intervention. Modeling might have contributed to the development of spontaneous vocalizations and augmented requesting across participants in the current study. Other studies reported similar results during the implementation of aided AAC interventions. For example, Wendt et al. (2019) reported that some participants demonstrated increases in vocalizations after the implementation of vocal modeling during PECS Phase IV, which was supported by other PECS studies (Charlop-Christy et al., 2002; Ganz & Simpson, 2004; Tincani, 2004) as reviewed by Preston and Carter (2009) and Flippin, Reszka, and Watson (2010). Further, pairing the name of the referent with the delivery of the requested item also led to increases in vocalizations (Hu & Lee, 2019; Yoon & Feliciano, 2007). Future studies are encouraged to investigate the efficacy of modeling with non-augmented and augmented interventions.

Clinical implications

The results of the study provide initial evidence of the effectiveness of NLP and time delay in the development of vocalizations and augmented requesting in children with ASD and limited functional communication. Practitioners should consider combining both AAC and non-AAC interventions to develop spoken language skills in children with ASD. Including time delay with the intervention package was shown to increase spontaneous vocalizations in all participants. Therefore, practitioners are encouraged to combine time delay with communication interventions to increase children's motivation to produce spoken language for requesting. Further, given the positive outcomes of the social validity questionnaire regarding the practicality and cost-efficiency of the NLP and time delay combined with AAC, practitioners should consider implementing the intervention in children with significant speech impairments.

Limitations and future directions

The study had some limitations. First, the research did not collect data on generalization across different contexts, people, and items. Future research should investigate the efficacy of the NLP combined with the AAC intervention in the occurrence of augmented and non-augmented communication in novel situations. Another limitation is related to the measurement of spontaneous vocalizations despite the fact that all participants uttered approximate vocalizations only. The way that vocalizations were measured provided general information about the occurrence of spoken language. Further research should consider measuring vocalizations in terms of approximate, full-word utterances and distinguish between prompted and unprompted vocalizations. Further, given the lack of information regarding the intelligibility of the vocalizations, future studies are encouraged to measure speech intelligibly. In addition, because all the participants had some spoken language in their repertoire, there was no way to know whether the naturalistic teaching strategy and augmented interventions would be effective in the emergence of vocalizations in children with ASD without spoken language in their repertoires. Finally, the social validity ratings of the instructors could have been influenced by the demand characteristics (Nichols & Maner, 2008). Therefore, future research should assess the social validity of the study using other caregivers who did not take part in the experiment.

Conclusion

The findings of the current study indicated that the NLP with time delay might be effective in increasing spontaneous vocalization and augmented requesting in children with ASD and limited functional communication skills. Further, the implementation of the intervention in a natural context (during playtime) with common communication partners (teachers) as well as using mobile technology were other factors that could have contributed to the improvement of communication skills across all participants.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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