The Impact of an Intraverbal Webbing Procedure on the Emergence of Advanced Intraverbal Skills in Children with Autism Spectrum Disorder

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Abstract

This study investigates the effects of an intraverbal webbing procedure on the development of divergent and convergent intraverbal responses in 3 children with autism spectrum disorder between the ages of 4 and 7 years using a multiple-probe across-participants design. The participants were taught to list several members of a category (e.g., kitchen item, furniture) with a specific feature (e.g., handle, door) and to respond to fill-in-the-blank statements regarding the function, feature, and class of several item. Probes were conducted frequently to assess the emergence of untrained complex intraverbal responses. The results indicate that the intraverbal webbing procedure is effective for the acquisition of trained verbal responses to fill-in-the-blank statements. In addition, the emergence of convergent and divergent multiply controlled intraverbal responses was observed across untrained categories (e.g., school item, clothes).

Keywords Autism spectrum disorder · Divergent intraverbal skills · Emergence · Intraverbal webbing procedure

Developing preschoolers between the ages of 3 and 5 years typically begin to fill in words to favorite songs (e.g., “Twinkle, twinkle, little . . .”), comment (e.g., “I like your toy.”), and answer questions (e.g., “What is your favorite movie?”) without direct training. However, many children with autism spectrum disorder (ASD) require direct and intensive training to emit different forms of intraverbal responses. Thus, having a limited functional intraverbal repertoire poses a challenge for these children to acquire complex verbal behavior, despite having strong mand, tact, and listener responding skills (Miklos, 2010; Sundberg & Michael,

2001). Children with ASD have difficulty acquiring advanced intraverbal skills because most of their responses are under the control of a single feature of verbal conditional discrimination (VC_D), which, as a result, leads to the development of echoic or rote responding. For example, in order for a child to respond to the questions “What is a hot food you eat for breakfast?” the child must tact and respond correctly as he or she listens to the multiple verbal stimuli in the question. These stimuli include “eat,” “food,” “hot,” “hot food,” “breakfast,” “breakfast food,” and “hot breakfast food.”

Intraverbals are imperative for an individual to acquire and develop social interaction skills, and provide the basis for establishing more advanced communication skills, such as recalling past events, solving problems, and telling stories (Sundberg & Sundberg, 2011). In typical social interactions, young children can initiate, maintain, and terminate conversations with others using a variety of novel verbal responses. However, children with ASD often need direct, intensive training to develop an intraverbal repertoire. Some studies have reported that intraverbal training may lead to the emergence of untrained listener behavior (Petursdottir & Hafliadottir, 2009) and untrained intraverbal responses (Allan, Vladescu, Kisamore, Reeve, & Sidener, 2015). However, negative side effects can be observed as a result of receiving direct intraverbal training, especially emitting

Highlights

- Conducted a single-case design study to determine the effectiveness of intraverbal webbing procedure on the emergence of generative divergent and convergent intraverbal responses
- Three young children with autism were included
- Results indicate that intraverbal webbing procedure was effective on the acquisition of trained intraverbal set
- Emergence was evident on the untrained intraverbal set across all participants

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repetitive or restricted verbal responses (e.g., repeatedly saying “Fine” in response to “How are you?”). Many children with ASD are prone to show repetitive patterns of responding when verbal prerequisite skills (e.g., mand, tact, listener responding) are missing (Sundberg & Sundberg, 2011). Accordingly, there is an urgency to develop strategies to promote emergent verbal behavior for these children to effectively acquire social and academic skills.

From the review of the intraverbal literature by Stauch, LaLonde, Plavnick, Bak, and Gatewood (2017), there are some studies that have established effective strategies for developing intraverbals in children with ASD, one of which is the transfer of the stimulus control procedure. In this strategy, the response is under the control of a supplementary stimulus (e.g., visual, echoic, physical prompts). Subsequently, the response comes under the control of the natural stimulus by gradually delaying the delivery of the prompts (Cooper, Heron, & Heward, 2007). The main benefit of this procedure is to enable the learner to emit the response under the natural discriminative stimulus (S^D). For example, in a study conducted by Valentino, Conine, Delfs, and Furlow (2015), the authors investigated the effects of using a combination of prompts (i.e., visual, echoic, textual) and a modified chaining procedure to teach storytelling to three young children with ASD. The antecedent verbal stimulus was presented by the experimenter, and a prompt (visual, textual, echoic) immediately followed in prompted trials. In transfer trials, the antecedent verbal stimulus was presented alone to transfer the control of the behavior from the prompt to the verbal stimulus. The results of these studies revealed that using prompts with modified background chaining was indeed effective for the acquisition of storytelling in children with ASD. Despite these studies having positive results, there is less known about effective strategies to develop a generative or untrained intraverbal repertoire (Shillingsburg & Frampton, 2019).

In attempts to develop emergent intraverbals, several studies have investigated the effects of teaching related skills (e.g., tact and listener responding by function, feature, and class [LRFFC], matching-to-sample) in relation to the emergence of untrained intraverbal responses. In Grannan and Rehfeldt (2012), two children with ASD were taught to emit tacts by name and category, as well as to sort pictures based on categories. After the training, the authors probed the participants’ responses to questions regarding listing several members of a category. The results demonstrated that tact and matching-to-sample training is effective for the emergence of untrained categorical intraverbals. In another study, Smith et al. (2016) investigated the effects of listener training on the emergence of untrained intraverbals in five children with ASD. The participants were trained to select a picture from an array after the experimenter presented an antecedent verbal stimulus regarding the function, feature, or class (FFC) of an item (e.g., “Which one is an animal?”). When a mastery criterion was

met, the authors probed emergent intraverbals by asking questions pertaining to the FFC of targeted items (e.g., asking “Which one is an animal?” without presenting pictures). Four out of the five participants were found to have gained untrained intraverbals following the training; one participant needed additional tact training to demonstrate untrained intraverbals. Further, the teaching of different response topographies to a certain antecedent stimulus (i.e., multiple-exemplar instruction [MEI]) has been shown to be effective for establishing an emergent intraverbal repertoire. In a recent study conducted by Shillingsburg and Frampton (2019), results indicated that MEI facilitates generative intraverbal responses after exposure to tact and listener training.

Despite the positive outcomes of training related skills on the emergence of untrained intraverbal responses, some studies have reported that the procedure fails in some cases to increase generative intraverbals (Allan et al., 2015; Perez-Gonzalez, Garcia-Asenjo, Williams, & Carnerero, 2007). Direct intraverbal training was necessary for participants to emit generative responses in some cases where the tact and the listener training alone was not effective. For instance, in a study by Shillingsburg, Frampton, Cleveland, and Cariveau (2018), four participants (out of six) were found to have gained generative intraverbals after receiving training on tact and listener relations. The other two participants needed additional multiple relations, including intraverbals, to acquire untrained intraverbal responses.

Per Skinner’s analysis of verbal behavior (1957), most verbal responses are under the control of multiple antecedent stimuli (e.g., motivating operation, verbal and nonverbal variables). From this, Michael, Palmer, and Sundberg (2011) introduced two types of multiple control that govern verbal behavior: divergent and convergent multiple control. *Divergent multiple control* refers to the emission of multiple responses as a result of a single antecedent stimulus (Michael et al., 2011). For example, a child says “Apple, orange, and grapes” in response to “Tell me some fruits.” When a response occurs under the influence of several antecedent stimuli, it is said to be *convergent multiple control* (Michael et al., 2011). For example, a child says “Apple” in response to “Tell me a red fruit.” In other words, multiple verbal stimuli (e.g., “red” and “fruit”) in the S^D cause the response (i.e., VC^D).

A recent review of the literature (Stauch et al., 2017) summarized work that delineates the development of divergent and convergent multiply controlled intraverbal responses in children with ASD. For divergent multiple control, participants were trained to emit multiple verbal responses following the presentation of simple (e.g., “What are some animals?”) or VC^D (e.g., “Tell me some animals that live in the sea.”). Several studies focused on teaching categorical intraverbals using different strategies, such as instruction feedback and prompt delay (Carroll & Kodak, 2015), a lag schedule of reinforcement (Contreras & Betz, 2016), tact-to-intraverbal transfer (Feng, Chou, & Lee, 2015; Grannan & Rehfeldt, 2012),

intraverbal prompts based on FFC (Lee, Chou, & Feng, 2017), and stimulus control transfer (Goldsmith, LeBlanc, & Sautter, 2007). As for convergent multiple control, studies used multiple components of verbal discriminative stimuli that lead to the emission of a verbal response. Several strategies have been reported to develop convergent multiple control, such as stimulus equivalence training (Daar, Negrelli, & Dixon, 2015), reverse intraverbal training (Dickes & Kodak, 2015), LRFFC training (Kodak & Paden, 2015), and visual and echoic prompts (Vedora & Conant, 2015). Despite the available research on establishing advanced intraverbal skills, it is unknown whether direct training on both divergent and convergent multiple control would lead to the emergence of untrained complex intraverbal responses.

Studies that combined both divergent and convergent multiply controlled intraverbals are very scarce (Feng et al., 2015; Grannan & Rehfeldt, 2012). In the study by Feng et al. (2015), a 6-year-old boy with ASD was trained to list several members of a category in response to a compound verbal stimulus (e.g., “What are some animals that live on land?”) using tact-to-intraverbal control transfer. The results showed that the procedure was effective in producing a spontaneous emission of untrained intraverbal responses. Similarly, one participant in the study by Grannan and Rehfeldt (2012) responded to both divergent and convergent multiply controlled stimuli (e.g., “What are four body parts?”) following tact training.

Because complex intraverbal skills are imperative for the development of language repertoires, the present investigation aimed to extend previous research (Feng et al., 2015; Grannan & Rehfeldt, 2012) by adopting an intraverbal webbing procedure (i.e., semantic feature mapping) suggested by Carbone (2018). In the intraverbal webbing procedure, the child learns to fill in several statements in succession regarding the FFC of a specific category (e.g., theme or topic). For example, a child says “Cup” in response to the VC^D “Tell me something with a handle.” Then, the instructor will say “And a cup is something you . . .,” and the child says “Drink.” After that, the child responds with “Handle” to the VC^D “And a cup has a . . .” Finally, the instructor will present the VC^D “Right, and a cup is a . . .,” and the child responds “Kitchen item.” The procedure accentuates the development of both convergent and divergent multiple control by establishing stimulus and response classes in a flexible manner and prevents the formation of rote or scripted responding. Further, the webbing procedure is designed to teach advanced intraverbal skills that would accelerate stimulus and response generalization, as well as correct responding to complex antecedent verbal stimuli (Carbone, 2018). In addition, it helps prompt the development of typical intraverbal behavior. Thus, the purpose of this study was (a) to evaluate the effects of an intraverbal webbing procedure on the development of convergent and divergent intraverbal responses and (b) to determine the extent to which the procedure increases the emergence of untrained advanced intraverbal skills.

Method

Participants and Setting

Three participants between the ages of 4 and 7 years were included in the study. All three participants received a diagnosis of ASD by a child psychiatrist. They were receiving applied behavior analysis (ABA) from an autism service provider in Saudi Arabia for 24 hr each week. John, a 5-year-old child, had been receiving services from an ABA provider for 4 months. Maddox, a 4-year-old child, and Rick, a 7-year-old child, had been receiving services for 6 and 8 months, respectively. The most recent Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008) was conducted 1 month prior to the initiation of the study. All three participants received scores that showed their skills were primarily in the 18- to 30-month range (Level 2): 81.5 for John, 89.5 for Maddox, and 82 for Rick. Table 1 contains additional information about the participants’ scores for language skills.

John and Maddox used one to two words for manding (e.g., “Want ball.”) and tacting (e.g., “Rolling ball.”). Rick, however, mainly emitted single words to mand for preferred items (e.g., “Juice.”) and two-word phrases for tacting (e.g., “Closing door.”). All participants were able to expressively and receptively identify the correct items for fill-in-the-blank statements and questions about the FFC of several items. For example, John pointed to a picture of a ball when asked to find an item that could be used for play. When asked to respond to the question “What do you do with a ball?” he was able to say “Play with.”

The study took place at the service provider’s clinic, and the sessions were conducted in the participants’ one-on-one room where they received an intensive behavior intervention service. The room contained a table, two chairs, a shelf with books, toys, and picture cards. Sessions were conducted 3 days per week, once to twice per day, and lasted for approximately 3 to 5 min.

Table 1 Participant VB-MAPP Milestone Scores

Milestones	John	Maddox	Rick
Mand	8.5	8	7
Tact	10	8.5	9
LR ^a / ^a Listener responding	8	8	8.5
LRFFC ^b / ^b Listener responding by function feature and class	5	3	3.5
Intraverbal	5	4	4.5

Verbal Behavior Milestones Assessment and Placement Program (Sundberg, 2008)

^a Listener responding by function feature and class

^b Listener responding by function feature and class

Materials

There were four categories of fill-in-the-blank statements (i.e., kitchen items, furniture, school items, and clothes): two categories (i.e., kitchen items, furniture) were used for training, and the other two categories (i.e., school items, clothes) were used to test for emergence. In each category, there were 12 antecedent verbal stimuli regarding the FFC of three items within the category. For S^D s regarding the function of items, single-word responses were accepted with the action without the appropriate preposition (e.g., “drink from,” “cook with,” “sleep on”) given that all participants did not receive tact or listener response training in prepositions. Tables 2 and 3 show target items and responses for trained and untrained categories.

Experimental Design

We used a multiple-probe design across participants to evaluate the effectiveness of the intraverbal webbing procedure on the acquisition of divergent and convergent intraverbal skills. Baseline probes were implemented across all categories and participants. When the baseline data reached stability for John (i.e., no more than 5% variability on the dependent measure), he moved to the intensive training phase while the

experimenter continued to collect baseline probe data on Maddox and Rick. The same procedure was followed for moving from baseline and the intervention phase. Baseline probes were conducted once to twice per day and three times per week. After baseline probes, four sessions of intensive training were conducted on two categories (i.e., kitchen item, furniture). Then, a postintervention phase was conducted on the trained categories until the participants reached the acquisition criterion (at least 11 correct responses across two consecutive sessions for both categories) while the experimenter probed emergence on the other categories (i.e., school item, clothes). During the initial postintervention phase, a single probe was conducted for each untrained category. When the participants scored at least eight correct responses across two consecutive sessions, probes on untrained categories were conducted once a day for each category three times per week.

Response Measurement and Interobserver Agreement

The dependent measure was the number of correct verbal responses emitted during daily probes. For a response to be considered correct, the participant had to emit a verbal response that was under the control of the antecedent verbal

Table 2 Intraverbal Targets for Training

Category	Target	Discriminative Stimulus	Response
Kitchen item	Cup	“Tell me a kitchen item with a handle.”	“Cup.”
		“And a cup has a . . .”	“Handle.”
		“And a cup is something you . . .”	“Drink.”
		“Right, and a cup is a . . .”	“Kitchen item.”
	Fridge	“So tell me a kitchen item with a door.”	“Fridge.”
		“And a fridge has a . . .”	“Door.”
		“And a fridge keeps food . . .”	“Cold.”
		“And a fridge is a . . .”	“Kitchen item.”
	Pot	“Tell me kitchen item with a lid.”	“Pot.”
		“And a pot has a . . .”	“Lid.”
		“And a pot is something you . . .”	“Cook.”
		“Right, and a pot is a . . .”	“Kitchen item.”
Furniture	Bed	“Tell me a furniture with blankets.”	“Bed.”
		“And a bed has . . .”	“Blankets.”
		“Right, a bed is something you . . .”	“Sleep.”
		“And a bed is . . .”	“Furniture.”
	Couch	“Tell me furniture with cushions.”	“Couch.”
		“And a couch has . . .”	“Cushions.”
		“And a couch is something you . . .”	“Sit.”
		“And a couch is . . .”	“Furniture.”
	Bathtub	“So tell me a furniture with a faucet.”	“Bathtub.”
		“And a bathtub has . . .”	“Faucet.”
		“Right, a bathtub is something you . . .”	“Bathe.”
		“And a bathtub is . . .”	“Furniture.”

Table 3 Intraverbal Targets for Emergence

Category	Target	Discriminative Stimulus	Response
School item	Pen	“Tell me a school item with ink.”	“Pen.”
		“And a pen has . . .”	“Ink.”
		“Right, a pen is something you . . .”	“Write.”
		“And a pen is a . . .”	“School item.”
	Book	“Tell me a school item with pages.”	“Book.”
		“And a book has . . .”	“Pages.”
		“And a book is something you . . .”	“Read.”
		“And a book is a . . .”	“School item.”
	Pencil	“So tell me a school item with an eraser.”	“Pencil.”
		“And a pencil has an . . .”	“Eraser.”
		“Right, an eraser is something you . . .”	“Erase.”
		“And an eraser is a . . .”	“School item.”
Clothes	Shirt	“Tell me clothes with sleeves.”	“Shirt.”
		“And a shirt has . . .”	“Sleeves.”
		“Right, a shirt is something you wear on your . . .”	“Arm.”
		“And a shirt is . . .”	“Clothes.”
	Pants	“And tell me clothes with pockets . . .”	“Pants.”
		“And pants have . . .”	“Pockets.”
		“And pants are something you wear on your . . .”	“Legs.”
		“And pants are . . .”	“Clothes.”
	Shoes	“So tell me clothes with laces . . .”	“Shoes.”
		“And shoes have . . .”	“Laces.”
		“And shoes are something you wear on your . . .”	“Feet.”
		“And shoes is . . .”	“Clothes.”

stimulus presented by the experimenter within 5 s. For example, if the participant responded with “Cup” to the statement “Tell me a kitchen item with a handle,” the response would be scored as correct. If, however, the participant said “Door,” this response would be scored as incorrect.

In intervention probes, the experimenter presented four trials for each target and one trial for each S^D . For example, the probe would start with “Tell me furniture with blankets” and ran the remaining S^D s related to the target item (e.g., “And a bed is a . . .,” “And a bed has . . .,” “Right, a bed is something you . . .”). As for the baseline probes, the experimenter ran three trials, one for the main S^D s for each target (e.g., “Tell me something with cushions.”). If the participant responded correctly to the statement, the experimenter presented another randomly selected S^D related to the target. For example, if the participant responded to “Tell me something with cushions” with “Couch,” the experimenter would then present a new trial: “And a couch is . . .” However, if the participant did not respond or provided an incorrect answer, the experimenter moved to the next main S^D (e.g., “Tell me a kitchen item with a handle.”).

An independent observer collected interobserver agreement data by recording the number of correct verbal responses for each session across all phases and participants. The average agreement for John and Maddox was 98% during baseline, intensive training, and postintervention. For Rick, the

average agreement was 99% across all phases. The independent observer also collected procedural integrity data on all sessions, and the integrity was 100% across all phases.

Procedures

Pretest A pretest was conducted to select target members of several categories for training and to probe for emergence. The pretest consisted of categorical intraverbals, LRFFC, and TFFC on potential targeted categories: kitchen item, furniture, school item, and clothes. Table 4 shows the pretested LRFFC and TFFC for the targeted members and categories. The following sections provide a description of each section of the pretest.

Categorical Intraverbals The participant was expected to list at least three items (e.g., “Cup, pot, fridge.”) in 5 s when the experimenter provided the antecedent verbal stimulus (e.g., “Tell me some kitchen items.”). The experimenter conducted a probe for each category, for a total of three probes per day for 3 consecutive days. In each probe, the experimenter provided each antecedent verbal stimulus in a single trial. For a category to be selected as a target, the participant had to list three target items within a category in each probe.

Table 4 Pretest listener responding by function feature and class (LRFFC) and tact function feature and class (TFFC) for Targeted Categories

Category	Function	Feature	Class
School item	You write with a . . .	What has ink?	Find a school item. [Pen]
	You read a . . .	What has pages?	Find a school item. [Book]
	You erase with a . . .	What has an eraser?	Find a school item. [Pencil]
Furniture	You sleep in a . . .	What has blankets?	Find furniture. [Bed]
	You sit on a . . .	What has cushions?	Find furniture. [Couch]
	You take a bath in a . . .	What has a faucet?	Find furniture. [Bathtub]
Clothes	You wear on your arm a . . .	What has sleeves?	Find a clothing item. [Shirt]
	You wear on your legs . . .	What has pockets?	Find a clothing item. [Pants]
	You wear on your feet . . .	What has laces?	Find a clothing item. [Shoes]
Kitchen item	You drink from a . . .	What has a handle?	Find a kitchen item. [Cup]
	You keep food cold in a . . .	What has a door?	Find a kitchen item. [Fridge]
	You cook with a . . .	What has a lid?	Find a kitchen item. [Pot]

Tact Pretest The experimenter placed a six-card array (e.g., one picture of a target item, five pictures of nontarget items) in front of the participant and provided the antecedent verbal stimulus. The participant was given 5 s to tact the item when given the function (e.g., “You write with a . . .”), feature (“What has ink?”), or class (e.g., “Find a school item.”) of the target item. The location of cards was randomly rotated prior to each trial. The experimenter conducted one probe per day for 3 consecutive days. In each probe, the experimenter ran 12 trials for each possible target item FFC, for a total of 36 trials. For a member to be selected as a target, the participant had to tact the item when given the FFC in each probe across three consecutive probes.

Listener Pretest The experimenter placed a six-card array (e.g., one picture of a target item, five pictures of nontarget items) in front of the participant and provided the antecedent verbal stimulus. The participant was given 5 s to select the item when given the function (e.g., “You sleep in a . . .”), feature (“What has blankets?”), or class (e.g., “Find a furniture.”) of the target item. The location of the cards was randomly rotated prior to each trial. The experimenter conducted one probe a day for 3 consecutive days. In each probe, the experimenter ran 12 trials for each possible target item FFC, for a total of 36 trials. For a member to be selected as a target, the participant had to select the item when given the FFC in each probe across three consecutive probes.

Baseline The experimenter conducted one probe per target, for three probes total for each category. In each probe, the experimenter started by presenting the antecedent verbal stimulus related to naming the item with a specific feature (e.g., “Tell me a kitchen item with a lid.”). If no response occurred within 5 s, the experimenter moved to the next target (e.g., “Tell me a kitchen item with a handle.”). The order of the probes was randomized in each session to prevent rote learning and to ensure that the response was under the control of the

verbal stimulus. For example, the experimenter might start with “So tell me a kitchen item with a door”; then move to the next target, “Tell me a kitchen item with a handle”; and finally conduct the last probe, “Tell me a kitchen item with a lid.” Further, the order of the S^Ds related to the targets was also randomized. For example, if the participant responded correctly (“Cup.”) to the antecedent verbal stimulus “Tell me a kitchen item with a handle,” the experimenter then presented a randomly selected antecedent verbal stimulus related to the target, “Right, and a cup is . . .”; then presented “And a cup is something you . . .”; and finally, ended the probe with “And a cup has a . . .” The experimenter did not provide differential consequences for correct, incorrect, and no responses. Verbal praise and tangible reinforcers (e.g., tokens) were provided for appropriate session behavior (e.g., sitting appropriately, putting hands in lap) after a 30-s interval. At the end of the session, the experimenter exchanged the tokens (6–10) for backup reinforcers (e.g., Play-Doh, slime, ball, cars).

Intensive Training The experimenter followed the first step in the errorless teaching procedure (prompt, transfer, distract, check) in this condition by immediately providing echoic and visual prompts (0 prompt delay) after the presentation of the antecedent verbal stimulus. For example, the experimenter immediately showed a picture highlighting the feature of the item and emitted the word “Cup” after presenting the verbal stimulus “Tell me a kitchen item with a handle.” If the participant responded correctly to the visual and verbal stimuli, the experimenter provided verbal praise and a token. In each session, there were 12 trials, with one trial for each antecedent verbal stimulus.

Postintervention The experimenter followed the second step of errorless teaching by transferring the stimulus control from the echoic and visual prompt to the verbal stimulus by delaying the delivery of the prompts and differentially reinforcing responses. The experimenter delayed the delivery of

an echoic prompt by 1 s in the first two trials. Then, the experimenter increased the delay by an additional 1 s in the following set of trials until the delay reached a terminal of 6 s. For instance, the experimenter would deliver the echoic prompt (e.g., “Cup.”) if the participant did not respond to the antecedent verbal stimulus (e.g., “Tell me a kitchen item with a handle.”) in the first trial. In the third trial, the experimenter would wait for 2 s before providing the prompt if no response occurred after issuing the verbal stimulus. After every prompted response, the experimenter provided a distracter trial (third step of errorless teaching) by instructing the participant to perform mastered motor imitation or unrelated listener tasks (e.g., “Touch your eyes.”). The experimenter then represented the antecedent verbal stimulus (fourth step of errorless teaching) to ensure that the verbal response was under the control of the target stimulus and not the echoic prompt. Reinforcers in the form of verbal praise and tokens were delivered immediately after independent and correct verbal responses. For incorrect responses, the experimenter waited 5 s and then implemented the following steps: (a) repeat the verbal stimulus, (b) immediately deliver the echoic prompt, (c) provide a distracter (mastered motor imitation or listener responding task), and (d) probe the trial. In each session, there were 12 trials, with one trial for each antecedent verbal stimulus.

Emergence Probes The experimenter probed emergence for the “School item” and “Clothes” categories. The procedure that the experimenter followed to test for emergence was exactly the same as the baseline probes previously explained.

Results and Discussion

Figure 1 shows the number of correct verbal responses given by John (top panel), Maddox (middle panel), and Rick (bottom panel) during baseline and intervention across trained and untrained sets. During baseline, none of the participants responded correctly across all sets. After the intervention, all three participants were able to meet the acquisition criterion for training sets. For the “Kitchen item” set, the average number of correct verbal responses was 10.5 (range 6–12) for John, 11.7 (range 10–12) for Maddox, and 11.3 (range 9–12) for Rick. John and Rick met the acquisition criterion in four sessions, and Maddox met the criterion in three sessions. For the “Furniture” set, the average number of correct verbal responses was 9.5 (range 4–12) for John, 11.6 (range 11–12) for Maddox, and 9.9 (range 5–12) for Rick. John reached the acquisition criterion in five sessions, and Maddox met the criterion in two sessions. Rick, however, needed a few more trials to reach the criterion compared to the other participants. He met the criterion in seven sessions.

During the postintervention period, all participants emitted generative verbal responses across all sets. For the “School item” set, the average number of correct responses was 7.1 (range 0–11) for John, 4.4 (range 0–10) for Maddox, and 4 (range 0–8) for Rick. For the “Clothes” set, the average number of correct responses was 7.3 (range 0–12) for John, 5.7 (range 0–11) for Maddox, and 3.7 (range 0–8) for Rick.

The current study investigated the effects of an intraverbal webbing procedure on the acquisition and emergence of convergent and divergent multiply controlled intraverbal responses in young children with ASD. All participants demonstrated divergent (e.g., “cup,” “fridge,” and “pot” for kitchen item) and convergent (e.g., “bed” for the variables “furniture” and “blankets” in the VCD) multiply controlled intraverbal responses for both trained categories. After reaching mastery-level responses for trained categories, participants demonstrated varying degrees of emergence for the untrained categories. Both John and Rick showed a high number of correct responses (of the divergent control) for the “School item” category compared to the untrained “Clothes” category. They demonstrated less emergence of convergent multiple control for the “School item” category compared to the “Clothes” category. This may be a result of the similarity in the features (e.g., erase, ink) of some of the targeted items (e.g., pen, pencil) in the “School item” category. Maddox’s results indicate that emergence was observed for the convergent multiply controlled intraverbal responses (e.g., “shirt,” “pants,” and “shoes” for the verbal stimuli “clothes” with “sleeves,” “pockets,” and “laces”) for both untrained categories. He showed little emergence for the divergent multiply controlled intraverbal responses for the “School item” category compared to the untrained “Clothes” category. Overall, two participants out of three demonstrated more generative responses for one untrained set (i.e., the “School item” category) compared to the other set (i.e., the “Clothes” category).

These findings add to our understanding of teaching advanced intraverbal skills to children with ASD in three ways. The use of a combination of visual and echoic prompts was shown to be an effective strategy to develop advanced intraverbal skills in young children with ASD and is consistent with the results of prior studies (Feng et al., 2015; Grannan & Rehfeldt, 2012; Ingvarsson & Hollobaugh, 2011; Valentino et al., 2015; Vedora & Conant, 2015). Some studies have compared the effectiveness of echoic and visual prompts in developing intraverbal skills and commonly found that visual prompts led to a rapid increase in acquisition compared to echoic prompts (Ingvarsson & Hollobaugh, 2011; Vedora, Meunier, & MacKay, 2009). One possible reason for the superiority of visual, compared to auditory, stimuli might be that most children with ASD are visual learners (West, 2008). However, future research is needed to investigate whether using visual prompts or echoic prompts, individually, will lead to the establishment of emergent divergent and convergent multiply controlled intraverbal responses.

Fig. 1 The number of correct verbal responses for trained and untrained categorical intraverbals across all participants

Furthermore, the emergence of advanced intraverbal skills may result from tact responding and also having previously received training in LRFFC. Previous studies have shown that LRFFC and tact training facilitate the

emergence of untrained intraverbal skills in some individuals with ASD (e.g., Smith et al., 2016). Even though all three participants in this study demonstrated the acquisition of trained advanced intraverbal responses and the

emergence of untrained advanced intraverbal responses, their performance did not correspond with their scores in the LRFFC and tact domains (i.e., VB-MAPP; Sundberg, 2008). For example, Maddox's performance for the trained intraverbal sets was superior to the performances of John and Rick, despite Maddox having lower scores in both the LRFFC and tact domains. Therefore, it is not clear whether having tact and listener repertoires leads to the development of advanced skills (Sundberg & Sundberg, 2011).

Another factor that may have led to the emergence of untrained advanced intraverbal skills is the inclusion of the same component of verbal discriminative stimuli (VS^Ds) for the trained (e.g., "Tell me a [kitchen item] with [a handle].") and untrained (e.g., "Tell me a [school item] with [ink].") sets. Similar results were also reported in a study by May, Hawkins, and Dymond (2013), in which the ability to emit untrained responses in relation to common VS^Ds across trained and untrained sets was demonstrated. Future research should compare the emergence of untrained advanced intraverbal responses across sets with and without common VS^Ds.

The results of this study should be considered in light of some limitations. First, maintenance data were not collected for the acquired advanced intraverbal skills. Therefore, it is unknown whether the participants were able to maintain their intraverbal response after the intervention. Second, the occurrence of novel responses across trained and untrained sets was not measured. However, none of the participants emitted novel intraverbal responses for both sets. Future research should collect data on the emission of novel advanced intraverbal responses.

In conclusion, the current study provides preliminary results that support the use of an intraverbal webbing procedure for the development of a multiply controlled divergent and convergent intraverbal repertoire. Future research should replicate the procedure to determine its effects on maintenance and generalization across novel stimuli.

Compliance with Ethical Standards

Conflict of Interest The author declares that she has no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional committee (Research Ethics Committee, King Saud University, KSU-HE-18-110) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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

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