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DISCUSSION/REVIEW ARTICLE

Intraverbal Training for Individuals with Autism: The Current Status of Multiple Control

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Abstract Teaching complex intraverbal responding to children with autism spectrum disorder (ASD) can be challenging and often requires careful programming. Divergent and convergent multiple control are particularly important elements to incorporate into intraverbal training programs, as well as procedures to ensure responding is under control of both discriminative and conditional vocal verbal stimuli. The current study systematically reviewed research articles on intraverbal training methods for individuals with ASD published and available from 2005 to 2016. The purpose of the review was to assess the extent to which divergent and convergent control was incorporated into training and to determine whether systematic instruction ensured correct verbal conditional discriminations. Thirty-six studies met inclusion criteria and were included in this reviewed. A total of 5 studies taught intraverbal responding under divergent control and 21 taught responding under convergent control. Two studies sufficiently described procedures to ensure accurate verbal conditional discriminations across trials. The results highlight the need for additional research on systematic teaching procedures for complex intraverbal repertoires.

Keywords Autism spectrum disorder · Intraverbal · Divergent control · Convergent control

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The Current Status of Multiple Control

Much of verbal behavior is under the control of multiple antecedent stimuli (e.g., motivational variables and verbal stimuli) and virtually all advanced intraverbal interactions are multiply controlled (Skinner, 1957). Skinner (1957) introduced the role of multiple causation on verbal behavior and outlined two types that have since been termed divergent and convergent multiple control (Michael, Palmer, & Sundberg, 2011). Divergent control is the emission of multiple responses upon one antecedent variable (Michael et al., 2011). For example, "Tomato, Green Pepper, and Potato" would be reinforced as a response to the statement "Tell me some vegetables." A response is under convergent control when multiple antecedent variables influence the strength of a single response (Michael et al., 2011). The response, "tomato" would be reinforced in the presence of the verbal stimulus, "Tell me a red vegetable." The verbal stimuli "red" and "vegetable" converge to occasion the response "tomato." Conversely, a response under control of only one of these variables, such as strawberry or carrot, would be incorrect and, therefore, would not be reinforced. Some responses may be under both divergent and convergent control, such as responding "tomato and radish" when asked to "tell me some red vegetables."

The manner in which the multiple components of a particular antecedent converge to evoke the appropriate response has been discussed as a process of developing verbal conditional discriminations (VC^D; Axe, 2008; Sundberg & Sundberg, 2011) and, alternatively, as the result of compound stimuli (Eikeseth & Smith, 2013). A compound stimulus is present when a response is jointly controlled by two or more stimuli or elements of a stimulus. Conversely, in conditional discriminations, the effect of an S^D depends (is conditional) on other stimuli. Although there is uncertainty as to the precise sources of control involved in complex intraverbals, multiple antecedent stimuli converge to control responding in both the VC^D and compound stimuli accounts. One way to confirm that responding is under the control of both components of the antecedent is to vary instructions with multiple stimulus combinations of overlapping components and observe responding (e.g., responses to "tell me some red vegetables," "red fruits," "green fruits," and "green vegetables").

Children begin emitting complex intraverbals without explicit instruction between the ages of 3 and 4 years, and by 5 years of age most children accurately make VC^Ds, are able to hold conversations, talk about past and present events, and tell short stories (Sundberg & Sundberg, 2011). However, some children with autism spectrum disorders (ASD) have difficulty acquiring a complex intraverbal repertoire without explicit instruction (Miklos, 2010). Several of the core characteristics associated with ASD, such as stimulus overselectivity and rote or echolalic responding could impact the acquisition of complex intraverbals for children with ASD (Lovaas, Koegel, & Schreibman, 1979; Walpole, Roscoe, & Dube, 2007; Pollard, Betz, & Higbee, 2007). Overselectivity, also referred to as restricted stimulus control, is commonly observed in individuals with ASD and occurs when an individual responds to a compound stimulus based on a single feature (e.g., Kogel & Wilhelm, 1973; Sundberg & Sundberg, 2011). Such restricted stimulus control is likely to impede an individual's ability to emit intraverbals under convergent control. Likewise, individuals with ASD are more likely

than typically developing children to engage in rote or echolalic responding (Sundberg & Sundberg, 2011) impeding their ability to emit intraverbals under divergent control. For example, a child might learn one response and repeatedly emit only that response when a variety of other responses could occur. As such, specialized interventions may be required to teach individuals with ASD simple and complex intraverbals.

The ability to emit intraverbals that are multiply controlled is necessary for more advanced language skills and it is often the rule, not the exception, that most responses involve a VC^D (Axe, 2008) and/or responding to compound stimuli (Eikeseth & Smith, 2013). Failure to consider the role of multiple control when teaching intraverbals to individuals with ASD can result in rote responding or responding under the control of just one relevant component of the antecedent stimulus. Take for example an individual who provides the same response to the following questions, "What did you do this weekend?" and, "Who did you see this weekend?" When responses fail to come under the control of multiple antecedent variables, it greatly impedes an individual's ability to succeed academically and socially. As such, it is essential that behavior analysts and researchers design and implement instructional programs that bring intraverbals under proper sources of multiple control, a process which requires careful analysis of teaching arrangements.

In 2008, Axe reviewed a sampling of the literature published from 1983 to 2007 to identify the extent to which researchers have examined and incorporated VC^Ds in intraverbal teaching procedures for individuals with disabilities. Axe concluded that the literatures of conditional discriminations and Skinner's (1957) analysis of verbal behavior have not influenced each other. In this review, Axe reported only one experimental study (i.e., Braam & Poling, 1983) that putatively analyzed VC^Ds in the intraverbal relation.

Braam and Poling (1983) conducted three experimental studies in which they taught three individuals with developmental disabilities to name items in a category (food, clothes, and school) using a tact-to-intraverbal transfer of stimulus control procedure. The S^Ds (e.g., school things, work things) might have occasioned a VC^D, but the evidence for participants doing so was not clearly presented. Thus, to show that responding was under control of all relevant verbal stimuli, researchers in this study arranged S^Ds in a manner that varied overlapping components across trials (e.g., school things, work things, school people, work people). By doing so, they ensured that responses aligned with each component of the verbal stimulus.

Given the difficulties individuals with ASD may have in acquiring a complex intraverbal repertoire, the purpose of the current review was to examine strategies used to teach intraverbals to individuals with ASD using Axe's (2008) conceptualization of intraverbals under divergent and convergent control as well as VC^Ds. The current study extends Axe by assessing studies published from 2005 to 2016 and utilizing a systematic search and coding protocol. Finally, procedures were evaluated to determine whether instructional trials were arranged in a manner that ensured participants made VC^Ds.

Method

Search Procedures

A four-step model for locating studies was used in the present investigation. First, researchers conducted an electronic search of the databases, *Pro-Quest* and *Education*

Resources Information Center (ERIC), using the following terms: *intraverbal* and *autism, aut*, ASD,* or *Asperger*. Second, the reference list of each article that met inclusion criteria (described below) was reviewed by a member of the research team to identify studies that included the terms autism and intraverbal in the title or abstract. Third, researchers reviewed the table of contents of each issue of *The Analysis of Verbal Behavior* from 2005 to 2016 in order to identify studies that included the terms autism and intraverbal in the title. Fourth, authors included any studies they knew had been published in the designated time period but that did not emerge from the preceding search procedures. The search was restricted to articles published and available in an English language, peer-reviewed journal in print or online through 2016. All abstracts identified from the initial search procedures were reviewed to determine eligibility for inclusion in this review. A total of 65 non-duplicated articles were located via the search procedures described above.

Inclusion and Exclusion Criteria

The abstracts of the 65 articles containing the search terms were screened for the following inclusion criteria: (a) the study explicitly taught intraverbals, (b) included at least one individual diagnosed with ASD, and (c) the study utilized a single case experimental design. If a study included participants with and without ASD and the data for the participant with ASD could be extracted from the rest, that participant was included and those without ASD were excluded from review. If the data for the participant with ASD could not be separated from the rest, the study was excluded.

Coding of Studies

The third author created a coding protocol that was used to summarize relevant information from included studies. The following variables were extracted from each article and are described in more detail below: participant characteristics, type of S^D presented, total number of S^Ds, and type of prompting procedures used in the investigation. In addition, the research methods were reviewed to determine the extent to which divergent control, convergent control, and conditional discriminations were incorporated into the instructional procedures and response requirements.

Participant Characteristics

Data were collected on the number and age in years of participants diagnosed with ASD in each study. Results of standardized or non-standardized assessments that were administered to participants prior to the start of the study were recorded. Verbal behavior repertoires, including tact, echoic, and intraverbal skills, were coded as a yes if researchers reported that participants possessed the skill, as a no if participants did not possess the skill or indicated the skill was absent or weak, or as not applicable if researchers did not explicitly state whether participants had the skill in their repertoire. To get a better understanding of participants' intraverbal skills, the written description of participants' intraverbal repertoire (e.g., ability to answer fill in statements or answer "wh" questions) was also recorded.

Types of Discriminative Stimulus

Researchers coded whether the intraverbal S^D was a question, statement, single word, or list of items in a category. Researchers also coded the total number of different S^Ds included in the study.

Types of Instructional Procedures

Researchers coded the type of controlling prompt that was initially used to occasion the correct response. Prompt types were coded as: echoic, tact (with objects or pictures), textual, gestural, manual (physical), or not applicable if no prompts were used.

Divergent Multiple Control

Researchers determined whether the S^D was delivered in such a manner that could occasion varied responding (e.g., "Tell me types of fruit" as opposed to "Tell me your name") and, if so, whether varied responding was required by researchers. For example, if instructed to name "home things" and the child responded "desk" followed by another trial with same S^D and the child was required to name an item that varied from the previous trial, such as "refrigerator," this variable was coded as yes. If the child could emit the same response for each trial, this item was coded as no. If varied responding was required, the researchers coded the study as one in which divergent multiple control was incorporated into the procedures. Similarly, if participants were required to respond with multiple responses to an S^D in a single trial (e.g., the S^D "name some toys" required participants to list multiple toys), this was also coded as a study in which divergent multiple control was incorporated.

Convergent Multiple Control

Each study was assessed to determine whether responding was under convergent multiple control and whether the order of stimulus presentation (i.e., trials) made conditional discriminations necessary. A study was coded as bringing responding under convergent multiple control if participants had to respond to two parts of the vocal stimulus in order to produce an accurate response. For example, if a participant was asked, "What is a red fruit?" convergent control was involved because a correct response was under the control of "red" and "fruit." Conversely, if the S^D was simply "Fruit," the study did not involve convergent control.

Verbal Conditional Discriminations

Studies were also evaluated to determine if antecedent stimuli were arranged in such a manner as to require a conditional discrimination across S^Ds (i.e., ensure control by multiple components). In order to be scored as requiring a VC^D, an article had to include enough information to determine whether multiple vocal-verbal antecedent stimuli controlled responding on a given trial and whether these antecedent stimuli were sequenced in a manner that systematically manipulated both the conditional and discriminative stimuli across trials (Axe, 2008).

Intercoder Agreement

All authors reviewed the coding definitions and independently coded two practice articles that were published prior to the inclusion years for the present review to reach 100% intercoder agreement with the third author. Once intercoder agreement was established among authors, reviewers independently coded studies. All studies were coded by at least two reviewers. Each item on the coding document (available from the first author) was scored as an agreement or disagreement across reviewers. Total agreements for an individual study were divided by the sum of agreements and disagreements for that study and multiplied by 100 to derive a percentage of agreement for each study. Mean intercoder agreement for all included studies was 82% (range, 63 to 100%). Any discrepancies in scoring were discussed by both coders until a consensus was reached and final codes were derived for each study. The third author then randomly selected 30% of studies to conduct a reliability assessment. Mean intercoder agreement for this second reliability assessment was 94% (range, 82 to 100%).

Results

Overview of Studies

Of the 65 articles identified in the initial search, 28 published papers with 29 total experiments (one paper included two experiments) met inclusion criteria for investigating interventions to teach intraverbals to children with ASD. A review of the table of contents from The Analysis of Verbal Behavior from 2005 to 2016 produced six additional studies; a seventh study was identified by the authors as a known published manuscript that did not emerge in the search (Feng, Chou, & Lee, 2015), for a total of 36 experiments reviewed in the present investigation. Table 1 summarizes the antecedent variables involved in the training protocol, the types of multiple control, and whether a VC^D across trials was necessary for each study.

Participant Characteristics

There were 91 total participants across all included studies, with a mean age of 7 years, 11 months (range, 3 to 44 years old). Thirty-six percent (n = 13) of studies provided information from standardized language and intelligence assessments (e.g., Peabody Picture Vocabulary Test, Stanford Binet Verbal) and 25% (n = 9) of studies provided participant information from non-standardized assessments such as The Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP; Sundberg, 2008). Eighty-six percent (n = 31) of studies provided a description of participant's verbal repertoires by operant, and the remaining studies (n = 5) did not provide information on specific verbal repertoires of participants.

Among the 31 studies that reported information on participants' verbal repertoire, 52% (n = 16) of studies reported that participants had an echoic repertoire, 3 reported that participants did not have an echoic repertoire, and 12 studies did not provide sufficient information to code this variable. Similarly, 58% (n = 18) of studies reported participants had a tact repertoire, 3 studies stated participants had an absent or weak tact

Table 1 Antecedent variables involved in the training protocol

Author (year)	Type of S^D	Condition discriminations and/or control in training			Type of prompt
		Divergent	Convergent	Conditional discrimination	
Allan et al. (2015)	Single word	No	No	No	Echoic
Arntzen, Tønnessen, and Brouwer (2006)	Question	–	–	–	Echoic, gestural, verbal, model
Carnett and Ingvarsson (2016)	Question	No	No	No	Verbal, textual
Carroll and Kodak (2015)	Statement	Yes	No	No	Echoic
Contreras and Betz (2016)	Statement	Yes	No	No	Tact (visual)
Daar et al. (2015)	Question	No	Yes	–	Tact (visual), physical, verbal
Dickes and Kodak (2015)	Question	No	Yes	–	Echoic
Emmick et al. (2010)	Question, statement	No	Yes	No	Verbal, textual, model, gestural
Feng et al. (2015)	Question statement	Yes	Yes	No	Tact (visual)
Goldsmith et al. (2007)	Question	Yes	No	No	Tact (visual)
Grannan and Rehfeldt (2012)	Question	Yes	Yes	Yes	Echoic, manual
Greer, Yaun, and Gautreaux (2005)	Statement	No	No	No	Verbal
	Statement	No	No	No	Verbal
Haq et al. (2015)	Question	–	–	–	Echoic
Humphreys, Polick, Howk, Thaxton, and Ivancic (2013)	Question	No	Yes	–	Echoic
Ingvarsson, Cammilleri, and Macias (2012)	Question	No	Yes	No	Echoic, tact
Ingvarsson and Hollobaugh (2010)	Question	No	Yes	No	Visual
Ingvarsson and Hollobaugh (2011)	Question	No	–	No	Visual, vocal
Ingvarsson et al. (2016)	Question	No	Yes	Yes	Echoic
Ingvarsson and Le (2011)	Question	No	Yes	No	Echoic, textual, tact
Kisamore et al. (2016)	Question	No	Yes	Yes	Echoic
Kodak et al. (2012)	Question	–	–	–	Echoic, tact

Table 1 (continued)

Author (year)	Type of S^D	Condition discriminations and/or control in training			Type of prompt
		Divergent	Convergent	Conditional discrimination	
Kodak and Paden (2015)	Statement	No	Yes	No	Echoic
Lerman et al. (2005)	Statement	No	Yes	No	–
Lorah et al. (2015)	Question	No	No	No	Physical
Mason et al. (2015)	Question	No	No	No	–
May et al. (2013)	Question	No	Yes	Yes	Tact (visual)
Pérez-González et al. (2007)	Statement	No	Yes	No	Verbal, model
Polick et al. (2012)	Question	No	Yes	Yes	Echoic
Scattone and Billhofer (2008)	Statement	No	No	No	Model, physical
Valentino et al. (2015)	Question statement	No	–	–	Textual, echoic
Valentino and Shillingsburg (2011)	Statement	No	Yes	–	–
Valentino, Shillingsburg, and Call (2012)	Question	No	Yes	No	Echoic, model
Vallinger-Brown and Rosales (2014)	Question	No	Yes	No	Gestural, echoic
Vedora and Conant (2015)	Question	No	Yes	No	Echoic, textual, tact
Vedora, Meunier, and Mackay (2009)	Question	No	Yes	No	Textual, echoic

repertoire, and 10 studies did not report information on participants' tact repertoire. A total of 64% ($n = 21$) of studies reported participants had at least some intraverbal skills prior to the start of the study, three stated participants did not have an intraverbal repertoire, and seven did not provide sufficient information to code this variable.

Types of Discriminative Stimuli

Among the studies included in this review, the most common S^D was in a question format presented by the researcher (64%; $n = 23$). In nine studies, statements were reported as the vocal S^D. Three of the studies included both questions and statements as the S^D (Emmick, Cihon, & Eshleman, 2010; Feng et al., 2015; Valentino, Conine, Delfs, & Furlow, 2015) and one study involved a single word as the S^D (Allan, Vladescu, Kisamore, Reeve, & Sidener, 2015). One to seventy-eight different questions or statements as S^Ds were included in the sampled studies. Nine studies included one to five questions or statements, ten studies included five to ten questions or statements, eleven studies included 11 to 20 questions or statements, and two studies included more than 20 questions or statements. Four studies provided insufficient information to code the number of different questions or statements.

Types of Instructional Procedures

A total of 36% ($n = 13$) of studies reported using an echoic prompt, manual prompt, or gestures to teach the target response. Four studies reported using a picture to prompt the correct response (Contreras & Betz, 2016; Feng et al., 2015; Goldsmith, LeBlanc, & Sautter, 2007; May, Hawkins, & Dymond, 2013), one study reported using manual guidance to prompt the selection of a correct intraverbal on a speech-generating device (Lorah, Karnes, & Speight, 2015), one study reported using both an echoic and textual prompt (Carnett & Ingvarsson, 2016), and three studies did not report using a prompt (Lerman et al., 2005; Mason, Davis, & Andrews, 2015; Valentino & Shillingsburg, 2011).

Type of Multiple Control in Intraverbal Training

Divergent Control

There were 31 studies that described procedures sufficiently to code whether the S^D occasioned the opportunity for multiple responses or responding under divergent control. Among these 31 studies, 56% ($n = 20$) involved an S^D that could occasion varied responding or multiple responses and 11 studies involved an S^D that occasioned a single response topography (e.g., "What is your name?"). The remaining five studies did not provide a sufficient description of the S^D to determine whether multiple response forms were possible or required.

The 20 studies that used an S^D that could occasion multiple responses were further evaluated to determine if participants were required to emit varied response topographies thereby demonstrating intraverbal responding under divergent control. Thirteen of these studies did not require varied responding, two studies (Haq et al., 2015; Kodak, Fuchtman, & Paden, 2012) provided insufficient information about the

response requirement to reach a conclusion about divergent control, and five required varied responding or multiple responses and are described below.

Goldsmith et al. (2007) investigated whether children with ASD could learn to respond to questions about items in categories using a transfer of stimulus control procedure. The S^D required responding to questions about function (e.g., "What are some things you wear?") or class (e.g., "What are some fruits?") across various categories (e.g., furniture, clothes, fruits). Following the S^D, the researchers immediately placed a picture of a correct response in front of the participant to prompt a response, which was then immediately reinforced and a picture of another correct response within the designated category was presented, without presentation of another vocal S^D. This continued until participants emitted five predetermined correct responses to the S^D for each category. Picture prompts were faded using a continuous 3-s time delay. All participants acquired the targeted responses, with categorical intraverbals emerging faster for the second and third sets than the first. However, following the intervention, none of the participants demonstrated response generalization to a novel category when probed.

Grannan and Rehfeldt (2012) also examined categorical responding by two children with ASD following training to tact pictures, training to tact categories when presented with a picture (e.g., "body part" when presented with ear), and training to match pictures to other pictures in the same category (e.g., cars and planes in the vehicle category). Before and after tact and match-to-sample training, researchers probed participants' responding to questions about each category (e.g., "What are four vehicles?"). Both participants emitted intraverbals under divergent control (i.e., stating multiple responses for a given category) across all categories during the post-test despite emitting no intraverbals during the pre-test.

Carroll and Kodak (2015) compared the effects of prompt delay and prompt delay with instructive feedback on the emission of varied intraverbals to categories by two children with ASD. During the instructive feedback condition, researchers vocally listed additional items within a given category following the participants' initial response. Although participants were not required to echo the additional responses modeled by the therapist, both participants demonstrated increased variability in responding during subsequent trials in this condition.

The investigation by Contreras and Betz (2016) also targeted varied responding across trials. The investigators used a lag schedule of reinforcement to produce novel responding to instructions such as, "Tell me something you find in a kitchen." Two participants emitted varied responding to each vocal S^D with a lag reinforcement schedule only. A third participant required variability training, which involved presenting a picture of a correct response as a prompt, then fading the prompt to transfer stimulus control to the vocal S^D.

Feng et al. (2015) taught a 6-year-old boy with ASD to vary responding to questions about fruits and animals using pictures to prompt responses under divergent control both within and across trials. The participant was initially required to provide at least two correct intraverbals to questions about subcategories (e.g., "What are animals that live on land?"). On subsequent trials, the researchers used pictures of stimuli the child did not previously emit to prompt novel responses to the vocal S^D. The participant emitted varied responses across all subcategories which maintained for 3 months post-intervention.

Convergent Control

Of the 36 studies included in this review, 58% of studies (n = 21) used an S^D that occasioned responses under convergent control, 10 studies did not occasion a response under convergent control, and 5 studies provided insufficient information to reach a conclusion about responding under convergent control. The most recent studies that taught intraverbals under convergent control are described below, with the remaining studies outlined in Table 1.

Daar, Negrelli, and Dixon (2015) utilized a relational training protocol to teach children with ASD to respond to wh- questions regarding community helpers. A three-phase teaching process was used to establish equivalence classes among wh-questions that included community helper stimuli (e.g., doctor, teacher, or police office), community locations (e.g., hospital, classroom, or police station), and community activities (e.g., makes people feel better, teaches children, or helps people). Each phase utilized match to sample tasks and included intraverbal-transfer trials until participants were able to respond to the final intraverbal wh-questions such as "Who teaches kids?" "What does a doctor do?" or "Where does a police officer work?." Following equivalence training, two of the three participants were able to respond to the untrained wh- questions, thereby demonstrating intraverbals under convergent control of the specific type of wh- question, as well as the community helper, location, and activity.

Dickes and Kodak (2015) extended the findings of Pérez-González, García-Asenjo, Williams, and Carnerero (2007) by examining whether novel reverse intraverbals were produced by training only the original intraverbal or training of the original and reverse intraverbals. Sets of intraverbals with compound stimuli across categories (e.g., opposites, function, or feature) included the original, such as "What do you play with?," and the reverse, "What do you do with a doll?." Although experimental control was not demonstrated consistently, results suggest that teaching original intraverbals under convergent control was sufficient in producing the emergence of reverse intraverbals under convergent control, though the protocol was not effective in producing generalization to untrained reverse intraverbals.

Kodak and Paden (2015) examined the acquisition of intraverbals and listener responses by feature, function, and class for two children with ASD. During the listener training procedure, participants selected the correct picture from a field of three based on the conditional stimulus (e.g., "You carry groceries in a ____"). Similarly, in the intraverbal training condition, participants provided a verbal response to the conditional stimulus, such as "You cook with a ___." Participants acquired intraverbals and listener responses at similar rates; however, intraverbal training consistently produced listener responses, but listener training did not consistently produce intraverbals among participants.

Vedora and Conant (2015) compared the effectiveness of visual (textual or tact) and echoic prompts to teach intraverbals to young adults with ASD. Questions for each participant were selected based on their Individualized Education Plan and although not explicitly stated, were related to feature, function, or class (e.g., "What do you eat with?" or "Who lives on a farm?"). Although all participants reached mastery criterion for intraverbals in both conditions, results were not consistent enough to indicate a more efficient prompting strategy across participants.

Convergent and Divergent Multiple Control

Among the 21 studies that involved convergent control, two of the studies are worth noting as the procedures brought responding under both convergent and divergent multiple control (Feng et al., 2015; Grannan & Rehfeldt, 2012). Feng et al. (2015) used a multiple probe design across subcategories, which necessitated responding under convergent control. That is, participants were required to provide multiple exemplars from the superordinate category (e.g., fruits), which aligned with the subcategory (e.g., green). Since responding was experimentally assessed across subcategories (e.g., green, red, orange, purple), convergent multiple control was established as the intervention was sequentially applied to subcategories. Additionally, for one participant in the Grannan and Rehfeldt (2012) study, some questions required a divergent response to the questions, "What are four things in the bathroom?" and "What are four things that take you places?." The vocal stimuli "things" combined with "bathroom" and "take you places" converge to control a specific set of correct intraverbals.

Verbal Conditional Discriminations

The VC^D variable assessed the extent to which successive trials were sequenced in a manner that required a participant to make a conditional discrimination of vocal stimuli during intraverbal training. Out of 36 studies, two required a conditional discrimination across trials (Ingvarsson, Kramer, Carp, Pétursdóttir, & Macias, 2016; Kisamore, Karsten, & Mann, 2016), 58% (n = 21) did not require a conditional discrimination across trials, eight provided insufficient information to code this variable, and five of the studies delivered S^Ds in a manner that *may* have involved a VC^D across trials (Feng et al., 2015; Grannan & Rehfeldt, 2012; Ingvarsson & Hollobaugh, 2011; May et al., 2013; Polick, Carr, & Hanney, 2012). However, because there were no trials that explicitly tested whether the participants' responding came under control of both the conditional and discriminative stimuli, it was not possible to conclude definitively that participants were making correct VC^Ds.

Ingvarsson et al. (2016) utilized a blocked-trial procedure to teach VC^Ds across trials to four children with ASD. Participants were required to make discriminations across question pairs that included two forms, such as, "What do you play" and "What do you play with." The researchers used a five-step blocked-trials procedure to teach participants to make VC^Ds. Only one participant required teaching of all five steps, whereas the remaining participants started at step three. In a blocked trial procedure, the interventionist initially delivers the same S^D for all trials in a session, which would not require a VC^D. In subsequent sessions, additional S^Ds with overlapping components are gradually faded in. For two of the participants, the blocked-trials procedure resulted in acquisition of complex intraverbals that required a VC^D. Two of the participants required additional training in the form of error correction for one and error correction plus distracter trials for the other during the first discrimination in order to learn additional discriminations through the blocked-trial procedure.

Kisamore et al. (2016) examined acquisition of intraverbals requiring VC^Ds among individuals with ASD using procedures commonly used to teach other conditional discriminations. The researchers initially used prompt delay and error correction (as in Braam & Poling, 1983) to teach VC^Ds to participants. This procedure was sufficient for

three of seven participants. If participants did not meet a criterion for a particular set of VC^Ds, researchers added a differential observing response whereby participants repeated the essential components of the S^D. For example, when presented with the S^D "tell me an animal that is green," participants were required to repeat "animal, green." Two participants demonstrated VC^Ds following training with the differential observing response. The final two participants required a modified differential observing response, whereby they repeated the essential components during and following the trial, or a blocked trial procedure.

Five additional studies included S^Ds that might require participants make VC^Ds, though authors did not provide enough information about the order of S^Ds across trials to ensure a VC^D occurred. For example, Ingvarsson and Hollobaugh (2011) compared tact-to-intraverbal and echoic-to-intraverbal transfer of stimulus control procedures to teach intraverbals. Although VC^Ds across trials are not explicitly discussed as a purpose of the investigation, the researchers selected S^Ds that had some similar components (e.g., "What do you use to …") with some varied components (e.g., "… tell time" vs. "… paint with") and delivered the S^Ds in a random order. The delivery of S^Ds in this format arranged for a situation in which a correct response may have involved a VC^D.

Discussion

The current systematic review provides an extension to previous research (Axe, 2008) by examining studies focused on teaching intraverbals to individuals with ASD published between 2005 and 2016. Identified studies were coded to examine the role of multiple control in the responses targeted. Additionally, participant characteristics and instructional procedures were summarized. A slight majority of the reviewed studies included an S^D that could occasion a response under divergent (56%) or convergent (58%) control. Of the 36 studies included in the review, only two studies arranged procedures to test whether responding was under appropriate control of all vocal verbal stimuli (i.e., verbal conditional discriminations) and five studies arranged S^Ds in a manner that may have required a VC^D.

A majority (i.e., 85%) of studies provided information on participant characteristics from standardized assessments (e.g., PPVT), non-standardized assessments (e.g., VB-MAPP), or a written description of the participant's verbal skills by specific operant. However, the amount of detail provided across studies varied and five studies provided little to no information regarding participants' verbal skills. Thorough description of participant characteristics may be beneficial in comparing results across studies and, ultimately, aiding in determining external generalization in clinical practice. A set of guidelines for describing participant characteristics does not currently exist in verbal behavior research, though the study by Carroll and Kodak (2015) included a careful description of participants that may serve as an example for future researchers. Participant descriptions should include a description of the participant's existing intraverbal repertoire (e.g., number and types of intraverbals), previous intraverbal learning histories, and types of errors observed prior to the start of the study. In combination with the more commonly reported participant information (e.g., age, diagnosis), detailed accounts of intraverbal repertoires could help to identify variables (e.g., prerequisite skills) that may affect treatment outcomes and also help clinicians in selecting procedures that are most appropriate for the clients they serve.

Error analyses may be a particularly important participant characteristic to describe in research on the intraverbal (Kisamore et al., 2016). Take for example, two children with ASD who have different intraverbal learning histories; the first child has no intraverbals and the second can emit a few simple intraverbals. When asked "Where do you wash your hands?" the first child echoes the last word of the vocal-verbal S^D and requires substantially more trials than the second child who at first fails to conditionally discriminate (e.g., says "Soap") but quickly responds to the treatment. The participants' pre-intervention intraverbal repertoire, in combination with the error analysis, suggests that a simple intraverbal repertoire may be a prerequisite for learning from the instruction that was administered. Relatedly, researchers could provide information regarding the type of intervention programs that have been both successful and unsuccessful in establishing intraverbals among individual participants.

In the studies reviewed, the most common type of S^D used during instruction was a question typically related to function, feature, class, or naming items within a specific category (e.g., "What is a circle?"). No studies taught responses to common social questions (e.g., "What did you do this weekend?") or questions encountered in the community (e.g., "What did you think about the movie?) which would be highly beneficial for individuals with ASD.

The selection of targets for teaching intraverbals to individuals with ASD is an important area for research as many socially relevant targets involve compound stimuli or VC^Ds. In addition, social interactions involve intraverbals under divergent control. Given the social deficits associated with ASD, it would be beneficial to teach complex intraverbals as soon as possible, though a thorough empirical understanding of prerequisite skills is necessary to inform practice in this regard. Take, for example, a common interaction among school-aged children that involves identifying players on one's favorite sports team. Intraverbals under divergent control are an essential skill for such an interaction, though it is unclear how many different types of other categories (e.g., types of fruits, types of vehicles, types of furniture) a child would need to master prior to participating in a discussion about favorite basketball players on his or her favorite team.

The current review identified 36 studies in the last 11 years that taught a response that was under multiple control of antecedent variables. About a third (n = 11) of the studies that were reviewed were published in 2015. The only studies (Ingvarsson et al., 2016; Kisamore et al., 2016) that explicitly required VC^Ds were published in 2016. The recent attention to the role of multiple control on intraverbals among individuals with ASD suggests this is a promising line of research in need of additional empirical attention in at least two main areas: (a) intraverbals that require a conditional discrimination (which most likely includes a response under convergent control) and (b) intraverbals under divergent control.

There have been several recent conceptualizations of complex intraverbals that researchers will find helpful in developing experimental procedures (Axe, 2008; Eikeseth & Smith, 2013; Palmer, 2016; Sundberg & Sundberg, 2011). Axe makes several recommendations for ensuring intraverbals come under the proper sources of stimulus control. A single S^D with multiple components arranges for a response to be controlled by two verbal stimuli, but only a set of questions that vary these verbal stimuli ensure that a conditional discrimination is being made (see Axe, 2008, Table 1). As in Kisamore et al. (2016), a clinician could identify at least two nouns (e.g., food

and drink) and at least two adjectives of these nouns (e.g., yellow and red). The clinician could then generate four or more S^Ds that combine the nouns and adjectives (e.g., What do you eat that's red?, What do you drink that's red? What do you eat that's yellow?, and What do you drink that's yellow?). Within a teaching session, these four questions would be presented in random order to ensure responses are under control of all relevant stimuli.

The instructional arrangement pertaining to complex intraverbals is particularly relevant for the five studies in the present review that might have required a VC^D, as all could have ensured the participants made VC^Ds if the S^Ds were delivered in a varied manner as described above. For example, in Grannan and Rehfeldt (2012), researchers asked participants to name things you find in a bathroom. Additional S^Ds related to a bathroom, such as, "Where is the bathroom?" or "When do you use the bathroom?" could be added to ensure the response is a correct VC^D. Carefully arranging S^Ds in future research on the intraverbal relation would lead to an improved understanding of the acquisition of intraverbals under convergent control.

The current review identified five studies that arranged instructional procedures to teach intraverbals under divergent control. As such, very little is known about teaching responses under divergent control. This is concerning for individuals with ASD because many simple (e.g., "What do you wear?") and complex S^Ds (e.g., "Tell some things you do for fun") occasion responses that are under divergent control. In the process of conducting the current review, the importance of S^D arrangement and response requirements emerged as a general theme when teaching intraverbals to individuals with ASD. Researchers can present a single S^D that evokes multiple responses (e.g., a list) or the same S^D can be presented in succession and researchers can require varied responses across trials (e.g., when asked, "Tell me an animal" the first time, a participant is taught to say "cow," on the second trial is taught to say "dog," and so on).

Goldsmith et al. (2007) arranged for participants to say a list of the same five items in the presence of an S^D, although the order of the tactual prompts was randomly presented. One concern to consider is the potential for prompting and reinforcing the same five responses to produce rote responding in individuals with ASD and its potential to affect subsequent learning (Carroll & Kodak, 2015). Future research may therefore investigate teaching multiple responses within and across teaching sessions and procedures to promote varied responding.

Teaching intraverbals under control of compound stimuli or VC^Ds to children with ASD is an important next step given the current state of research. However, it is possible that neither addresses the full complexity of intraverbal responding as described by Palmer (2016). Palmer calls for behavior analysts to distinguish between the intraverbal, as a class of verbal operants, and intraverbal control, which he calls the potentiating effect, of a verbal antecedent on a verbal response. All of the studies identified in the present review examined intraverbals according to Palmer's definition: "a verbal antecedent, as a result of a history of contiguous or correlated usage, is sufficient to evoke the putative intraverbal response" (Palmer 2016, p. 96). Due to a history of reinforcement, intraverbals are readily evoked by the antecedent variables. However, much of our verbal behavior is multiply controlled by variables both within and outside of an individual and antecedents may often fail to evoke a response without an individual engaging in supplementary or mediating responses. Palmer (1991)

previously suggested that individuals often engage in problem solving responses (or precurrent behaviors) such as organizing and grouping stimuli, observing the environment, visual imagining, and covert intraverbal behavior to respond to questions successfully. Precurrent behaviors allow for an individual to prompt his or her own behavior (Kisamore, Carr, & LeBlanc, 2011; Skinner, 1957).

Although no investigations of precurrent behavior or problem solving strategies have been applied to teaching intraverbals to children with ASD, at least two studies have investigated teaching problem-solving strategies to typically developing children to facilitate the acquisition of intraverbal categorization responses (e.g., Kisamore et al., 2011; Sautter, LeBlanc, Jay, Goldsmith, & Carr, 2011). In these studies, three or four categories (e.g., animals, vehicles, kitchen items, or furniture) each containing three subcategories (e.g., the vehicles category was divided into land, air, and water) with four individual items in each subcategory (e.g., the land category included bus, car, motorcycle, and truck) were directly targeted. In the Sautter et al. (2011) investigation, researchers utilized a mediating-response strategy that taught participants to self-prompt four different rule statements in order to produce an intraverbal to a categorization statement (e.g., "Tell me some vehicles"). Similarly, Kisamore et al. (2011) utilized visual imagery to teach responses to intraverbal categorizations. Visual imagery instruction involved the researcher presenting a visual example (e.g., a picture of the four different vehicles in the air) of what one might imagine or visualize when thinking of the subcategory of items. Participants in both studies demonstrated an increase in responding only after the strategy was modeled and prompted, both of which were faded. Participants provided correct responses for each category by naming the items within each subcategory (e.g., all land vehicles, then air vehicles, followed by water vehicles), often while overtly stating the rules. Participants demonstrated a decrease in the number of overt statements recited, but based on the order in which items were named within each category, they were likely covertly using precurrent behaviors to emit intraverbals to categorization statements. These types of mediating strategies may be beneficial when teaching intraverbal skills to children with ASD, but are in need of empirical investigation.

Some children with ASD and language deficits require explicit instruction across a variety of intraverbals in order to respond to basic social interactions. Preliminary work in sequencing intraverbals has emerged in recent years (e.g., Sundberg & Sundberg, 2011), and recent experimental investigations have shown that children with ASD can acquire complex intraverbal repertoires in highly structured settings (e.g., Kisamore et al., 2016). Although there are relatively few examples of interventions to teach complex intraverbals, studies published in 2015 and 2016 (i.e., studies establishing divergent and convergent control) offer some guidance to practitioners who need protocols that ensure proper sources of stimulus control over the intraverbal. Ongoing research that examines procedures for teaching socially relevant complex intraverbals will be essential to guide service providers going forward. The extent to which individuals with ASD require explicit instruction across a range of simple or moderately complex intraverbals in order to demonstrate a functional repertoire in common social situations is unknown. It may be possible that teaching individuals with ASD to engage in problem solving strategies may facilitate verbal behavior under intraverbal control and future research in such areas will be essential in guiding practitioners delivering behavioral language training to individuals with ASD.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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