Emergent listener responses following intraverbal training in children with autism

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ABSTRACT

We examined the emergence of listener responses following intraverbal training in four children with autism. Intraverbal training consisted of a transfer-of-control procedure in which the participants were taught to answer questions in the form of “What is the state bird of [name of state]” using either picture prompts (tact-to-intraverbal transfer-of-control procedures) or vocal prompts (echoic to intraverbal transfer-of-control procedures). Prior to intraverbal training, the participants were able to tact pictures of all the birds. Following training, listener posttests showed that the participants were able to correctly point to pictures of the birds upon hearing the spoken name of the state, although those responses had not been directly taught. For one participant, the tact-to-intraverbal transfer-of-control procedure resulted in greater number of emergent listener responses.

In his book Verbal behavior, Skinner (1957) used the term “intraverbal” to refer to verbal behavior evoked by a verbal discriminative stimulus and maintained by generalized reinforcement. An additional defining feature of intraverbal behavior is the lack of formal correspondence between the verbal discriminative stimulus and the response. This feature distinguishes intraverbal from echoic behavior; the latter verbal operant is defined in terms of formal correspondence between verbal stimuli and responses. Intraverbal behavior encompasses a wide range of topographically dissimilar responses, which also vary in terms of stimulus control complexity. Some examples include answering questions about animal sounds, singing songs, and reciting the alphabet, definitions, poetry, and scientific formulas (Vargas, 1986). Recent descriptive research by Sundberg and Sundberg (2011) suggests children with autism show marked deficits in intraverbal behavior compared with typically developing children. These authors demonstrated that although typically developing children show steady gains in intraverbal behavior between the ages of 2 and 5, children with autism show much more variability in their outcomes, and many show marked deficits in this skill area.

Research with typically developing preschoolers suggests the functional independence of tact and intraverbal repertoires (Kisamore, Carr, & LeBlanc, in 2011; Miguel, Carr, & Péturðóttir, 2005; Partington & Bailey, 1993; Sautter, LeBlanc, Jay, Goldsmith, & Carr, 2011). In Skinner's Verbal Behavior (1957), the tact is a verbal operant in which a verbal response is evoked by nonverbal stimuli, and maintained by generalized reinforcers. In these studies, typically developing children were taught to tact items and the categories to which the items belong (e.g., “This is a cow and it's a farm animal”). The children were then asked questions about category membership (e.g., “Name some farm animals”), but intraverbal categorization responses did...
not occur. However, the children were able to name multiple items belonging to categories following training using transfer-of-stimulus-control procedures (Miguel et al., 2005; Partington & Bailey, 1993), and these procedures have also been successful in teaching intraverbal responses with children with autism and other developmental disabilities (e.g., Goldsmith, LeBlanc, & Sautter, 2007; Ingvarsson & Hollobaugh, 2010; Luciano, 1986).

Transfer-of-stimulus-control procedures involve the presentation of a stimulus prompt, which is then faded with the goal of transferring stimulus control to the target verbal antecedent stimulus (e.g., a question). Previous research has demonstrated the effectiveness of three prompting tactics to establish intraverbal responses during transfer-of-control training: (1) textual prompts, in which the target intraverbal response is presented in textual format (e.g., Finkel & Williams, 2001), (2) picture prompts (utilizing tact-to-intraverbal transfer-of-control), in which a picture representing the target response is presented along with the verbal antecedent stimulus (e.g., Goldsmith et al., 2007) and (3) vocal prompts (utilizing echoic-to-intraverbal transfer-of-control), in which a vocal model is presented following the target verbal antecedent stimulus (e.g., Ingvarsson & Hollobaugh, 2011). In each case, the goal of training is to use pre-existing textual, tact, or echoic relations in a transfer-of-control procedure. Thus, the student must have one or more of these repertoires well established prior to the training.

Of primary interest in the current study is the relation of the intraverbal responses, which are under stimulus control of verbal stimuli, to tact and listener responses, which are under the stimulus control of nonverbal stimuli. To avoid teaching “meaningless” or “rote” intraverbal responses – intraverbal responses that are not functionally related to nonverbal events or objects in the environment – it has been recommended that students display strong tact and listener repertoires prior to intraverbal training (Sundberg & Partington, 1998; Sundberg & Sundberg, 2011). For example, it is advisable that a child be able to tact a cow and receptively identify (respond as a listener) a cow prior to learning an intraverbal relation involving the word “cow,” such as “A cow says moo.” If tact and listener responses are already well established before this intraverbal relation is taught, the child might be able to respond as a listener to a picture of a cow when presented with the auditory stimulus “moo” (e.g., “Point to the one that says moo”). In this example, the listener responses are not directly trained, but emerge from previously taught relations (e.g., Hayes, Barnes-Holmes, & Roche, 2001; Sidman, 1994; Rehfeldt, 2011).

It is unclear under what conditions untargeted listener responses occur following intraverbal training, and only a limited number of studies have explored this topic. Luciano (1986) taught three children with intellectual disabilities intraverbal categorization responses using tact-to-intraverbal transfer-of-control. Following acquisition, the children could receptively identify some of the items when presented with the category name. However, there were limited measures of listener responses in baseline, and results were inconsistent across participants. In a study with adults with mental retardation, Sundberg and Sundberg (1990) found that following tact and intraverbal training using sign language and arbitrary stimuli, listener responses emerged above chance levels. However, pretests of listener responding were not conducted. Most recently, in a study examining procedures to establish a small foreign vocabulary with two typically developing preschoolers, Petursdóttir and Hafliðadóttir (2009) found that listener relations (i.e., pointing to a picture when given its Italian name) emerged after the children were taught the intraverbal relation between the Italian name and the corresponding name in their native language.

The current study explored whether listener responses would emerge following intraverbal training using tact-to-intraverbal and echoic-to-intraverbal transfer-of-control procedures. Specifically, children with autism were taught to answer questions about state birds (e.g., “What is the state bird of Idaho?”). Prior to intraverbal training, the children demonstrated the ability to tact pictures of all the birds. Following intraverbal training, we tested whether the children would be able to point to the picture of the relevant bird when asked to “Point to the state bird of ____” even though the relation between the state name and the picture of the bird had never been directly trained. A second purpose of the current study was to evaluate whether tact-to-intraverbal or echoic-to-intraverbal transfer of control procedures would be differentially or equally likely to result in the emergence of this type of relation. Luciano (1986) has previously suggested that this kind of untrained relation might be especially likely to occur when tact-to-intraverbal transfer-of-control procedures are used.

1. Method

1.1. Participants

Four children with a diagnosis of autism participated. All the children attended day-programs at a multidisciplinary center that served children with developmental disabilities. The children were nominated for the study by their supervising clinicians and teachers because their intraverbal repertoire was judged to be deficient relative to same-age typically developing peers. Nevertheless, all the participants had mastered some intraverbal skills prior to the study (see below for further detail). All the participants had relatively good echoic, mand, and tact repertoires. All the participants could speak in multi-word sentences and were able to follow 2–3 step instructions. Two of the participants (Gary and Andrew) previously participated in a study comparing prompting methods to teach intraverbal behavior (Ingvarsson & Le, 2011). All participants attended the center 5 days per week, except Andrew, who attended two days per week.

Gary was a 4-year-old Caucasian boy who had attended the center’s early and intensive behavioral intervention program for one year and five months at the time of the study. Five months after the conclusion of the current study, his IQ was measured at 103 using the WPPSI-III test. Three months after the conclusion of the current study, he received a standard
The formal dissimilarity of their associated birds, as well as the dissimilarity of the state and bird names. Corresponding state birds were chosen for the intraverbal pretest. The twelve states chosen for the pretest set were based on a stimulus set including a large number of birds and states from which to draw, should the need arise. Twelve states and the bird names given items, answer questions about previous statements, and state an activity when given sequence of actions.

Andrew was an 8-year-old African-American boy who had attended the center's early and intensive behavioral intervention program for one year and four months at the time of the study. Six months prior to the start of the current study, his IQ was measured at 52 using the WISC-IV test. At the same time, he received standard scores of 66 on the PPVT-IV test of receptive language, and 72 on the EOWPVT test of expressive language. Andrew had mastered many listener and tact programs. For instance, he was able to identify shapes, familiar people, and common objects, pictures in a book, objects by function, common places, and community helpers. He was able to tact common items, size, shapes, letters, familiar people, ongoing live actions, environmental sounds, rooms, places, and community helpers. Andrew had mastered the following intraverbal programs: Rote counting, fill-in words from a song, animal sounds, items given function, function given item, states class given multiple exemplars, opposites, what-questions, and when-questions. However, how- and why-questions still presented considerable challenges. John was adept in memorizing the lyrics to contemporary songs, but could not explain the "meaning" of the songs.

Debbie was a 10-year-old Caucasian girl who had attended the center's special education classroom for 2 years and six months. Debbie was John's classmate and experienced the same student to teacher ratio as John. The Woodcock–Johnson III achievement test was conducted with Debbie around the time of the current study and showed a reading age equivalency of 7 years, 9 months. Two years prior to the study, her IQ had been measured at 66 using the WISC-IV test. John had mastered many listener, tact, and intraverbal programs. For example, he could follow multi-step directions, and could tact common household, school, and community items. He was also quite proficient in solving addition, subtraction, multiplication, and division math problems. Despite a decoding reading level that was nearly commensurate with age-level expectancy, John had difficulty with reading comprehension. Specifically, his ability to surmise the main point of a story, and to make inferences of future events based on past information was below age level expectancy. Nonetheless, he was able to answer some simple what-, where-, who-, and when-questions. However, how- and why-questions still presented considerable challenges. John was adept in memorizing the lyrics to numerous contemporary songs, but could not explain the "meaning" of any of the songs.

All sessions were in a small library, which measured approximately 5.5 m × 4.3 m, located at the center the children attended. The room contained bookshelves, child sized tables and chairs, decorated walls, and a computer. During sessions, the only people in the library were the experimenter, the child, and one or two observers. The experimenter and the child sat at one of the desks facing each other, and the observer(s) sat to the side approximately 2 m from the table. Their vantage point allowed them to observe the experimenter's stimulus presentations and the child's responses.

1.2. Target responses, stimulus sets, and materials

The target responses in the intraverbal baseline and intraverbal training phases of this study were answering questions about state birds (e.g., "What is the state bird of Idaho?" "Bluebird.") We chose this set of target responses because it was unlikely that the children had acquired them previously or that they would acquire the responses outside of the experimental context. Equally important, the set of state birds fit the purpose of the current study because relations between the spoken name of the bird, the spoken name of the state, and the picture of the bird could be evaluated. Further, this stimulus set includes a large number of birds and states from which to draw, should the need arise. Twelve states and the corresponding state birds were chosen for the intraverbal pretest. The twelve states chosen for the pretest set were based on the formal dissimilarity of their associated birds, as well as the dissimilarity of the state and bird names.

Laminated stimulus cards, 19.5 cm × 15.5 cm in size, were used to present color pictures of state birds. The pictures were procured from various online sources. The experimenters examined the pictures and determined whether they appeared to clearly depict each bird, and whether the birds, bird names, and state names were easily discriminable.

1.3. Measurement, interobserver agreement, and procedural fidelity

Observers used pencils, clipboards, and datasheets to collect data on participant behavior. During listener probe sessions, the observers scored which of the birds the participant pointed to (or touched) within 10 s of the experimenter presenting the vocal stimulus "Point to the state bird of ______." If the participant pointed to more than one bird, the bird that he or she pointed to first was scored.
During intraverbal training, the observers scored the occurrence of correct answers and whether the answers were unprompted, prompted, or incorrect. Correct answers were defined as answers that occurred within 5 s of the experimenter’s question and corresponded to the target answer that was designated for that particular trial (e.g., saying “Bluebird” when asked “What is the state bird of Idaho”). If the participants said an incorrect answer followed by a correct answer, a correct answer was not scored. If the participants said the correct answer within 5 s of the experimenter’s prompt, the answer was scored as a prompted response. Prompts consisted of either verbally modeling the correct answer or showing a picture depicting the correct answer, and were only presented during intraverbal training, and not intraverbal baseline. If no correct answer occurred, either following the question or the prompt, an incorrect answer was scored. The listener responses were the primary dependent variables in the current study, and intraverbal responses were the secondary dependent variable.

A second observer independently collected data during 45.7% of sessions for Gary, 77.8% of sessions for Andrew, 73% of sessions for John, and 46.3% of sessions for Debbie. Interobserver agreement (IOA) was calculated by dividing the number of agreements for each session with the number of agreements plus disagreements and converting the resulting number to a percentage. IOA averaged 98.4% for Gary (range, 91.7–100%), 99.1% for Andrew (range, 91.7–100%), 100% for John, and 99.3% for Debbie (range, 91.7–100%). IOA data were collected in all experimental conditions.

A separate datasheet was used to collect data on procedural fidelity during 25.8% of Gary’s sessions, 53.1% of Andrew’s sessions, 48.5% of John’s sessions, and 28% of Debbie’s sessions. During intraverbal training sessions, the observers used a checklist to score whether the experimenter presented the antecedent stimuli, prompting procedures, and reinforcement correctly. During the listener probes, the observers scored whether the experimenter presented the visual stimuli and delivered instructions correctly and also whether the experimenter withheld prompting and reinforcement as prescribed. Overall procedural fidelity averaged 98.2% for Gary’s data (range, 93.8–100%), 99.9% for Andrew’s data (range, 97.9–100%), 99.9% for John’s data (range, 97.9–100%), and 100% for Debbie’s data (range, 100–100%). IOA on procedural fidelity was collected during 37.5% of Gary’s sessions, 41.2% for Andrew’s sessions, 50% for John, and 28.6% for Debbie’s sessions. (This applies to sessions in which procedural fidelity data were collected.) IOA on procedural fidelity averaged 95.8% for Gary (range, 91.7–100%), 99.4% for Andrew (range, 95.8–100%), 99.3% for John (range, 95.8–100%), and 100% for Debbie.

2. Procedures

2.1. Overview

Fig. 1 shows an overview of the experimental phases. We first conducted intraverbal pretests to evaluate whether the participants could already answer questions about state birds. Immediately afterward, we conducted echoic pretests in order to determine whether the participants could echo all the bird names, and tact pretests to evaluate whether the participants could tact pictures of the birds. Tact training was then conducted with the birds the participants did not tact in the pretest. We then conducted the intraverbal baseline and listener pretests concurrently. This was followed by the intraverbal training phase, in which one question set was taught using tact-to-intraverbal transfer-of-control, and one set with echoic-to-intraverbal transfer-of-control. When the mastery criterion had been reached with both sets, we immediately conducted the listener posttests.

Fig. 2 shows a schematic of the relations trained and tested in the study. Tact relations (i.e., tacting pictures of state birds) were partially trained and partially preexisting, and intraverbal relations (answering questions about state birds) were trained. We then tested for the emergence of untrained listener relations (i.e., pointing to state birds upon hearing the name of the state).
2.2. Intraverbal pretest

Each question (e.g., “What is the state bird of Idaho?”) was presented once and no prompts were delivered. Each pretest session consisted of 10–12 trials. Correct answers would have been praised, but none occurred. Incorrect answers were followed by a brief pause, and then the next question was presented. To maintain a sufficient density of reinforcement, the pretest questions were interspersed with questions that the participants had learned to answer previously in their regular curriculum, and correct answers to those questions were followed by praise. We conducted two pretest sessions on two separate days. The intraverbal pretest showed the participants did not answer any questions correctly during either session.

2.3. Tact and echoic pretests

Because the intraverbal training consisted of tact-to-intraverbal and echoic-to-intraverbal transfer-of-control procedures, it was necessary to ensure the participants could tact pictures of the state birds and echo the names of the state birds. Therefore, we conducted tact and echoic pretests (in that order) with the state birds. Each pretest session consisted of 12 trials. During the tact pretest, the experimenter presented a picture of the bird, ensured that the participant was looking at the picture, and asked “What is this?” In the echoic pretest, the experimenter established the participant’s attention and said: “Say (name of state bird).” In both of these tests, the experimenter praised correct answers, while incorrect answers resulted in a brief pause, followed by the presentation of the next trial. Because a sufficient number of correct answers occurred during the tact and echoic pretests, interspersal of previously mastered tasks was unnecessary.

Although each participant tacted at least some of the birds correctly on the pretest, none had enough correct responses to create the two sets of three questions that were needed for the intraverbal phase. Therefore, tact training was conducted until enough stimuli met the requirements for inclusion in the sets (see description of tact training below). To select which stimuli to include, we used the following procedure with each participant: First, we randomly assigned “known” birds (i.e., birds that the participant had tacted correctly during the pretest) to each of the two stimulus sets, such that an equal number of known stimuli were included in each set. Thus, either one or two previously known birds were included in each set (if an odd number of known birds had been identified in the pretest, one known bird was left out). We then randomly selected the appropriate number of the remaining birds for inclusion in tact training with each participant. Thus, either two or four “unknown” birds were included in tact training. When the mastery criterion was reached during tact training, the stimulus sets were completed by randomly assigning the “trained” birds to the sets. The birds that were selected for each participant are shown in Table 1. Echoic training was not needed because all participants scored 100% correct on the echoic pretest.

2.4. Tact training

The stimuli (i.e., pictures of birds) that had been selected for tact training (see above) were taught individually and then interspersed with the other stimuli used with each participant. During tact training, the experimenter presented the picture of the bird, ensured that the participant was looking at the picture, and asked “What is this?” Correct answers resulted in praise, but incorrect answers were corrected by presenting a vocal prompt (e.g., “Say: Bluebird”). The experimenter also presented a prompt if no correct answer occurred within 5 s (i.e., a constant prompt delay; Halle, Marshall, & Spradlin, 1979). Correct answers following experimenter prompts (i.e., echoing the prompt) were also followed by praise. The experimenter began by presenting trial blocks in which two unknown stimuli were alternated non-randomly. Each trial block consisted of 12 trials and each stimulus was presented 6 times. When the participant scored 100% correct in a single trial block, trial blocks with random alternation of the two stimuli were conducted until two consecutive trial blocks with 100% correct
tacting occurred. For the children with whom four stimuli were targeted during tact training, the process was repeated for the remaining two stimuli. All 12 stimuli used during training were then presented randomly – with each stimulus presented once within the trial block – until two consecutive trial blocks with 100% correct tacting occurred; this constituted the mastery criterion for tact training.

2.5. Listener tests (pre and post)

The listener pre- and posttests involved an auditory–visual conditional discrimination procedure in which 4 pictures of birds were presented as comparisons on a table top. The experimenter started each trial by asking the participant to point to one of the state birds. The instruction was presented in the form of the sentence: “Point to the state bird of [_______].” Each listener probe session consisted of 12 trials with the order of trials randomized from session to session. Each of the pictures served as an S+ (i.e., the target stimulus designated as correct) during two trials, and S/ (i.e., stimulus designated as incorrect) during 6 other trials. The position of the S+ stimuli was determined prior to each session, and randomized and counterbalanced such that the position of the S+ changed unpredictably from trial to trial, but each stimulus appeared equally often in each position. The experimenter provided no prompts or error correction during listener probe sessions, and delivered no differential consequences for correct responses. Prior to each listener probe session, the experimenter told the participants they would not be told whether they made a correct response, and asked them to do their best. Each session was divided in half such that the participants got a brief break following 6 trials. During the break, the children played with preferred toys or interacted informally with the experimenter. Every second to third trial, the experimenter praised the children for sitting at the table and paying attention to the task.

2.6. Intraverbal training baseline

Each session in this phase consisted of presenting the three questions assigned to one of the stimulus sets. The order of questions was randomized, and the experimenter asked each question four times in each session; therefore each session consisted of 12 questions. No prompts or error correction were implemented in baseline. Because of the possibility that correct intraverbal responses might occur in baseline due to previous exposure to tact training (which occurred with Debbie), the intraverbal baseline was conducted under extinction. We chose this approach because of our interest in establishing a stable baseline to evaluate the effects of different prompting procedures, rather than evaluating whether differential reinforcement would lead to acquisition. Identical to the listener probe sessions, breaks were inserted into each session and the experimenter praised the children for cooperating and attending.

2.7. Intraverbal training

During intraverbal training, sessions were identical to baseline except that a 5 s constant prompt delay was used to teach the correct answers. That is, the experimenter asked the question, and allowed for up to 5 s for a response to occur. If no response occurred within 5 s, a prompt was delivered. If an incorrect response occurred within 5 s, the experimenter delivered the prompt immediately.

In the picture prompt (tact-to-intraverbal transfer-of-control) condition, prompting was implemented by presenting the picture showing the relevant state bird in front of the participant until he or she attempted to tact the bird. Vocal instructions were not delivered concurrent with the visual prompt. If the participant did not tact the bird within 5 s of prompt presentation, the experimenter was scheduled to point to the picture of the bird while looking expectantly at the participant, but this never occurred (i.e., the participants always tacted the picture of the birds immediately). In the vocal prompt (echoic-to-intraverbal transfer-of-control) condition, the experimenter said the name of the bird (e.g., “bluebird”). If the

Table 1
Stimulus sets for all participants.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Visual prompt set</th>
<th>Vocal prompt set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary</td>
<td>Duck (Mississippi)</td>
<td>Chicken (Delaware)</td>
</tr>
<tr>
<td></td>
<td>Pelican (Louisiana)</td>
<td>Turkey (South Carolina)</td>
</tr>
<tr>
<td></td>
<td>Goose (Hawaii)</td>
<td>Robin (Michigan)</td>
</tr>
<tr>
<td>Andrew</td>
<td>Chicken (Delaware)</td>
<td>Duck (Mississippi)</td>
</tr>
<tr>
<td></td>
<td>Bluebird (Idaho)</td>
<td>Turkey (South Carolina)</td>
</tr>
<tr>
<td></td>
<td>Pelican (Louisiana)</td>
<td>Oriole (Maryland)</td>
</tr>
<tr>
<td>Jacob</td>
<td>Duck (Mississippi)</td>
<td>Chicken (Delaware)</td>
</tr>
<tr>
<td></td>
<td>Oriole (Maryland)</td>
<td>Pelican (Louisiana)</td>
</tr>
<tr>
<td></td>
<td>Quail (Georgia)</td>
<td>Bluebird (Idaho)</td>
</tr>
<tr>
<td>Debbie</td>
<td>Turkey (South Carolina)</td>
<td>Bluebird (Idaho)</td>
</tr>
<tr>
<td></td>
<td>Pelican (Louisiana)</td>
<td>Robin (Michigan)</td>
</tr>
<tr>
<td></td>
<td>Goose (Hawaii)</td>
<td>Quail (Georgia)</td>
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</tbody>
</table>
participant did not echo the name of the bird within 5 s, the experimenter was scheduled to repeat the name of the bird, while adding the instruction “say” (e.g., “say bluebird”). However, this never occurred because the participants always echoed the vocal prompt.

For all four participants, the experimenter provided descriptive praise following correct prompted responses (e.g., “That’s right; bluebird is the state bird of Idaho!”). For John and Debbie, descriptive praise was also the only consequence for correct unprompted responses. For Gary and Andrew, tokens were delivered for correct unprompted responses in addition to descriptive praise. Based on our history delivering instructional programs to these four children, we believed their individualized token systems would be necessary to maintain engagement for Gary and Andrew, but not for John and Debbie. During session breaks and following the session, Gary and Andrew exchanged their tokens for access to preferred activities (e.g., playing in the center gym and favorite toys).

The mastery criterion for each condition was two consecutive sessions with at least 11 out of 12 answers correct, but with the additional stipulation that all 12 answers had to be correct in at least one of the two sessions. If the mastery criterion was reached earlier in one condition, we continued to conduct alternating sessions in both conditions until the mastery criterion was reached in the other condition. This was done to ensure equal exposure to the question sets.

2.8. Experimental design

We used a nonconcurrent multiple baseline design across participants to evaluate the effects of intraverbal training on the acquisition of intraverbal responses. Pre- and post-listener tests were embedded in the design to evaluate the effects of intraverbal training on the emergence of listener responses, and the number of listener pretests was systematically varied across participants. The effects of intraverbal training using tact-to-intraverbal versus echoic-to-intraverbal transfer-of-control were evaluated within participants in an adapted alternating treatments design embedded within the multiple baseline design (Sindelar, Rosenberg, & Wilson, 1985).

3. Results

The results of intraverbal training and listener tests for all four participants are shown in Fig. 3. Only correct unprompted answers are displayed. Gary’s results are presented in the top panel. In baseline, he answered zero questions correctly in the intraverbal sessions. In the listener pretests (displayed in the baseline phase), an average of 1.13 correct responses occurred across both sets (chance level responding was 1.5 out of 6 possible correct responses on average). During intraverbal training, an upward trend was quickly evident in both prompting conditions. However, Gary reached the mastery criterion sooner in the picture prompt set condition (session 16) relative to the vocal prompt condition (session 26). Trials to criterion were calculated by adding all the trials presented in each condition, starting with the first session in the intraverbal training phase and ending with the session in which the mastery criterion was reached. For Gary, trials to criterion were 72 in the picture prompt set and 132 in the vocal prompt set. In the listener posttest (displayed toward the end of the intraverbal training phase), Gary scored 100% correct (i.e., 6 out of 6) for both sets.

Andrew’s results are shown in the second panel of Fig. 3. In baseline, he answered zero questions correctly in the intraverbal sessions. In the listener pretests, an average of 1.00 correct responses occurred across stimulus sets. During intraverbal training, an upward trend was quickly evident in both prompting conditions. Andrew reached the mastery criterion in the picture prompt condition (session 26) earlier than in the vocal prompt condition (session 30). Trials to criterion were 120 for the picture prompt set, and 144 for the vocal prompt set. In the listener posttest, Andrew scored 100% correct (i.e., 6 out of 6) for both sets.

John’s results are presented in the third panel of Fig. 3. In baseline, he answered zero questions correctly in the intraverbal sessions. In the listener pretests, an average of 1.34 correct responses occurred across stimulus sets. During intraverbal training, an upward trend was quickly evident in both prompting conditions. John reached the mastery criterion in the picture prompt set condition (session 22) earlier than in the vocal prompt condition (session 25). Trials to criterion were 84 in the picture prompt set and 108 in the vocal prompt set. In the listener posttest, John initially scored 5 out of 6 correct for the picture prompt set, and 4 out of 6 correct for the vocal prompt set. However, this posttest was conducted at the end of a school day, and John appeared tired. When the same posttest was repeated in an identical manner the next morning, John scored 6 out of 6 correct for both sets.

Debbie’s results are presented in the bottom panel of Fig. 3. In baseline, she answered on average 0.67 questions correctly in the picture prompt set and 2.5 questions correctly in the vocal prompt set. Despite the unequal averages, inspection of the data paths reveals that performance was stable and approximately equal between the two sets toward the end of the baseline phase. In the listener pretests, an average of 1.42 correct responses occurred for across both sets. The pattern of responding during Debbie’s intraverbal training phase was somewhat different from the other participants in that a greater number of correct responses occurred with the picture prompt set in the first half of the phase. In the picture prompt condition, Debbie reached the mastery criterion relatively quickly (session 23), compared with the vocal prompt set (session 40). (Note that an additional session in each condition was conducted following mastery of both sets due to experimenter mistake.) Trials to criterion were 72 in the picture prompt set and 168 in the vocal prompt set. In the listener posttest, Debbie initially scored 6 out of 6 correct for the picture prompt set, and 3 out of 6 correct for the vocal prompt set. When the same posttest was repeated later that same day, Debbie scored 5 out of 6 correct for the picture prompt set, and 3 out of 6 correct for the vocal prompt set.
4. Discussion

We evaluated the effects of intraverbal training on the emergence of listener responses with four children with autism. The participants were first taught to tact pictures of state birds. Prior to intraverbal training, they could neither answer questions about state birds (e.g., “What is the state bird of Idaho”) nor identify pictures of state birds when given the name of the state (e.g., “Point to the state bird of Idaho”). We then conducted intraverbal training in which we established relations between the names of the state birds and the names of the states. For each child, half of the intraverbal responses were taught using tact-to-intraverbal transfer-of-control (picture prompt) procedures, and the other half using echoic-to-intraverbal transfer-of-control (vocal prompt) procedures. Following intraverbal training, three of the four children passed the listener relation posttest with 100% accuracy for all targeted relations, regardless of which transfer-of-control procedure had been used. That is, the children were able to point to the correct picture of a bird (out of an array of four) when asked to “Point to the state bird of _____.” For the fourth child (Debbie), listener responses occurred with 100% accuracy on the first posttest (and 92% accuracy on the second posttest) for stimuli that had been trained using tact-to-intraverbal transfer-of-control procedures, but 50% accuracy with stimuli that had been trained using echoic-to-intraverbal transfer-of-control procedures. These findings systematically replicate and extend previous research on the emergence of listener responses following intraverbal training (Luciano, 1986; Pétursdóttir & Haflíðadóttir, 2009; Sundberg & Sundberg, 1990). To our knowledge, this is the first study on this topic to include children with autism.

The relation between the name of the state and the picture of the state bird was not directly targeted during training, but emerged as a result of teaching other types of relations. This type of emergent relation is similar to the transitive relation that
is characteristic of stimulus equivalence (Sidman & Tailby, 1982). We suggest that the listener relation might have emerged as a result of teaching the relation between the pictures of the birds and the names of the birds (i.e., through tact training) and the name of the state and the name of the bird (i.e., through intraverbal training). These two types of training amounted to teaching overlapping conditional discriminations that resulted in the emergence of an untrained relation (Sidman, 1994).

Most stimulus equivalence research has been conducted in a match-to-sample paradigm in which the responses are selection-based, whereas the current study involved an intraverbal training component in which the antecedent stimuli were auditory and the responses were vocal. However, the current study did not demonstrate an equivalence class in the traditional sense (e.g., we did not test for symmetry).

It is possible to speculate in more detail on how the listener responses may have been established as a result of the teaching procedures. In picture prompt (i.e., tact-to-intraverbal transfer-of-control) condition of the intraverbal training, the participants were required to orient toward and look at the picture of the state bird after the name of the state had been presented vocally. Programmed reinforcement was delivered following the correct vocal response (the state–bird name), but the orienting/observing response might also have been reinforced. The orienting and observing responses can also be considered listener responses. According to this analysis, listener behavior may have been reinforced during picture prompt trials, although the topography of those potential listener responses was different from the responses that were measured in the listener probes. It is possible that orienting, looking, and pointing are the members of a common class of listener responses, and the emergence of pointing responses during the listener posttests may be thus explained in terms of response induction (Segal, 1972). The analysis is different, however, for the vocal prompt condition because the pictures of birds were not presented during intraverbal training and potential listener responses could therefore not come under the control of the pictures. Nevertheless, it is possible that the tact training and intraverbal training resulted in a pattern of responding during the listener posttests in which the participants stated the name of the bird (e.g., “bluebird”) – either overtly or covertly – in response to the spoken state name (e.g., “Idaho”), and this response in turn served as a discriminative stimulus setting the occasion for pointing to the picture of the bird. This analysis is consistent with Horne and Lowe (1996) naming account. However, it also rests on the assumption that bidirectional tact and listener relations existed in the participants’ repertoire – that is, that tact training would result in emergent listener responding. Although this bi-directional relation was not tested directly, it is likely that it would have emerged, given the participants’ age and existing skills.

The emergence of listener relations following intraverbal training shows the newly taught intraverbal responses were functionally related not only to the verbal antecedent stimulus (e.g., “What is the state bird of Idaho?”) but also the corresponding nonverbal stimulus (i.e., the picture of the bird). This is important because the acquisition of intraverbal responses is unlikely to lead to effective interactions with nonverbal aspects of the environment if the stimuli involved in the intraverbal relation are not functionally related to corresponding nonverbal stimuli (Sundberg & Partington, 1998). To return to a previous example; if a child were taught the intraverbal response “moo” under the control of the spoken word “cow” (e.g., by answering the question “What does a cow say?”) without having been taught to tact a cow, it is unlikely that the recently taught response (“moo”) would be functionally related to nonverbal stimuli involving cows (e.g., pictures of cows, toy cows, and actual cows). Thus, the new response would be unlikely to be related to any stimuli other than the particular verbal antecedent presented during training (e.g., “What does a cow say?”). Therefore, its addition to the child’s repertoire would be of limited value.

One could argue that the emergence of listener relations is one criterion by which to judge the relevance or importance of teaching intraverbal behavior. The emergence of functional relations between verbal and nonverbal stimuli would be likely to occasion description of the recently learned relation as “meaningful,” but absence of a relation to nonverbal stimuli would be likely to set the occasion for talk of the intraverbal responses as being “rote” or “meaningless.” While these lay terms are not useful as explanations of behavior from the standpoint of radical behaviorism, they nevertheless appear to be frequently evoked by important aspects of behavior–environment relations. Indeed, leading behavioral researchers have stated that emergent relations (i.e., those characteristic of equivalence classes or relational frames) are one type of variable that set the occasion for the use of the terms “meaning” and “meaningful” in describing language or verbal behavior (Hayes et al., 2001, p. 43; Sidman, 1994, p. 563). Thus, the presence of emergent relations may form a part of the operational definition of these lay terms, at least as they apply to situations similar to those in the current study (Skinner, 1945).

With only one child (Debbie), untrained listener relations were more likely to occur following tact-to-intraverbal transfer-of-control training. During this condition, the picture of the state bird was present during intraverbal training, in which the spoken names of the bird and state were also present. One might expect the contiguity between the three stimuli in this training condition would facilitate the emergence of the listener relation compared with the echoic-to-intraverbal transfer-of-control condition, in which the picture of the bird and the name of the state never occurred contiguously (cf., Luciano, 1986). However, this possible facilitating effect only occurred with Debbie. It thus appears that tact-to-intraverbal transfer-of-control during intraverbal training will not necessarily facilitate the emergence of listener relations, at least with the relatively advanced participants in this study. The emergence of listener responses following echoic-to-intraverbal transfer-of-control training is somewhat surprising because the pictures of the birds included in that set were never presented during the intraverbal training phase, and considerable time (5–10 weeks) passed between tact training and the listener posttest, during which the participants never saw the pictures of the birds included in the listener posttest for that stimulus set. Therefore, it is possible that echoic-to-intraverbal transfer-of-control would not lead to emergent listener relations in children with relatively limited verbal repertoires, but tact-to-intraverbal transfer-of-control would facilitate the
emergence of these relations. A priority for future research is to replicate the current procedures with children that have mastered numerous tact and listener relations but who have not yet mastered many intraverbal relations.

The results of the pre- and post-listener tests in the current study are not without limitations. Variable responding occurred during the pretests, and the number of posttests was small. The variability observed in pretests was anticipated, because some correct responses will inevitably occur by chance, and the number of correct responses is bound to vary from session to session. Overall, the number of correct responses in baseline for all participants was very close to that expected by chance, and no systematic bias in responding (such as a position bias) was observed. Nevertheless, John and Andrew’s baselines would have benefited from additional listener test sessions because there is a hint of an upward trend in their data. However, we determined additional sessions were not needed, because the last listener pretest sessions for both of these participants was close to chance levels. In addition, a greater number of posttest probes would have more firmly established the difference between pre- and posttest responding. We reasoned that 100% correct responding in the posttest would be so unlikely to occur by chance that further posttests were not needed. Nevertheless, future research would benefit from investigating the effects of a greater number of pre- and post-listener tests.

The comparison of tact-to-intraverbal and echoic-to-intraverbal transfer-of-control procedures in the current study is limited in that the number of intraverbal training trials in each condition was equated while the number of prompts was not. Because there were more correct unprompted responses in the picture prompt condition, each participant was exposed to a greater number of vocal prompts than picture prompts. However, it was also the case that each participant engaged in a correct answer in each trial (either prompted or unprompted) and the experimenter always delivered descriptive praise, which consisted of repeating the correct answer embedded in a praise statement. Thus, the participants were exposed to the auditory form of the response (spoken both by themselves and the experimenter) on each trial in each condition. Therefore, the greater number of vocal prompts is unlikely to have contributed specifically to the emergence of listener responses for the stimuli included in one condition over the other. Nevertheless, future researchers should consider yoking the number of prompts delivered between conditions to remove speculation and facilitate interpretation of results. This would prevent situations in which interpretation of results would be challenging, for instance if picture prompts resulted in a greater likelihood of emergent responses, but more picture prompts relative to vocal prompts had been delivered previously.

Overall, the results of our study elucidate the importance of evaluating the emergence of listener relations following intraverbal training in an effort to determine whether recently acquired intraverbal responses are functionally related to environmental stimuli other than to a specific antecedent verbal stimulus. For this to be possible, it seems likely that children must have a robust tact and listener repertoire prior to the start of intraverbal training, but future research should further evaluate this possibility. Indeed, Debbie’s results further suggest that the use of echoic-to-intraverbal transfer-of-control procedures during intraverbal training might, in some cases, reduce the likelihood of such responses occurring. Finally, future research should evaluate whether similar outcomes might occur for children with verbal repertoires that are more limited than was the case in the current study.

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