Psychol Rec (2016) 66:351–368
DOI 10.1007/s40732-016-0177-0

ORIGINAL ARTICLE

Emergence of Intraverbals with Antonyms Derived From Relations with Verbal and Nonverbal Stimuli

Luis Antonio Pérez-González[1] · **Lorena García-Asenjo**[1]

Published online: 5 May 2016

Abstract The present research studied the emergence of intraverbals with antonyms (e.g., "Name the opposite of *empty*"–"*Full*") derived from learning skills with verbal and nonverbal stimuli. Five 3-year-old children learned to select the nonverbal comparison identical to a sample stimulus or of an opposite category from the sample, with a conditional discrimination procedure (e.g., selecting an empty cup in the presence of an empty cup when the contextual stimulus was "same" and selecting a full cup when the contextual stimulus was "opposite"). Then, an intraverbal probe related to these concepts was presented (e.g., "Name the opposite of *empty*"–"*Full*"). If the participant failed in the intraverbal probe, additional skills were taught or probed, and the intraverbal probe was repeated, which included conditional discriminations with more verbal stimuli than the initial conditional discrimination (e.g., selecting a full cup when told, "Point to the opposite of 'empty'"). All 5 children demonstrated the emergence of most or all intraverbals. Two children received the sequence with a second stimulus set; they showed the emergence of intraverbals quicker than with the first stimulus set. Thus, the emergence of intraverbals after learning relations with nonverbal stimuli was demonstrated in young children. The identification of the skills present when the intraverbals emerged suggests that learning some of these skills is required for emergence, and they may be important to understand the emergence of verbal skills.

Keywords Intraverbals · Emergent relations · Categorization · Language · Speaker · Listener · Transfer

✉ Luis Antonio Pérez-González
laperez@uniovi.es

[1] Department of Psychology, University of Oviedo, Despacho 209, Plaza Feijoo s/n. 33003, Oviedo, Asturias, Spain

The intraverbal is a type of verbal behavior characterized by the emission of a verbal response after the presentation of a verbal stimulus that shows no point-to-point correspondence with the response (Skinner, 1957). Intraverbal behavior is important in human development for several reasons. First, intraverbals are extremely frequent in everyday life, especially in social interactions with others, such as conversations, songs, stories, or verbal plays; if a child has a weak or delayed intraverbal repertoire, then it may affect this kind of behavior. Second, most academic and scientific skills (e.g., reciting the alphabet, answering questions, counting or opposite concepts, algebraic or logic operations, reasoning) are based on intraverbal repertoires; therefore, a delay in the acquisition of these intraverbal repertories could affect the academic performance. Third, more sophisticated verbal skills (e.g., answering questions related to what one did on the weekend; describing the weather) include intraverbals; therefore, intraverbals need to be learned before more complex verbal skills are acquired. For these reasons, analyzing the learning processes involved in the acquisition of intraverbals seems necessary for theoretical reasons and for reasons related to its impact on education and development (e.g., Greer & Ross, 2008; Partington & Bailey, 1993; Sundberg & Michael, 2001).

Intraverbals Directly Taught

Intraverbals can be taught directly, such as when toddlers are taught to answer questions such as "How old are you?" or "What is your favorite team?" Learning of intraverbals has been demonstrated with several procedures (see reviews by Axe, 2008; Cihon, 2007; Pérez-González, Salameh, &

García-Asenjo, 2016). Intraverbals can be established with transfer-of-stimulus control procedures from echoics, text, and tacts, multiple tact training, teaching selection-based conditional discrimination, visual imagining, and other problem-solving strategies (Coon & Miguel, 2012; Emmick, Cihon, & Eshleman, 2010; Ingvarsson & Hollobaugh, 2011; Ingvarsson & Le, 2011; Kodak, Fuchtman, & Paden, 2012; Valentino, Shillingsburg, & Call, 2012; Vedora, Meunier, & Mackay, 2009). Yet, when a person learns an intraverbal directly, the resulting acquisition does not demonstrate any particular skill beyond the fact of acquisition itself. For example, when a toddler responds "two" when asked to say his or her age, typically he or she does not show any related skill. The behavior is not under the same complex sources of control as when the intraverbal is emitted by most adults. Therefore, it is unlikely that that child generalizes this skill to other skills. In lay terms, it seems evident that children at this age hardly understand the concept of time. Nonetheless, learning intraverbals may be important for the further acquisition and emergence of many verbal skills.

Emergent Intraverbals

Alternatively, intraverbals can emerge after learning other intraverbals or other verbal operants. An example of intraverbals emerging from other intraverbals is the following: A Paris visitor learns that the opposite to "*joli*" in French is "laid," and then she could say correctly that the opposite to "laid" is "*joli,*" even if that person does not know the meaning of these words in French (e.g., has not acquired the tact of a *joli* face or the selection of a *joli* face upon hearing "select '*joli*'"). A few studies have demonstrated the emergence of intraverbals after learning other intraverbals. For example, Pérez-González, García-Asenjo, Williams, and Carnerero (2007) demonstrated the emergence of intraverbals with antonyms after participants learned the relational frame that relates the two intraverbals (such as, "Name the opposite of *laid*, "–"*Joli*" and, "Name the opposite of *joli*"–"*Laid*"). Furthermore, emergence involving only intraverbals has been demonstrated (e.g., Carp & Petursdottir, 2012; Pérez-González, Herszlikowicz, & Williams, 2008; Pérez-González et al., 2016; Polson & Parsons, 2000). This type of emergence occurs after experience with the verbal stimuli alone, and, consequently, intraverbal relations may or may not result in a repertoire of relations involving nonverbal stimuli, in the absence of further learning. Regarding the previous example, the Paris visitor can learn to respond that the opposite of "*joli*" is "laid" and vice versa, but this skill does not imply that she can tact these properties or that she can make correct selections of properties when presented with these verbal stimuli (i.e., respond as a listener when hearing the name).

Intraverbals and Nonverbal Stimuli

The emergence of intraverbals from other intraverbals plays a role in everyday life. It is obvious, however, that the usefulness of the intraverbal repertoire, as in the above example with the Paris visitor, may be limited unless other related verbal operants are learned. Thus, the real utility of an intraverbal repertoire comes when the stimuli in intraverbals are related to nonverbal stimuli by learning skills with verbal and nonverbal stimuli—in lay terms, when the words are related to the things or events they refer to. In that regard, intraverbals can also emerge from learning operants other than intraverbals. Emergence is important because it is a process that allows humans to learn more than what is directly taught. As well, emergence may be important for survival and other practical purposes. For example, once the Paris visitor in the above example learns that "laid" in French means "ugly," a lady could express her interest in French for meeting a French "*joli*" gentleman when her hosts ask her. Many studies on intraverbals have shown the emergence of intraverbals after learning verbal operants different from the intraverbal (e.g., Belloso-Díaz & Pérez-González, 2015a, b, 2016; Grannan & Rehfeldt, 2012; Greer, Yaun, & Gautreaux, 2005; Miguel, Petursdottir, & Carr, 2005; May, Hawkins, & Dymond, 2013; Petursdottir, Carr, Lechago, & Almanson, 2008; Petursdottir & Haflidadóttir, 2009; Petursdottir, Ólafsdóttir, & Aradóttir, 2008; see also related studies that show how intraverbals are brought about with teaching strategies by Kisamore, Carr, & LeBlanc, 2011; Sautter, LeBlanc, Jay, Goldsmith, & Carr, 2011). The inclusion of verbal operants different from the intraverbal brings nonverbal stimuli to the verbal repertoire of a person. For example, in several studies conducted in our laboratory (e.g., Belloso-Díaz & Pérez-González, 2015a, b, 2016), children were presented with the picture of a woman and they learned to say the tribe and the country to which the woman belongs. Thereafter, intraverbals related to the tribe and the country were probed (i.e., "Name a tribe of Pakistan"–"Kalash" and "Name the county of the Kalash"–"Pakistan"). Notice that in these experiments, the emergence of the intraverbal has to do with relating verbal stimuli that have been related themselves to one single nonverbal stimulus (i.e., the picture). Yet, the presence of this emergent intraverbal could be useful for the production of many other verbal behaviors.

Intraverbals Derived From Relations with Nonverbal Stimuli

In spite of the good research on this difficult and complex topic, the studies published to date have evaluated a small portion of the potential variables involved in the emergence of intraverbals. In addition, little is known about how

intraverbals emerge after learning other verbal operants. Thus, more sophisticated phenomena remain to be studied. The present research is an attempt to study intraverbals that are related to nonverbal stimuli in complex ways, which have not been studied so far. The starting point was the analysis of intraverbals that contain antonyms, such as, "Name the opposite of *empty*"–"*Full.*" As demonstrated by Pérez-González et al. (2007), children show the emergence of an intraverbal after learning the intraverbal with the elements in the alternative stimulus-response functions (e.g., learning, "Name the opposite of *empty*"–"*Full*" results in the emergence of "Name the opposite of *full*"–"*Empty*"). As explained before, a person can show this type of emergence without knowing the meaning of the words, but the implications for his or her life come from learning other operants.

The present research intended to explore the emergence of these intraverbals from other operants. In fact, more complex relations exist among the verbal stimuli of these intraverbals and the nonverbal stimuli related to them. In this example, the verbal stimuli of the intraverbal "empty" and "full" are related to the nonverbal stimuli of these two properties (namely, empty and full objects, respectively). This preparation brings the possibility of analyzing novel types of emergence: If a skilled person who had acquired the abstract concept of opposite is faced with two new concepts, A and B, that are opposite to one another, he or she can emit a verbal operant (e.g., "A is the opposite of B") that further serves that person and many others to produce appropriate responses in the presence of nonverbal stimuli. Notice the crucial importance of the emergence in that the description (or the corresponding intraverbals) does not exist until it emerges; only after its emergence can the description be taught to other people and serve the person and others for producing appropriate verbal and nonverbal behaviors in novel situations. In analytic terms, the verbal operant is composed only of words, but it describes the relations between nonverbal stimuli. Moreover, the relations between the nonverbal stimuli are physical relations. The emergence of intraverbals like this is a requisite for the emergence of other related operants involving verbal and nonverbal stimuli and responses or only nonverbal stimuli and responses.

Purpose

The purpose of this research was to study the emergence of intraverbals like those just described, after learning relations among nonverbal stimuli. The operants that are involved and are presumably necessary for demonstrating this type of emergence are the following (see Fig. 1): (a) Intraverbals such as "Name the opposite of"—for example, "Name the opposite of *empty*"–"*Full*,"—and the reverse intraverbal, "Name the opposite of *full*"–"*Empty,*" identical to those used in the Pérez-González et al. (2007) study. (b) Tacts of each opposite property presented in pictures; for example, saying, "Empty" in the presence of the picture of the empty jar. (c) Selection-based discriminations of the opposite properties, which consist of selecting the picture with the property indicated by the experimenter between two pictures of the same object with the two properties. These selections and the related tacts constitute the operants that define naming (e.g., Carnerero & Pérez-González, 2014; Greer & Longano, 2010; Horne & Lowe, 1996). (d) The Auditory-Visual-Visual Conditional Discrimination (Auditory-Visual CD) of the properties (see Fig. 2) with two sample stimuli or a contextual stimulus and a sample: the auditory stimulus, "Point to the opposite" or "Point to the same," and a picture. (e) The Auditory-Auditory-Visual Conditional Discrimination (Auditory-Auditory CD) of the opposite properties. This was identical to the Auditory-Visual CD except that the samples were composed by the auditory stimuli of the propriety (instead of the picture with the property).

Given this set of interrelated operants, learning three operants that involve all the stimuli may result in the emergence of the remaining operants (e.g., see analysis about nodes in stimulus equivalence conducted by Fields & Verhave, 1987; Fields, Verhave, & Fath, 1984). According to the characteristics of this relational network, we hypothesize that intraverbals

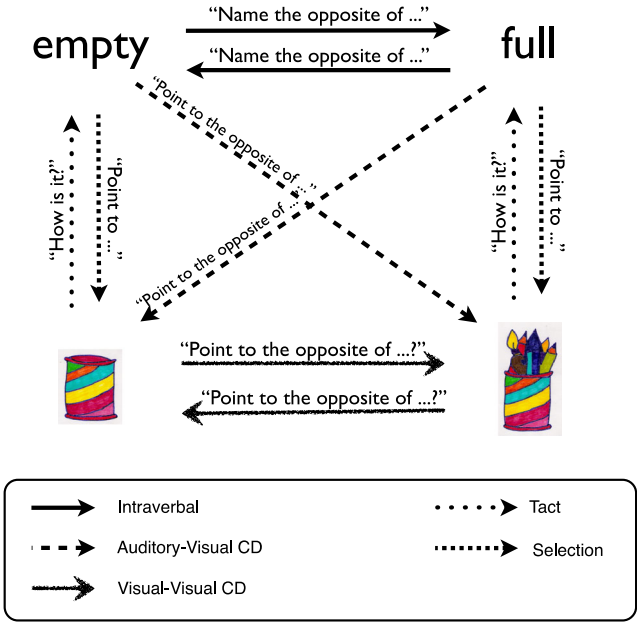

Fig. 1 Examples of the relations taught and probed. The arrows go from the stimuli to the responses or from the samples to the correct comparison (in conditional discriminations). Each operant included the stimulus displayed in the origin of the arrow and the response (or the comparison), indicated by the destination of the arrow; for example, the upper arrow indicates the intraverbal, "Name the opposite of *empty*"–"*Full.*" Auditory-Visual CD is short for Auditory-Visual-Visual Conditional Discrimination, which is depicted in Fig. 3. Auditory-Auditory CD is short for Auditory-Auditory-Visual Conditional discriminations. The conditional discriminations were also presented with "Point to the same as . . . " (not displayed here)

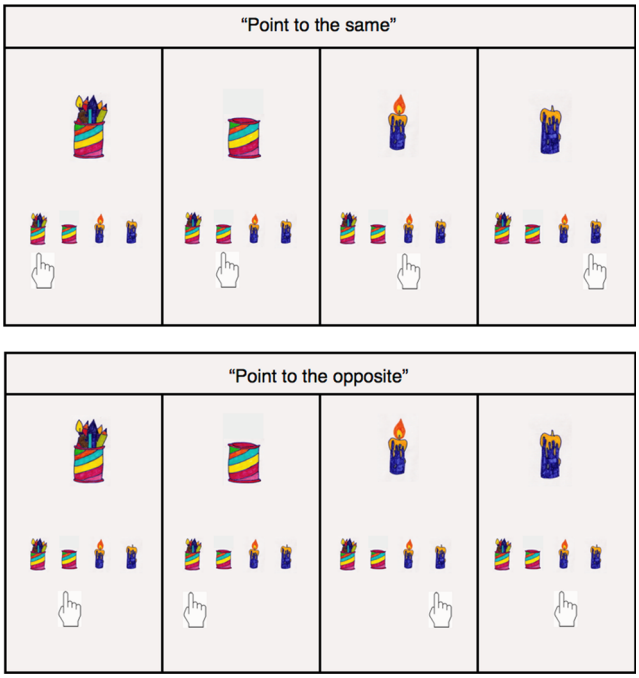

Fig. 2 The Auditory-Visual-Visual Conditional Discrimination (Auditory-Visual CD). The auditory stimulus was the expression "Point to the same" or "Point to the opposite." The first visual stimulus was the picture depicted above in each panel. The second visual stimulus was the picture with the function of correct comparison, indicated by the hands. In a typical conditional discrimination, all comparisons (e.g., the four pictures below) are of the same modality and are presented at random locations in all the trials of a phase

may emerge after learning (a) to identify properties as opposite to other properties under the contextual cues "same" and "opposite," (b) the relations between the abstract properties "empty" and "full" and their respective words. In other words, we hypothesize than an individual must learn the Auditory-Visual CD and the tacts or selection-based discrimination or both for demonstrating the emergence of intraverbals. Even though learning these operants may suffice for a verbally sophisticated human to show the emergence of intraverbals, it is very likely that a child requires more components and that, as he or she acquires verbal skills, he or she needs progressively less components (actually, this is what occurs with the requirements for the emergence of the intraverbals demonstrated by Pérez-González et al., 2008, as analyzed by Belloso-Díaz & Pérez-González, 2016). Thus, we incorporated the Auditory-Auditory CD because it has one verbal stimulus (e.g. "Full" in "Point to the opposite of full") that the Auditory-Visual CD does not have (i.e., *full* is a property of the visual stimulus that functions as the sample), and this feature can facilitate the emergence of the intraverbal, which has that verbal stimulus (e.g., "Name the opposite of *full*"). Finally, we also used a phase in which the Auditory-Auditory CD was intermixed with the tacts, because studies on conditional discriminations showed that intermixing learned relations facilitates emergence (e.g., Alonso-Álvarez & Pérez-González, 2006).

The main goal of the present study was to test for the emergence of intraverbals with antonyms after learning relations among nonverbal stimuli and the corresponding relations between each nonverbal stimulus and its verbal stimulus. The study required implementing lengthy and, we believe, never before used procedures in young children. For this reasons, additional goals were secondary.

The second goal was to initially explore the conditions for the intraverbal emergence. We hypothesized that (a) the only relations necessary for the intraverbal emergence would be the tact, the selection, and the Auditory-Visual CD and (b) the Auditory-Auditory CD, without and with tacts, could facilitate the intraverbal emergence in some children. Thus, probes for the emergence of intraverbals were inserted (a) after the acquisition of the tact, the selection and Auditory-Visual CD, (b) after probing or teaching the Auditory-Auditory CD without tacts, and (c) after probing the Auditory-Auditory CD with tacts.

The third goal was to conduct a preliminary exploration on whether the experience with all the relations with a first stimulus set would facilitate the emergence of intraverbals with novel stimuli. In fact, a multiple exemplar intervention (MEI) has been demonstrated to bring about the emergence of novel relations (see reviews by Greer & Longano, 2010; Greer & Ross, 2008). To address this purpose, the entire procedure was replicated with an additional stimulus set with two children to determine whether the intraverbals would emerge with fewer components than with the first stimulus set. We hypothesized that (a) intraverbals could emerge with the second set even if not all of them had emerged with the first set, and (b) the Auditory-Auditory CD would not be necessary for intraverbal emergence with the second set even though it was necessary with the first set.

Method

Participants

Five typically developing children participated in this study: Marina (3 years, 10 months), Marta (3 years, 8 months), Sara (3 years,10 months), Luisa (3 years, 4 months), and Nayara (3 years, 2, months). They were Spanish speakers and attended public schools in Oviedo, Spain.

Stimuli and Relations

The nonverbal stimuli were visual and the verbal stimuli were auditory. There were two sets of stimuli. In each set, the visual stimuli were four pictures of objects in which opposite properties were apparent (see Fig. 3): In Set 1, the pictures were an empty jar, a full jar, a lit candle, and an unlit candle; in Set 2,

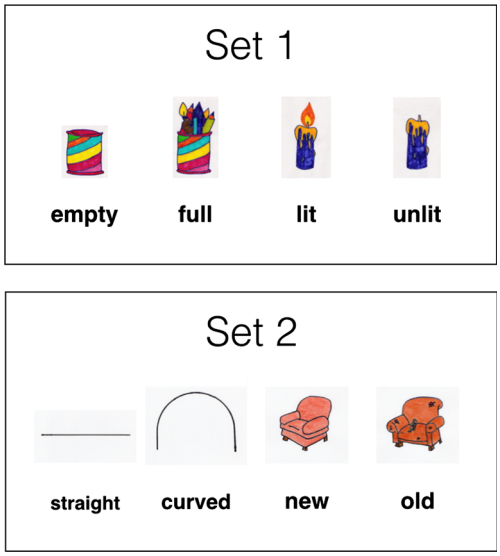

Fig. 3 Visual stimuli used in Set 1 and Set 2

the pictures were a curved line, a straight line, an old armchair, and a new armchair. The pictures measured 6 cm by 5.5 cm and were printed in white cards (10 cm by 12.5 cm). The auditory stimuli were the names of these properties presented in sentences spoken to the children (e.g., "Point to the opposite of empty"). All the auditory stimuli were in Spanish, as well as all verbal instructions.[1] (The words used were *jarra vacía*–empty jar, *jarra llena*–full jar, *vela encendida*–lit candle, *vela apagada*–unlit candle, *línea curva*–curved line, *línea recta*–straight line, *sillón viejo* –old armchair, and *sillón nuevo*–new armchair).

Among the stimuli of each set, five types of relations resulted from combining the visual stimuli and their corresponding names in intraverbals, tacts, and selection-based discriminations (see Fig. 1). First, the intraverbals that relate "empty" and "full" under the contextual cue "Name the opposite of" ("Name the opposite of *empty*"– "Full" and "Name the opposite of *full*"– "Empty"; in Spanish, they were, *"Dime el opuesto de vacío"–"Lleno"* and *"Dime el opuesto de lleno"–"Vacío"*).

Second, a conditional discrimination in which the sample in each trial was an object with a property (either empty or full), and the comparisons were, among other stimuli, the same object with the same property and the same object with the opposite property. Because we wanted to be sure that the participant selected according to the word "opposite," we used two contextual cues: "Point to the same" or "Point to the opposite" (in Spanish, *"Señala el mismo"* and *"Señala el opuesto,"* respectively). The resulting operant was a second-order conditional discrimination with auditory and visual stimuli as samples and with visual stimuli as comparisons; this was the Auditory-Visual-Visual Conditional Discrimination (denoting the modality of the first conditional stimulus or contextual stimulus, e.g., "same"; the second conditional stimulus or sample, e.g., the picture of an empty jar; and the comparisons, e.g., the pictures of an empty jar, a full jar, a lit candle, and an unlit candle). For clarity, we will shorten this denomination to Auditory-Visual CD.

Third and fourth, two relations established between the words and the physical properties. There are two types of relations, depending on whether the word was spoken or heard. The first operant type is an auditory-visual conditional discrimination, which consists of the participant selecting the appropriate picture when the experimenter presents the contextual cue, "Point to" (in Spanish *"Señala")* and says the name of the property (e.g., "full"). We denominated this operant type "selection," for the sake of simplicity. The second operant type is a tact, which consists of the participant saying the property of the object (empty or full) in the presence of a picture with an object and the contextual cue, "How is it?" (in Spanish, *"¿Cómo esta?")*

Fifth, a conditional discrimination similar to the Auditory-Visual CD except that the samples were words instead of figures (i.e., the comparisons were figures). We denominated this conditional discrimination the Auditory-Auditory-Visual Conditional Discrimination; also, for clarity, we will shorten this denomination to Auditory-Auditory CD.

Procedure

Overview A sequence of probing and teaching phases was implemented, with the probes for the emergence of the intraverbals (a) at the start the experiment, to control that the children had not acquired these before the experimental manipulations; (b) after teaching the Auditory-Visual CD; (c) after probing/teaching the Auditory-Auditory CD; and (d) after reviewing the Auditory-Auditory CD with tacts. This sequence appears in Fig. 4.

First, a preintervention probe of the intraverbals was conducted. Second, the *tacts* and the selection-based discrimination of the properties were probed because we supposed that mastery of them was a prerequisite for the emergence of the targeted intraverbals. If the child did not show the tacts or the selection-based discrimination, those relations were taught. Following these probes, the Auditory-Visual CD was taught. Then, we explored the effect of acquiring the tacts, selections, and the Auditory-Visual CD on the intraverbals by repeating the intraverbal probe. If the child showed the emergence of the intraverbals, the Auditory-Auditory CD was probed and the child finished the experiment with this stimulus set. Third, if the child did not show the emergence of the intraverbals, then the Auditory-Auditory CD was also probed. The goal was to explore if the experience with a discrimination that involves nonverbal and verbal stimuli would facilitate intraverbal emergence. If the child showed the emergence of the Auditory-Auditory CD relations, the probe of the intraverbals was

[1] The English translations are presented in text with the original Spanish, because extensions with English speakers could imply functional differences between the two languages.

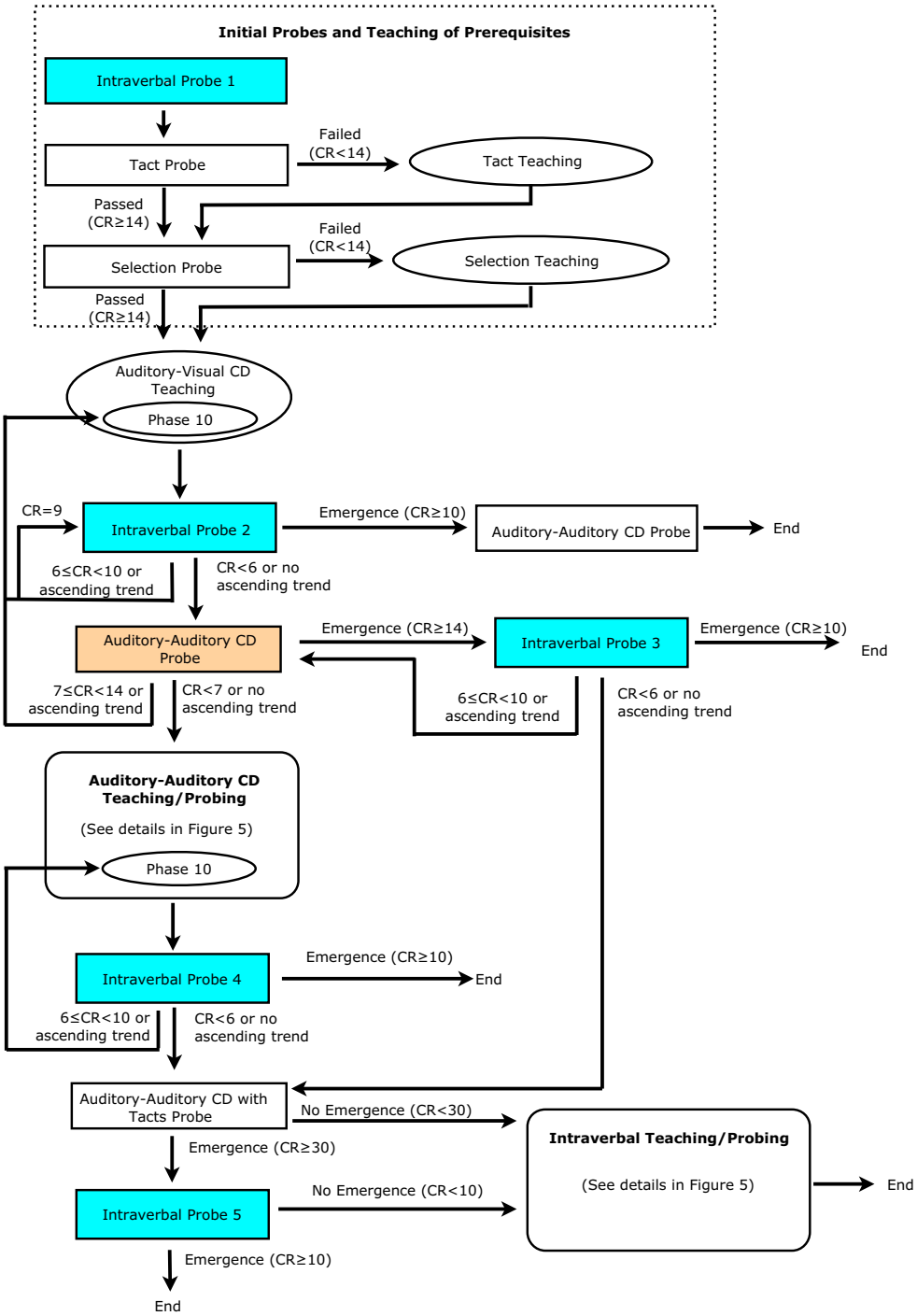

Fig. 4 Sequencing of the procedure. Rectangles indicate probes. Ovals indicate teaching. Rounded rectangles indicate stages with taught and probed relations. CR indicates correct responses in a probe. Rectangles in cyan indicate the intraverbal probes. Rectangles in orange indicate the Auditory-Auditory-Visual Conditional Discrimination (Auditory-Auditory CD). (Color figure online.)

repeated again. If, on the contrary, the child did not show the emergence of the Auditory-Auditory CD, then the four discriminations of the Auditory-Auditory CD (each one with an opposite property) were taught one at a time. After teaching each one, the remaining discriminations were probed with the purpose of obtaining the emergence of as many discriminations as possible. After acquiring the Auditory-Auditory CD (with the emergence of any number of discriminations), the intraverbals were probed again. If the intraverbals emerged, then the child finished the experiment with this stimulus set. Fourth, if the intraverbals still did not emerge, then we considered that the acquisition of the relations learned in the Auditory-Visual CD and the Auditory-Auditory CD did not facilitate emergence at this time with this participant. For these children, we provided experience with the intraverbals of the current stimulus set as a multiple exemplar intervention for facilitating the further emergence of the intraverbals with a novel stimulus set. Toward that goal, the four intraverbals

were taught one at a time. After teaching each one, the intraverbal probes were repeated to try to find the emergence of as many intraverbals as possible.

When a child demonstrated the emergence of intraverbals, the experiment was finished or continued with another stimulus set. Three children (Marina, Marta, and Sara) received the procedure with Set 1 and were no longer available; the other two children (Luisa and Nayara) were available and received the procedure with Sets 1 and 2.

Variables and Design *Independent variables*—The main goal of the study was to explore the emergence of intraverbals. Thus, the main independent variable was the entire procedure. For the second goal, there were two independent variables that could affect the emergence of the intraverbals: (a) the acquisition of the tact, the selection and Auditory-Visual CD and (b) the acquisition, by probing or teaching, of the Auditory-Auditory CD. For the third goal, the independent variable was the effect of conducting the entire procedure with the first stimulus set (i.e., the multiple exemplar intervention with the first set).

Dependent variables—The main dependent variable was the emergence of the intraverbals. For the main goal, the dependent variable was evaluated several times across the procedures. For the second goal, the dependent variable was evaluated before and after implementing the procedure. For the third goal, the dependent variable was evaluated by comparing emergence of the intraverbals and also by the number of procedure components. Tacts and selections were probed, but they were not targeted as dependent variables in the present study.

Designs—The designs for analyzing the effect of all independent variables were pre–post designs. They were replicated across five participants and (in three children) across two stimulus sets.

Sessions The research took place in a quiet room at the child's school. The experimenter sat in front of the child at a table. During the session, she presented each question aloud, waited 5 s for the child's response, presented the consequences, and then recorded the child's response. Sessions lasted for about 20 minutes. There were at least three sessions per week.

Phases The experiment was divided in phases in which one or several skills were probed or taught until a criterion was reached. When several stimuli were presented in a phase, they were presented randomly across trials, with the restriction that each one was presented the same number of times across a block of trials equal to the number of stimuli (e.g., if there were four stimuli, each one was presented once every four trials). In a similar way, the visual stimuli presented as comparisons were located at random locations across trials with the restriction that every stimulus appeared equally often in each location. The procedures to teach each discrimination were adaptations of the procedure analyzed by Rodríguez-Mori and Pérez-González (2005), which proved to be useful for teaching conditional discriminations.

Definition of Correct Responses In tacts, the correct response was defined as saying the name of the property with at least 70 % of the phonemes correct. In selections, the correct response was to touch the card corresponding with the experimenter's instruction with a finger. In intraverbals, the correct response was to say the response with at least 70 % of the phonemes correct.

Consequences In teaching phases, correct responses were followed by expressions such as "Very good," "Great," or, "You are very clever." These expressions have been shown to function as reinforcers in the context of this type of research and other research conducted with children of this age in similar settings. Incorrect responses were followed by "No, [the correct response]," or just the correct response. In probes, the experimenter did not provide consequences after responses on probe trials. At the end of each session, the experimenter gave the child a stamp for participating.

Preintervention Probes The intraverbals, tacts, and selection-based discrimination of the properties were probed to verify that the children had not previously acquired them. First, in the first intraverbal probe, three trials of each intraverbal of the type "Name the opposite of" were randomly presented (see Table 1). This probe was repeated several times along the procedure (see details below) to determine what relations would be necessary for demonstrating the emergence of the intraverbals. Second, in the tact probe, we presented four pictures of opposite properties in a random sequence, four times each one. In each trial the experimenter presented one picture and asked the child, "How is it?" Finally, in the selection-based discrimination probe, four trials for each property were presented. In this probe, the comparisons were the two pictures of the same object with the two related properties (e.g., an empty jar and the same jar full). In each trial, the experimenter asked the child to "Point to [property]" ("*Señala* [property]). In tact and selection-based discrimination probes, the criterion was 14 or more correct responses. Failing in the intraverbal probe qualified the child for participating in the study; all children failed. If the child met the criterion in the tact probe and the selection-based discrimination probe, then the procedure continued with the teaching of the Auditory-Visual CD. If the child did not meet the criterion in the tact probe or in the selection-based discrimination probe or both, then the relations she did not shown were taught in tact teaching and selection-based discrimination teaching, respectively.

Tact Teaching Training was conducted in seven phases. In Phase 1, the experimenter presented a picture (e.g., a empty

Table 1 Intraverbals of Sets 1 and 2, in the order they were presented (in normal lettering) and the intraverbals used, in Spanish (in italics)

Antecedent Stimuli	Response
Set 1	
Name the opposite of empty	Full
Dime el opuesto de vacío	*Lleno*
Name the opposite of unlit	Lit
Dime el opuesto de apagado	*Encendido*
Name the opposite of full	Empty
Dime el opuesto de lleno	*Vacío*
Name the opposite of lit	*Unlit*
Dime el opuesto de encendido	*Apagado*
Set 2	
Name the opposite of curved	Straight
Dime el opuesto de curvo	*Recto*
Name the opposite of old	New
Dime el opuesto de viejo	*Nuevo*
Name the opposite of straight	Curved
Dime el opuesto de recto	*Curvo*
Name the opposite of new	Old
Dime el opuesto de nuevo	*Viejo*

jar) and asked, "How is it?" ("*¿Cómo es?*). In the first two trials, the experimenter prompted the response by saying the name of the property immediately after the question. After the third trial just the question was asked – that is, the prompt was not presented. Phase 1 was completed after three consecutive trials with correct responses with no prompt; then, the procedure continued in Phase 2. Had a child made three consecutive incorrect responses, then it was programmed that the experimenter introduced again the prompt in two consecutive trials (no child failed; thus, this piece of the procedure was never implemented). Phase 2 was identical to Phase 1 except that the experimenter taught the tact of another property (e.g., a lit candle). In Phase 3, the experimenter randomly presented trials of the two tacts taught in Phases 1 and 2, with no prompts. After reaching a criterion of six consecutive correct responses, the procedure advanced to Phase 4. If the child made four consecutive incorrect responses, Phases 1 to 3 were repeated. Phases 4, 5, and 6 replicated the procedure of Phases 1, 2, and 3 except that the experimenter taught two new tacts of properties (e.g., corresponding to a full jar and an unlit candle). In Phase 7, the experimenter randomly presented trials of the four tacts taught in Phases 1 through 6, with no prompts. Phase 7 was completed after reaching a criterion of 12 consecutive correct responses—three responses of each tact property. Thereafter, the children who did not meet the criterion in the selection-based discrimination probe continued with the selection-based discrimination teaching. The children who met the criterion in the selection-based discrimination probe continued with the teaching of the Auditory-Visual CD (see below).

Selection-Based Discrimination Teaching Teaching was conducted in seven phases, as in tact training. The difference was that the antecedent stimulus was "Point to [property]" (e.g., "Point to *empty*"), and the comparisons were two pictures of the same object but with the two related properties (in this example, the comparisons were a full jar and the same jar, empty). The comparisons were presented in random positions across trials. Once the child met the criterion, she continued with the teaching of the Auditory-Visual CD.

Auditory-Visual CD Teaching The Auditory-Visual CD was taught in 10 phases. In Phase 1, the experimenter taught the child to point to the same picture. The experimenter presented a picture with a property as a visual sample (e.g., the picture of the empty jar) and the four pictures of the set as comparisons (e.g., two pictures of a jar, one empty and the other full, and two pictures of a candle, one lit and the other unlit), and said, "Point to the same" as the auditory stimuli of the sample. Across trials, the experimenter randomly presented the pictures of the four properties and randomly varied the position of the comparisons. This phase finished after the child met the criterion of 12 consecutive correct responses.

In Phase 2, the experimenter taught the child to point to the opposite of the property depicted in the visual sample. The stimuli were the spoken sentence, "Point to the opposite" and the picture of one property (e.g., the picture of the empty jar). The comparisons were the four pictures of the set presented in a fixed position across trials (this arrangement was used only initially because the procedure was effective to teach conditional discriminations; Pérez-González & Williams, 2002; Williams, Pérez-González, & Queiroz, 2005; see Phase 10, below). In the first two trials, the experimenter provided a prompt by pointing to the correct picture comparison (in the example, by pointing to the picture of the full jar). Thereafter, the experimenter did not provide any prompts. After reaching the criterion of three consecutive correct responses with no prompts, the child moved to the next phase.

Phase 3 was identical to Phase 2 except that selecting the opposite of another property was taught (e.g., a full jar). In Phase 4, the experimenter randomly presented trials of the two opposite properties taught in Phases 2 and 3. After the child reached the criterion of six consecutive correct responses, the experiment moved to next phase.

Phases 5, 6, and 7 were identical to Phases 2, 3, and 4 except that selecting the opposite of the other two properties of the set was taught (e.g., pointing to the opposite of *lit* and to the opposite of *unlit*). In Phase 8, the experimenter randomly presented trials of each one of the four opposite properties. When the child met the criterion of 12 consecutive correct responses, the experiment moved to the next phase.

In Phase 9, the experimenter presented randomly intermixed trials of "Point to the same" and "Point to the opposite" for each property. The criterion to move to the next phase was to make 16 consecutive correct responses.

Phase 10 was as Phase 9 except that the comparisons were presented at random positions across trials. Following the conclusion of Auditory-Visual CD teaching, the experiment continued with the intraverbal probe.

Second Intraverbal Probe The procedures described related to the first intraverbal probe were repeated. The experiment continued depending on the score: First, if the child responded correctly to 10 or more responses out of 12, then she reached the criterion to demonstrate the emergence of the intraverbals and she moved onto the Auditory-Auditory CD probe, and she finished the study or continued with another stimulus set. Second, if the child made between six and nine correct responses out of 12, Phase 10 of the Auditory-Visual CD teaching and the intraverbal probe were repeated to explore whether the score in the emergence probe of the intraverbals would improve after these reviewing-probing cycles. (We did so because it has been observed that intraverbals emerge after repeated cycles; e.g., Belloso-Díaz & Pérez-González, 2015a, 2015b, 2016; Miguel et al., 2005). This cycle was repeated while the number of correct responses in the intraverbal probe was increasing from one probe to the next. If the child responded correctly to the last nine trials of the probe, it also was repeated. Third, if the child did not show the emergence of the intraverbals (because she made six or less correct responses or did not show an ascending trend), the Auditory-Auditory CD was probed and the procedure continued.

Auditory-Auditory CD Probes The Auditory-Auditory CD was probed to explore the effect of the Auditory-Visual CD teaching in the emergence of this type of relation. In this probe, the stimuli were spoken sentences of the type "Point to the opposite of [property]" (e.g., "Point to the opposite of *empty*"), and the comparisons were the four pictures of the set, which were presented at random positions across trials. This probe consisted of 16 trials, four of each property. The criterion was 14 or more correct responses. If the child did not meet the criterion but she made seven or more correct responses out of 16, Phase 10 of the Auditory-Visual CD teaching and the Auditory-Auditory CD probe was repeated to verify if the remaining properties emerged. This cycle was repeated if the number of correct responses in the Auditory-Auditory CD probe was increasing from one probe to the next. Thereafter, if the child met the criterion in the Auditory-Auditory CD probe, the intraverbal probe was repeated. If the child did not show the emergence of the Auditory-Auditory CD, then the experiment continued with the Auditory-Auditory CD teaching/probing.

Third Intraverbal Probe The procedures and criterion were the same as the previous intraverbals probes. If the child did not show the emergence, then she moved to the Auditory-Auditory CD with tacts probe.

Auditory-Auditory CD Teaching/Probing A cycle consisting of teaching the Auditory-Auditory CD with one property and probing the remaining Auditory-Auditory CD properties was applied (see Fig. 5). This cycle was used to explore whether some relations of the Auditory-Auditory CD would emerge. In Phase 1, the experimenter taught the child to point to the opposite of one property. The sample was composed by two auditory stimuli, "Point to the opposite of" and "Point to [the property]" (e.g., "Point to the opposite of *empty*" and "Point to *empty*"). The comparisons were the four pictures of the set and they were presented at random positions across trials. In the first two trials, the experimenter provided a prompt by pointing to the correct comparison; starting on Trial 3, the experimenter did not provide any prompt. The criterion to progress to Phase 2 was emitting three consecutive correct responses. In Phase 2, the experimenter probed the emergence of selecting the picture with the opposite of the remaining three properties (in Set 1, selecting the opposite of *unlit, full,* and *lit*). The experimenter presented randomly 16 trials of this discrimination, four trials for each property, included the property taught in Phase 1. The criterion was 14 out of 16 correct responses. If the child made seven or more correct responses out of 16, Phase 1 and Phase 2 were repeated to find out whether the relations with the remaining properties would emerge. This cycle was repeated if an ascending number of correct responses was observed. If the child showed the emergence of selections corresponding to the three untaught properties, then the intraverbal probe was repeated. If the child did not show the emergence of the rest of opposite properties, she moved to Phase 3. In Phase 3, the experimenter taught the child to "Point to the opposite of *unlit*." The procedure was

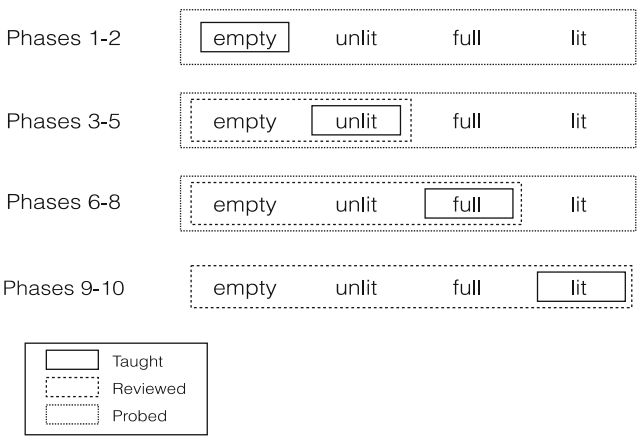

Fig. 5 Phases of teaching and probing in the Auditory-Auditory-Visual Conditional Discrimination (Auditory-Auditory CD) and the intraverbals (see text)

the same as in Phase 1. In Phase 4, the experimenter randomly presented trials of the properties taught in Phase 1 and Phase 3 (*empty* and *unlit*). The procedure moved to the next phase after reaching a criterion of six consecutive correct responses. In Phase 5, the experimenter probed the emergence of selecting the pictures with the opposite of the remaining two properties (selecting the opposite of *full* and *lit*). The procedure was the same as in Phase 2. Phases 6, 7, and 8 were the same as Phases 3, 4, and 5 except that the child was taught to point to the opposite of other property in Phase 6 (in Set 1, pointing to the opposite of *full*), and the three properties taught so far were reviewed in Phase 7. In Phase 9, the experimenter taught the child to point to the opposite of the remaining property (pointing to the opposite of *lit*). Finally, in Phase 10, the experimenter randomly presented trials of each property taught. After the child reached 14 or more correct responses, the procedure continued with the intraverbal probe.

Fourth Intraverbal Probe The procedures and the emergence criterion were the same as in the previous intraverbal probes. If the child did not meet the criterion, then she moved to the Auditory-Auditory CD with tacts probe.

Auditory-Auditory CD with Tacts Probe Before this probe started, the experimenter told the child, "Now you have to select the picture I ask and then you have to tell me how it is." In the first two trials, the experimenter helped the child to tact the picture by saying, "Point to the opposite of [property]" and, once the child selected a picture, the experimenter said, "How is it?" Starting on the third trial, the experimenter said only, "Point to the opposite of [property]." There were two correct responses: One was selecting the correct comparison as a function of hearing the word for the stimulus and the other was tacting at the same time the property that she selected (e.g., once the experimenter said "Point to the opposite of empty," the correct response was point to the picture of the full jar and at the same time say "Full"), therefore, for each trial we recorded two responses. Four trials of each opposite were randomly presented. If the child responded correctly to 30 out of 32 trials, then the intraverbal probe was repeated. If the child did not meet the criterion, the procedure continued in the intraverbal teaching.

Fifth Intraverbal Probe The procedures were the same as in the previous intraverbal probes. If the child made less than 10 correct responses, she continued with the intraverbal teaching.

Intraverbal Teaching/Probing If the child did not meet criterion in the emergence of the intraverbals under the conditions described, we tested whether teaching an intraverbal would produce the emergence of the remaining intraverbals. The purpose of it was to expose the child to multiple exemplar training (e.g., Greer & Ross, 2008) in an attempt to induce the emergence of the remaining intraverbals. This effect was probed further with stimulus Set 2. In the intraverbals teaching/probing, a cycle of teaching an intraverbal and probing the remaining was conducted with each of the four intraverbals (as it was done in the Auditory-Visual CD teaching/probe stage and as shown in Fig. 5).

In Phase 1, the experimenter taught to the child the intraverbal "Name the opposite of *empty*"–"*Full.*" First, she presented two trials in which she prompted the response by saying aloud the correct response just after making the request. Starting on the third trial, the prompts were no longer provided. After three consecutive correct responses with no prompt, the procedure moved to the next phase. In Phase 2, the experimenter probed the three intraverbals that had not been taught. She randomly presented 12 trials, three trials of each intraverbal, including the intraverbal taught in Phase 1, with the procedure used in the intraverbal probe. If the child made six or more correct responses out of 12, Phases 1 and 2 were repeated to find out whether the three remaining intraverbals emerge. This cycle was repeated while the number of correct responses in Phase 2 increased from one probe to the next. If the child met the criterion of 10 or more correct responses, the procedure finished or started with Set 2. If the child did not meet the criterion, the procedure moved to the next phase. In Phase 3, the experimenter taught a new intraverbal, "Name the opposite of *unlit*," with the same procedure as in Phase 1. In Phase 4, the experimenter randomly presented trials of the two intraverbals previously taught ("Name the opposite of *empty*" and, "Name the opposite of *unlit*"). When the child made six consecutive correct responses, the procedure moved to the next phase. In Phase 5, the intraverbal probe was repeated. If the child met the criterion of 10 or more correct responses, the procedure finished or started with Set 2. If the child did not meet the criterion, the procedure moved to the next phase. In Phase 6, a new intraverbal was taught ("Name the opposite of *full*"). The procedure was the same as in Phase 1. In Phase 7, the experimenter randomly presented trials of the three intraverbals previously taught ("Name the opposite of *empty*," "Name the opposite of *unlit*," and, "Name the opposite of *full*"). When the child made nine consecutive correct responses, the procedure moved to the next phase. In Phase 8, the intraverbal probe was repeated. If the child met the criterion of 10 or more correct responses, the procedure finished for that child or it was repeated with Set 2. If the child did not meet the criterion, the procedure moved to the next phase. In Phase 9, the last intraverbal was taught ("Name the opposite of *lit*") with the same procedure as in Phase 1. In Phase 10, the experimenter randomly presented trials of the four intraverbals taught. When the child met the criterion of 12 consecutive correct responses, the procedure finished for that child or it was repeated with Set 2.

Data Recording and Interobserver Agreement In addition to the experimenter, an observer recorded the children's

responses independently. In this study, 1,018 (41.23 %) trials of a total of 2,469 trials—both instructional and in probes—from all children were observed. The experimenter and the observer agreed on 1,010 of the 1,018 responses; thus, interobserver agreement (agreements / [agreements + disagreements]) was 99.21 %.

Results

Participant Marina

Figure 6 (top left) and Table 2 (see Appendix) display Marina's results. Marina did not respond correctly to any trial of the intraverbals and tact probe (she responded correctly to the 16 trials of selection-based discrimination probe). Therefore, she directly received tact teaching of the four properties. Marina learned the tacts in 112 trials (she failed in 10 trials). Thereafter, she learned the Auditory-Visual CD in 147 trials (she failed in 17 trials). In the intraverbal probe, she responded correctly to six of the 12 trials. Therefore, the last phase of the Auditory-Visual CD and the intraverbal probe were repeated. Marina responded correctly to all trials of the intraverbal probe. These results showed the emergence of the four intraverbals after learning the tacts and the relations with nonverbal stimuli. When the Auditory-Auditory CD was probed, Marina demonstrated these relations by responding correctly to 15 of the 16 trials.

Participant Marta

Figure 6 (top middle) and Table 2 (see Appendix) display Marta's results. Marta did not respond correctly to any trial of the intraverbal probe. She responded correctly to 14 of 16 trials of the tact probe and to the 16 trials of the selection-based discrimination probe. Therefore, she directly received the teaching of the Auditory-Visual CD. Marta learned the Auditory-Visual CD in 107 trials (she failed in two trials). In the intraverbal probe, she did not respond correctly to any trial. In the Auditory-Auditory CD probe, she responded correctly to one of the 16 trials presented. Thereafter, Marta learned the Auditory-Auditory CD with the first property ("Point to *empty*") in five trials. Then, she responded correctly to two of 16 trials in the probe of all properties. Thereafter, she learned the Auditory-Auditory CD of the second property ("Point to the opposite of *unlit*") in 11 trials. In the subsequent probe, she did not respond correctly to any trial with the remaining properties. Thereafter, Marta learned the Auditory-Auditory CD with the third property ("Point to opposite of *full*") in 18 trials; next, she responded correctly to three trials of the probe with the remaining property. Finally, she learned the Auditory-Auditory CD with the fourth property ("Point to the opposite of *on*") in 20 trials. Therefore, she moved in the intraverbal probe during which she responded correctly to seven of the 12 trials. When the last phase of the Auditory-Auditory CD and the intraverbal probe were repeated, Marta responded correctly to the 16 trials of the Auditory-Auditory CD and to 11 of 12 trials of the intraverbal probe. These results demonstrated the emergence of the four intraverbals, without direct teaching.

Participant Sara

Figure 6 (top right) and Table 3 (see Appendix) display Sara's results. Sara did not respond correctly on any trial of the intraverbal probe. She responded correctly to all the 16 trials in the tact and selection-based discrimination probes. Therefore, she directly received the teaching of the Auditory-Visual CD. Sara learned the Auditory-Visual CD in 156 trials (she failed only 10 trials). In the probe of the intraverbals and the Auditory-Auditory CD, she did not respond correctly to any trial. Therefore, Sara learned the Auditory-Auditory CD for the first opposite property ("Point to *empty*") in five trials, without errors. In the probe of all properties, she responded correctly to seven of 16 trials. Because she was showing some instances of emergence, the teaching of the Auditory-Auditory CD for the first property and the probe of all properties were repeated four times. In the last probe of the Auditory-Auditory CD of all properties, Sara responded correctly to the 16 trials. These results showed the emergence of the three remaining Auditory-Auditory CD properties. Next, in the intraverbal probe of intraverbals, she did not respond correctly to any trial. Thereafter, in the probe of the Auditory-Auditory CD with tacts she met the criterion (she responded correctly to 30 of 32 trials), but she did not respond correctly to any trial in the intraverbal probe. Then she directly received teaching of the first intraverbal ("Name to the opposite of *empty*"), she learned this intraverbal in five trials (she failed only in one trial). Therefore, in the probe of all intraverbals, she responded correctly to six of 12 trials. Thus, the experimenter reviewed the first intraverbal and the probed all intraverbals. Sara responded correctly to the 12 trials in the intraverbal probe. These results showed the emergence of the three intraverbals, after learning one of them.

Participant Luisa

Figure 6 (middle and bottom left) and Table 4 (see Appendix) display Luisa's results. In Set 1, Luisa did not respond correctly to any trial of the intraverbal probe. She responded correctly to 15 of 16 trials in the tact Probe and to 16 of the 16 trials in the selection-based discrimination Probe. Therefore, she directly received the teaching of the Auditory-Visual CD. Luisa learned the Auditory-Visual CD in 109 trials (she failed in only one trial). In the intraverbal probe, she did not respond

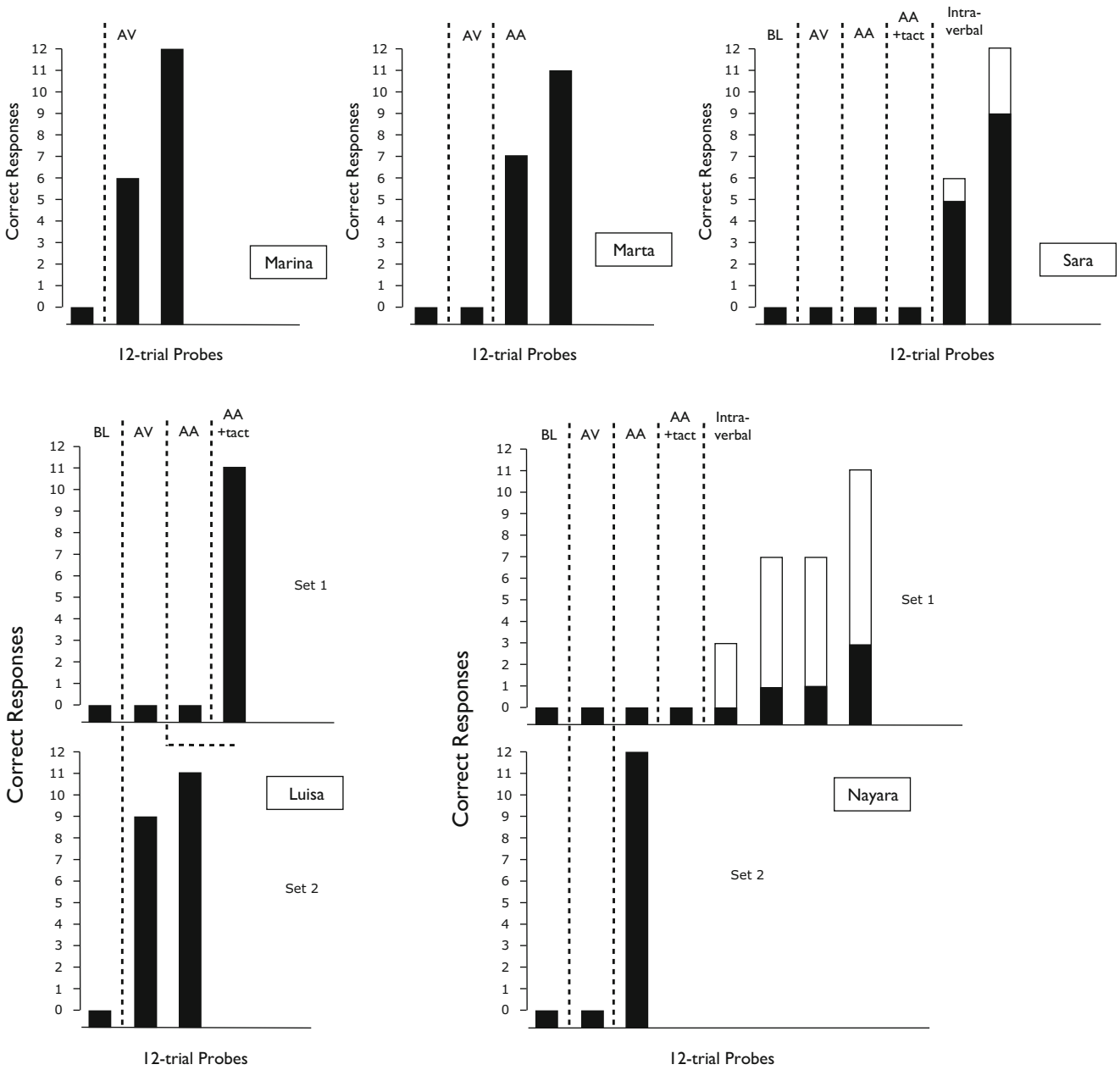

Fig. 6 Correct responses in the intraverbal probes, after the baseline (BL), learning the Auditory-Visual CD (AV), the Auditory-Auditory CD (AA), and the Auditory-Auditory CD probed with the tacts (AA + tact), and after 1 intraverbal was taught (Sara) and after 1, 2, 2, and 3 intraverbals were taught (Nayara, Set 1). Black bars indicate correct responses in the probes. White bars indicate correct responses in the intraverbals that were taught

correctly to any trial. In the probe of the Auditory-Visual CD, she responded correctly to one trial. Thereafter, Luisa learned the Auditory-Auditory CD with the first opposite property ("Point to the opposite of *empty*") in five trials, without errors. Next, she responded correctly in 15 of 16 trials of the probe of all properties. These results showed the emergence of the three remaining properties, without direct teaching. In the probe of intraverbals, however, she did not respond correctly to any trial. Then, she was probed in the Auditory-Auditory CD with tacts, and she responded correctly to 30 of 32 trials. Then, the intraverbal probe was repeated; she responded correctly to 11 of the 12 trials. These results showed the emergence of the four intraverbals.

In Set 2, Luisa did not respond correctly to any trial of the intraverbal and tact probes. In the selection-based discrimination probe, she responded correctly to all trials. Thereafter, she learned the tact of each opposite property in 53 trials, without errors, and she directly received the teaching of the Auditory-Visual CD. Luisa learned the Auditory-Visual CD in 85 trials (she failed in only one trial). In the intraverbal probe, she

responded correctly to nine of the 12 trials. Thereafter, the intraverbal probe was repeated and Luisa responded correctly to the 12 trials. These results showed the emergence of the four intraverbals, without direct teaching, after she learned the relations with the nonverbal stimuli. Then, the Auditory-Auditory CD was probed and she demonstrated the emergence of these relations by responding correctly to all trials.

Participant Nayara

See Figure 6 (middle and bottom right) and Table 5 (see Appendix). In Set 1, Nayara did not respond correctly to any trial of the intraverbal Probe. She responded correctly to 10 of 16 trials in the tact probe and to 16 of the 16 trials of the selection-based discrimination probe. Therefore, she directly received tact teaching. Nayara learned the tacts of each opposite property in 57 trials (she made only one error). Thereafter, she received directly the teaching of the Auditory-Visual CD. Nayara learned the Auditory-Visual CD in 107 trials (she made only two errors). In the intraverbal probe and the Auditory-Auditory CD probe, she did not respond correctly to any trial. Therefore, Nayara learned the Auditory-Auditory CD with the first opposite property ("Point to the opposite of *empty*") in five trials, without errors. Then she responded correctly to 10 of the 16 trials of the probe of all properties. Because she was showing some instances of emergence, the teaching of the Auditory-Auditory CD for the first property and the probe of all properties were repeated two times. In the third probe she responded correctly to 15 of the 16 trials. These results showed the emergence of the three remaining Auditory-Auditory CD properties. In the Intraverbal Probe, however, she did not respond correctly to any trial. Then, she was probed in the Auditory-Auditory CD with tacts, and she responded correctly to 31 of 32 trials. Next, the Intraverbal Probe was repeated, and she did not respond correctly to any trial. Therefore, she directly received intraverbal teaching. Nayara learned the first intraverbal ("Name the opposite of *empty*") in seven trials (she made only two errors). In the intraverbal probe, she responded correctly to three of the 12 trials. Then she was taught the second intraverbal ("Name the opposite of *unlit*") in 17 trials (she failed only one trial). In the intraverbal probe, she responded correctly to seven of the 12 trials. Therefore, the experimenter reviewed the second intraverbal and probed the remaining intraverbals. Nayara responded correctly to seven of the 12 trials in the intraverbal probe. Nayara learned the third intraverbal ("Name to the opposite of *full*") in 79 trials (she failed in nine trials). She repeated the intraverbal probe, and she responded correctly to 11 the 12 trials. These results showed the emergence of one of the intraverbals.

In Set 2, Nayara did not respond correctly to any trial in the intraverbal and tact probes. In the selection-based discrimination probe, she responded correctly to nine of the 16 trials. Next, Nayara learned the tact of each opposite property, in 81 trials (she made eight errors). Thereafter, she directly received selection-based discrimination teaching. Nayara learned the Selection-based Discrimination in 22 trials, without errors. Therefore, she directly received Auditory-Visual CD teaching. She learned the Auditory-Visual CD in 160 trials (she made 14 errors). In the Intraverbal Probe, she did not respond correctly to any trial. In the probe of the Auditory-Auditory CD she responded correctly to 16 of the 16 trials. Thus, she showed the emergence of this type of relation. Thereafter, the intraverbal probe was conducted again, and she responded correctly to all trials. These results showed the emergence of the four intraverbals without direct teaching.

Discussion

The first goal of the present study was to investigate whether the intraverbals would emerge after learning relations among nonverbal and verbal stimuli. Four children demonstrated the emergence of all the intraverbals with the present procedure, and the fifth child demonstrated the emergence of three of the four intraverbals: In Set 1, Marta, Marina, and Luisa demonstrated the emergence of the four intraverbals, Sara demonstrated the emergence of three intraverbals, and Nayara demonstrated the emergence of one intraverbal. In addition, when the procedure was repeated with a second stimulus set, Luisa and Nayara demonstrated the emergence of the four intraverbals. The emergence of all intraverbals, either in Set 1 or in Set 2, was observed across all five 3-year-old children, except for one of the four intraverbals in one child. Therefore, the emergence of intraverbals after direct learning of the relations with nonverbal stimuli has been clearly demonstrated.

The second goal was to initially explore the conditions for the intraverbal emergence. What was the role of learning the Auditory-Visual CD? The results suggests that intraverbals never emerge before the Auditory-Visual CD has been learned, even if tact and selection was demonstrated to be acquired (Marta and Sara). Moreover, all participants demonstrated the emergence of the intraverbals after learning the Auditory-Visual CD: Marina and Luisa in Set 2 demonstrated the emergence of the intraverbals just after learning Auditory-Visual CD. Marta, Sara, Luisa in Set 1 and Nayara demonstrated the emergence of the intraverbals after being taught and probed with other operants. These data suggest that learning the Auditory-Visual CD is necessary for the emergence of the intraverbals.

What was the role of learning the Auditory-Auditory CD? Two children demonstrated the emergence of the intraverbals before learning or being probed with this conditional discrimination (Marina and Luisa in Set 2). Therefore, these data suggest that the Auditory-Auditory CD is not necessary for the emergence of the intraverbals. Moreover, Marta and

Nayara in Set 2 demonstrated the emergence of the intraverbals after explicitly learning one or more discriminations of the Auditory-Auditory CD, and Luisa in Set 1 did so after this Auditory-Auditory CD learning and additional probes with this conditional discrimination and tacts. These data also indicate that learning the Auditory-Auditory CD, even though not being necessary, facilitates the emergence of intraverbals.

An interesting question is whether Auditory-Visual CD, Auditory-Auditory CD, or both are necessary for the emergence of intraverbals. We suppose that the Auditory-Visual CD is necessary, because for the intraverbals to emerge it seems necessary to acquire the relations with nonverbal stimuli that are shown in this conditional discrimination. Notice that the words "same" and "opposite" are stimuli in this conditional discrimination, and it is reasonable to suppose that an individual needs to learn some operant with these stimuli for being able to show the emergence of the intraverbals of the present study, which have the words "same" and "opposite." The results indicated that the Auditory-Visual CD discrimination alone was enough to show the emergence of the intraverbals and also that the Auditory-Auditory CD is not necessary. In spite of this, it is interesting to question what would have happened if the Auditory-Auditory CD were taught instead of the Auditory-Visual CD. It is possible that the intraverbals would eventually emerge. This hypothetical result would show that either the Auditory-Auditory CD or the Auditory-Visual CD is sufficient for the emergence of intraverbals. We did not conduct the controls regarding the order of teaching Auditory-Auditory CD and Auditory-Visual CD in the present study, because it was not its main goal of the study and also because of practical and ethical concerns (we believed that teaching the Auditory-Auditory CD before the Auditory-Visual CD would result in a procedure less efficient and therefore longer). Further research can address these hypotheses.

The third goal was to conduct a preliminary exploration of whether the experience with all the relations with stimulus Set 1 would result in the emergence of intraverbals with the novel stimuli of Set 2. Luisa and Nayara received the procedure with Sets 1 and 2. Collectively, the results for these two children showed the emergence of intraverbals with fewer requirements in Set 2 than in Set 1. Thus, it is possible that experience with the first set facilitated the emergence of intraverbals after learning a few relations with verbal and nonverbal stimuli (in lay terms, the procedure taught the child what both "opposite" and "same as" means). As a result, new pairs of opposites could be learned with an analogous set of relations, and the corresponding intraverbals could emerge. These results are congruent with the hypothesis that learning the sets of relations that relate all the stimuli facilitates the further emergence of intraverbals. In other words, these results are consistent with a main assumption of the relational frame theory (e.g., Hayes, Barnes-Holmes, & Roche 2001), in that learning a set of relations with one or several stimulus sets is necessary for the further emergence of one relation after learning other relations—as probed with additional stimulus sets. The results are congruent because all the relations taught and probed (the tacts, selections, Auditory-Auditory CDs, Auditory-Visual CDs, and intraverbals) constitute a relational frame, and, therefore, the experience with the first stimulus set could have resulted in emergences with the second set. These results are also congruent with those of many other studies on intraverbals conducted in our laboratory that show that the older the participant, the fewer operants he or she needs to learn in order to demonstrate the emergence of the intraverbals (Belloso-Díaz & Pérez-González, 2015b; Pérez-González, Belloso-Díaz, Caramés-Méndez, & Alonso-Álvarez, 2014).

The present study has interesting theoretical implications. One of them is that, as suggested by the present data, initially the child may have acquired several unrelated skills, which are not related until they receive specific experiences. In the present case, the children had acquired at a given point the tacts and the selections of opposite properties plus the Auditory-Visual CD with the stimuli "same" and "opposite." The first two relations, the tact and the selection, are presumably related to one another because they are the components of naming, and most typically developing children acquire them before they are 3 years old. Thereafter, they learned the Auditory-Visual CD. The subsequent data, that showed that most children did not show the emergence of the Auditory-Auditory CD or the intraverbals, suggest that tacts and selections (although related to one another) were independent from the Auditory-Visual CD and the intraverbals. Through the experience that combined probing and teaching, all those skills became mutually related. This process did happen in different ways for each child, as shown by the fact that each child required various types of experiences. The effects of teaching Set 1 on the acquisition of Set 2, which required fewer components, provided additional confirmation to this hypothesis.

Difficulties in the identification of the processes involved in the emergence of intraverbals were shown in some studies. Petursdottir et al. (2008) studied the function of learning category tacts and reverse intraverbals in the emergence of novel categorization intraverbals. Their procedure was effective for facilitating the intraverbal emergence in only one of the five children. In the same way, other studies have not shown the emergence of intraverbals until some intraverbals were explicitly taught (Partington & Bailey, 1993; Sundberg & Sundberg, 1990). In contrast, the procedure shown in the present study was demonstrated to be effective in the identification of the process involved in the emergence of intraverbals because the five children showed the emergence of these verbal operants, and one child showed the emergence twice. These data can be explained by having identified in the present study an important factor that facilitates emergence: the direct teaching or

observation of the differences among the properties of the objects in the relations with verbal and nonverbal stimuli (the Auditory-Visual CD).

The results of Sara and Nayara in Set 1 can be explained according to other studies that demonstrated transfer from learned intraverbals to novel intraverbals of the same type. Pérez-González et al. (2007) demonstrated the emergence of intraverbals of the type "Name the opposite of . . ." with children with pervasive developmental delays. Their results showed that learning several intraverbals of this type was not enough to produce the emergence of the related intraverbals with the stimuli-response elements reversed (e.g., showing the emergence of "Name the opposite of *empty*" after learning the intraverbal "Name the opposite of *full*"). The factor identified in the emergence of this type of intraverbals was learning pairs of related intraverbals (e.g., "Name the opposite of *empty*" and "Name the opposite of *full*"). After learning these pairs (e.g., after learning the *relational frame* or learning *multiple exemplars* related this way), learning an intraverbal resulted in the emergence of the related intraverbal. Pérez-González et al.'s data suggest that learning this relational frame was necessary to for the subsequent emergence of intraverbals (i.e., for the emergence of "Name the opposite of *full*" after learning "Name the opposite of *empty*"). In the present study, two children showed the emergence of some intraverbals after learning other intraverbals: Sara showed the emergence of three intraverbals after learning one, and Nayara, in Set 1, demonstrated the emergence of one intraverbal after learning three. These results can be explained according to the relational frame demonstrated by Pérez-González et al. Furthermore, the three remaining children, and Nayara, in Set 2, showed the emergence of the intraverbals before learning any intraverbal. Therefore, the learning process that facilitated the emergence with these children is different from that demonstrated by Pérez-González et al. Instead, the emergence of intraverbals occurred after the explicit teaching of the relations with nonverbal stimuli and the relations with verbal and nonverbal stimuli, as explained above.

The present study showed robust results in the emergence of intraverbals with young typically developing children. It strongly suggest that there are several prerequisites for the emergence that can be difficult to teach. However, learning these prerequisites may result in the emergence of intraverbal relations. Furthermore, the data of the present study suggest that learning to talk about and respond to things in their presence should occur before being able to talk about things in their absence. Again, the results suggest a way for making possible learning to talk in the absence of the nonverbal stimuli.

The present study has the limitation of using several pre–post designs that allow only demonstrations. Even though the results have been very strong, as five 3-year-old children showed the emergence, they need replication. Further studies should analyze the necessity of the Auditory-Visual CD and the Auditory-Auditory CD for the intraverbal emergence.

There is often too big of a rush to teach intraverbals to children with language delays. The outcomes are often a failure or learning an intraverbal with no relation to environmental stimuli that is not produced or generalized if the stimulation changes (a "rote" responding). For this reason, verbal conditional discriminations need to be established, and it is likely that each component of the discrimination needs to be established separately before being brought together in the conditional task. Moreover, cycles in which the taught skills are rapidly rotated and intermixed with probes are probably required (e.g., Greer & Ross, 2008). The way it was conducted in the present study was successful, but other, similar procedures can be effective as well. The designed procedure of this study should be replicated with children with language and developmental delays. It is very likely that these results could have important applications for the design of procedures for teaching this type of language to children with language delays.

Authors' note This research was supported by a grants BP06-108 and COF10-11 from the Fundación para el Fomento en Asturias de la Investigación Científica Aplicada y la Tecnología (FICYT), and grants SEJ2006-08055, of the Ministerio de Ciencia y Tecnología, and PSI2009-08644, of the Ministerio de Ciencia e Innovación, Spain. This research was conducted as partial fulfillment of the doctoral dissertation of the second author under the supervision of the first author. The authors thank María Baquero, Raquel Busto, and Vanessa González for their help in recording data for interobserver agreement and the principals and teachers of the schools Lorenzo Novo Mier and Colegio Público de la Corredoria, in Oviedo, for their collaboration in the research. Portions of these data were presented at the Annual Convention of the Association for Behavior Analysis, Phoenix, USA, 2009.

Compliance with Ethical Standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflicts of Interest Luis Antonio Pérez-González received grant SEJ2006-08055 from Ministerio de Ciencia y Tecnología, Spain, and grant 009-08644 from Ministerio de Ciencia e Innovación, Spain.

Lorena García Asenjo received grants P06-108 & COF10-11 from Fomento en Asturias de la Investigación Científica Aplicada y la Tecnología (FICYT), Spain.

Authors Luis Antonio Pérez-González & Lorena García Asenjo declare that they have no conflict of interest.

Animal Rights This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from the teachers and parents of all individual participants included in the study.

Appendix

Table 2 Correct and total responses made by participant Marina and Marta in the teaching and probes. AA CD is the Auditory-Auditory Conditional Discrimination; AV CD is the Auditory-Visual Conditional Discrimination. These children received only Set 1

Operants	Results			
	Marina		Marta	
	Order 1	Order 2	Order 1	Order 2
Probes				
Intraverbal	**0/12***		**0/12***	
Tact	0/16*		14/16*	
Selection	16/16*		16/16*	
Teaching				
Tacts	101/112		-	
AV CD Teaching				
Teaching	130/147	20/21	105/107	
Probes				
Intraverbal	**6/12***	**12/12***	**0/12***	
AA CD		15/16*	1/16*	
AA CD Teaching & Probing				
Teaching "empty"		-	5/5	
AA CD Probe		-	2/16*	
Teaching "unlit"		-	11/12	
AA CD Probe		-	0/16*	
Teaching "full"		-	18/18	
Auditory-Auditory CD Probe		-	3/16*	
Teaching "on"		-	20/21	16/16
Probes				
Intraverbal		-	**7/12***	**11/12***

Results in the intraverbal probes appear in boldface

* Results corresponding to probes

Table 3 Correct and total responses made by participant Sara. AA CD is the Auditory-Auditory Conditional Discrimination; AV CD is the Auditory-Visual Conditional Discrimination. This child received only Set 1

Operants	Results					
	Order 1	Order 2	Order 3	Order 4	Order 5	Order 6
Probes						
Intraverbal	**0/12***					
Tact	16/16*					
Selection	16/16*					
AV CD Teaching						
Teaching	146/156					
Probes						
Intraverbal	**0/12***					
AA CD	0/16*					
AA CD Teaching & Probing						
Teaching "empty"	5/5	5/5	5/5	5/5	5/5	
AA CD Probe	7/16*	12/16*	12/16*	13/16*	16/16*	
Probes						
Intraverbals					**0/12***	
AA CD & Tact					30/32*	
Intraverbals					**0/12***	
Intraverbal Teaching & Probing						
Teaching "empty"					5/6	5/5
Intraverbal Probe					**6/12***	**12/12***

Results in the intraverbal probes appear in boldface

* Results corresponding to probes

Table 4 Correct and total responses made by participant Luisa in the teaching and probes. AA CD is the Auditory-Auditory Conditional Discrimination; AV CD is the Auditory-Visual Conditional Discrimination

Operants	Results		
	Set 1	Set 2	
	Order 1	Order 1	Order 2
Probes			
Intraverbal	**0/12***	**0/12***	
Tact	15/16*	0/16*	
Selection	16/16*	16/16*	
Teaching			
Tacts	-	53/53	
AV CD Teaching			
Teaching	108/109	84/85	
Probes			
Intraverbal	**0/12***	**9/12***	**11/12***
AA CD	1/16*	-	16/16*
AV CD Teaching & Probing			
Teaching "empty"	5/5	-	-
AA CD Probe	15/16*	-	-
Probes			
Intraverbal	**0/12***	-	-
AA CD & Tact	30/32*	-	-
Intraverbal	**11/12***	-	-

Results in the intraverbal probes appear in boldface

* Results corresponding to probes

Table 5 Correct and total responses made by participant Nayara in the teaching and probes. AA CD is the Auditory-Auditory Conditional Discrimination; AV CD is the Auditory-Visual Conditional Discrimination

Operants	Results					
	Set 1				Set 2	
	Order 1	Order 2	Order 3	Order 4	Order 1	Order 2
Probes						
Intraverbal	**0/12***				**0/12***	
Tact	10/16*				0/16*	
Selection	16/16*				9/16*	
Teaching						
Tacts	56/57				73/81	
Receptive Discrimination	-				22/22	
AV CD Teaching						
Teaching	105/107				146/160	
Probes						
Intraverbal	**0/12***				**0/12***	
AA CD	0/16*				11/16*	16/16*
Intraverbal						**12/12***
AA CD Teaching & Probing						
Teaching "empty"	5/5	5/5	10/10			-
AA CD Probe	10/16*	12/16*	15/16*			-
Probes						
Intraverbal			**0/12***			-
AA CD & Tact			31/32*			-
Intraverbal			**0/12***			-
Intraverbal Teaching & Probing						
Teaching "empty"			5/7			
Intraverbal Probe			**3/12***			-
Teaching "unlit"			16/17	18/20		-
Intraverbal Probe			**7/12***	**7/12***		-
Teaching "full"			-	70/79		-
Intraverbal Probe			-	**11/12***		-

Results in the intraverbal probes appear in boldface

* Results corresponding to probes.

References

Alonso-Álvarez, B., & Pérez-González, L. A. (2006). Emergence of complex conditional discriminations by joint control of compound samples. *The Psychological Record, 56*, 447–463.

Axe, J. B. (2008). Conditional discrimination in the intraverbal relation: A review and recommendations for future research. *The Analysis of Verbal Behavior, 24*, 159–174.

Belloso-Díaz, C., & Pérez-González, L. A. (2015a). Effect of learning tacts or tacts and intraverbals on the emergence of intraverbals about verbal categorization. *The Psychological Record, 65*, 749–760. doi: 10.1007/s40732-015-0145-0.

Belloso-Díaz, C., & Pérez-González, L. A. (2015b). Exemplars and categories necessary for the emergence of intraverbals about transitive reasoning in children. *The Psychological Record, 65*, 541–556. doi: 10.1007/s40732-015-0131-6.

Belloso-Díaz, C., & Pérez-González, L. A. (2016). Emergence of symmetrical intraverbals facilitated by learning skills with the intraverbal responses. *The Psychological Record, 66*, 269–281. doi:10.1007/s40732-016-0169-0.

Carnerero, J. J., & Pérez-González, L. A. (2014). Induction of full naming after observing visual stimuli and their names in children with autism. *Research in Developmental Disabilities, 35*, 2514–2526.

Carp, C. L., & Petursdottir, A. I. (2012). Effects of two training conditions of the emergence of novel intraverbals. An extension of Pérez-González et al. (2008). *The Psychological Record, 62*, 187–206.

Cihon, T. M. (2007). A review of training intraverbal repertories: Can precision teaching help? *The Analysis of Verbal Behavior, 23*, 123–133.

Coon, J. T., & Miguel, C. F. (2012). The role of increased exposure to transfer-of-stimulus-control procedures on the acquisition of intraverbal behavior. *Journal of Applied Behavior Analysis, 45*, 657–666.

Emmick, J. R., Cihon, T. M., & Eshleman, J. W. (2010). The effects of textual prompting and reading fluency on the acquisition of intraverbals. *The Analysis of Verbal Behavior, 26*, 31–39.

Fields, L., & Verhave, T. (1987). The structure of equivalence classes. *Journal of the Experimental Analysis of Behavior, 48*, 317–332.

Fields, L., Verhave, T., & Fath, S. J. (1984). Stimulus equivalence and transitive associations: A methodological analysis. *Journal of the Experimental Analysis of Behavior, 42*, 143–157.

Grannan, L., & Rehfeldt, R. A. (2012). Emergent intraverbal responses via tact and match-to-sample instruction. *Journal of Applied Behavior Analysis, 45*, 601–605.

Greer, R. D., & Longano, J. (2010). Naming a rose: How we may learn to do it. *The Analysis of Verbal Behavior, 26*, 73–106.

Greer, R. D., & Ross, D. E. (2008). *Verbal behavior analysis: Developing and expanding verbal capabilities in children with languages delays*. Boston, MA: Allyn & Bacon/Merrill.

Greer, R. D., Yaun, L., & Gautreaux, G. (2005). Novel dictation and intraverbal responses as a function of a multiple exemplar history. *The Analysis of Verbal Behavior, 21*, 99–116.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. New York, NY: Plenum Press.

Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 185–241.

Ingvarsson, E. T., & Hollobaugh, T. (2011). A comparison of prompting tactics to establish intraverbals in children with autism. *Journal of Applied Behavior Analysis, 44*, 659–664.

Ingvarsson, E. T., & Le, D. D. (2011). Further evaluation of prompting tactics for establishing intraverbal responding in children with autism. *The Analysis of Verbal Behavior, 27*, 75–93.

Kisamore, A. N., Carr, J. E., & LeBlanc, L. A. (2011). Training preschool children to use visual imagining as a problem-solving strategy for complex categorization tasks. *Journal of Applied Behavior Analysis, 44*, 255–278.

Kodak, T., Fuchtman, R., & Paden, A. (2012). A comparison of intraverbal training procedures for children with autism. *Journal of Applied Behavior Analysis, 45*, 155–160.

May, R. J., Hawkins, E., & Dymond, S. (2013). Brief report: Effects of tact training on emergent intraverbal vocal responses in adolescents with autism. *Journal of Autism and Developmental Disorders, 43*, 996–1004.

Miguel, C. F., Petursdottir, A. I., & Carr, J. E. (2005). The effects of multiple-tact and receptive-discrimination training on the acquisition of intraverbal behavior. *The Analysis of Verbal Behavior, 21*, 27–41.

Partington, J. W., & Bailey, J. S. (1993). Teaching of intraverbal behavior to preschool children. *The Analysis of Verbal Behavior, 11*, 9–18.

Pérez-González, L. A., Belloso-Díaz, C., Caramés-Méndez, M., & Alonso-Álvarez, B. (2014). Emergence of complex intraverbals determined by simpler intraverbals. *The Psychological Record, 64*, 509–526.

Pérez-González, L. A., García-Asenjo, L., Williams, G., & Carnerero, J. L. (2007). Emergence of intraverbals with antonyms as responses in children with pervasive developmental disorders. *Journal of Applied Behavior Analysis, 40*, 697–701.

Pérez-González, L. A., Herszlikowicz, K., & Williams, G. (2008). Stimulus relations analysis and the emergence of novel intraverbals. *The Psychological Record, 58*, 95–129.

Pérez-González, L. A., Salameh, J., & García-Asenjo (2015). Emergence *of intraverbals with categories as responses after learning intraverbals with elements in reverse stimulus-response functions*. Manuscript submitted for publication.

Pérez-González, L. A., & Williams, G. (2002). Multi-component procedure to teach conditional discriminations to children with autism. *American Journal on Mental Retardation, 107*, 293–301.

Petursdottir, A. I., Carr, J. E., Lechago, S. A., & Almanson, S. M. (2008). An evaluation of intraverbal training and listener training for teaching categorization skills. *Journal of Applied Behavior Analysis, 41*, 53–68.

Petursdottir, A. I., & Haflidadóttir, R. D. (2009). A comparison of four strategies for teaching a small foreign-language vocabulary. *Journal of Applied Behavior Analysis, 42*, 685–690.

Petursdottir, A. I., Ólafsdóttir, A. R., & Aradóttir, B. (2008). The effects of tact and listener training on the emergence of bidirectional intraverbal relations. *Journal of Applied Behavior Analysis, 41*, 411–415. doi:10.1901/jaba.2008.41-411.

Polson, D. A. D., & Parsons, J. A. (2000). Selection-based versus topography-based responding: An important distinction for stimulus equivalence? *The Analysis of Verbal Behavior, 17*, 105–128.

Rodríguez-Mori, M., & Pérez-González, L. A. (2005). A simple procedure to teach conditional discriminations to children. *Experimental Analysis of Human Behavior Bulletin, 23*, 3–6.

Sautter, R. A., LeBlanc, L. A., Jay, A. A., Goldsmith, T. R., & Carr, J. E. (2011). The role of problem solving in complex intraverbal repertoires. *Journal of Applied Behavior Analysis, 44*, 227–244.

Skinner, B. F. (1957). *Verbal Behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Sundberg, M. L., & Michael, J. (2001). The benefits of Skinner's analysis of verbal behavior for children with autism. *Behavior Modification, 25*, 698–724.

Sundberg, C. T., & Sundberg, M. L. (1990). Comparing topography-based verbal behavior with stimulus selection-based verbal behavior. *The Analysis of Verbal Behavior, 8*, 31–41.

Valentino, A. L., Shillingsburg, M., & Call, N. A. (2012). Comparing the effects of echoic prompts and echoic prompts modeled prompts on intraverbal behavior. *Journal of Applied Behavior Analysis, 45*, 431–435.

Vedora, J., Meunier, L., & Mackay, H. (2009). Teaching intraverbal behavior to children with autism: A comparison of textual and echoic prompts. *The Analysis of Verbal Behavior, 25*, 79–86.

Williams, G., Pérez-González, L. A., & Queiroz, A. B. M. (2005). Using a combined blocking procedure to teach color discrimination to a child with autism. *Journal of Applied Behavior Analysis, 38*, 555–558.