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ORIGINAL ARTICLE

Emergence of Naming Relations and Intraverbals after Auditory Stimulus Pairing: Effects of Probing the Listening Skill First

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Abstract

We analyzed the emergence of selections in response to names heard, tacts, and intraverbals as a result of observing auditory stimulus pairing in 11 typical developing adults, as an extension of a previous study by Carnerero and Pérez-González (*The Psychological Record, 65*(3), 509–522, 2015). In Part 1, four sounds of musical instruments were paired with their respective names spoken by the experimenter; in Part 2, the sounds were paired with their native country names spoken by the experimenter. Participants in Condition 1 received the pairing sequence of Part 1 and 2; participants in Condition 2 received the pairing sequence of Part 2 and 1. After pairing, selections of buttons that emitted the sound corresponding to the names or countries heard emerged in all participants and tacts emerged in most participants. After the completion of the two pairing phases, intraverbals emerged in three participants of Condition 1. Two participants of Condition 2 also demonstrated instances of emergence, but fewer than those of Condition 1. Thus, the sequence of the pairing phases influenced the emergence. The findings have direct implications on the teaching procedures to facilitate these types of emergence.

Keywords Intraverbal · Naming · Pairing · Emergence · Categorization

People probably learn intraverbals (Skinner, 1957) in the first or second year of life when learning to answer questions such as, "How old are you?" or "What does the cow say?" and similar questions. Studies on intraverbals have dealt with how to teach intraverbals to children who do not acquire them in development (see a review in Carp & Petursdottir, 2012). Although the first intraverbals are directly acquired, a quantum leap in the life of a person is reached when the person is able to respond to novel, never previously taught intraverbals, which allows people to behave in a myriad of novel settings with success. Thus, a second area of research aimed to investigate processes involved in the generation of novel intraverbals—in other terms, how novel intraverbals may *emerge*. Research on the emergence of intraverbals has been also productive in recent years (see a compilation and an analysis by Pérez-González, 2018).

The emergence of intraverbals is an important process involved in categorization tasks, in which a nonverbal stimulus is related to its name and the name of the category it belongs to. For example, the nonverbal stimulus apple is related to the verbal stimulus "apple" and the verbal stimulus "fruit." After learning to select the apple both after listening to "apple" on some trials, and "fruit" on other trials, a person can demonstrate the emergence of intraverbals such as responding "apple" to the question, "Name a fruit," and responding "fruit" to the question, "What is an apple?" Categorization is crucial because learning verbal and nonverbal behaviors related to a category sometimes results in behaviors for many members of that category; for example, learning behaviors related to the category of "animal" may result in similar behaviors for any mammal, primate, or human. Studies on categorization have shown that the procedures were not successful in obtaining emergence at a criterion close to 100% with most participants (Carnerero & Pérez-González, 2015; Chase, Johnson, & Sulzer-Azaroff, 1985; Lechago, Carr, Kisamore, & Grow, 2015; Partington & Bailey, 1993; Petursdottir, Carr,

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Lechago, & Almason, 2008; Watkins, Pack-Teixeira, & Howard, 1989; Smith et al., 2016). This outcome indicates that variables involved in this type of emergence have not been clearly identified. Other studies have shown procedures that lead to successful results (Belloso-Díaz & Pérez-González, 2015b, 2016; Grannan & Rehfeldt, 2012; Lipkens, Hayes, & Hayes, 1993; May, Hawkins, & Dymond, 2013; see also an analysis on this matter in Pérez-González's, 2018; and successful procedures in similar intraverbals in Belloso-Díaz & Pérez-González, 2015a; Pérez-González, Belloso-Díaz, Caramés-Méndez, & Alonso-Álvarez, 2014; and Pérez-González, Herszlikowicz, & Williams, 2008).

Carnerero and Pérez-González (2015) studied processes involved in the emergence of intraverbals related to categorization skills. Because categorization skills involve relations between nonverbal and verbal stimuli such as those in the tact (in lay terms, objects and its names and objects and the names of the categories they belong to), they explicitly taught and probed these relations, which are those involved in *naming*: as described by Carnerero and Pérez-González (2015), naming has been defined as tacting an object and selecting it upon hearing its name derived from previous exposure to the object and the name (Horne & Lowe, 1996; see also Greer & Speckman, 2009; Miguel, Petursdottir, Carr, & Michael, 2008). Naming is essentially a capability (e.g., Carnerero & Pérez-González, 2014; Greer & Ross, 2008) that involves two processes: (1) after a child is explicitly taught to tact an object, the operant consisting of selecting it upon hearing its name emerges; and (2) the tact emerges after learning to select the object upon hearing its name. The capability that results from learning each skill and probing the other has been named the *tact-selection naming* capability (Carnerero & Pérez-González, 2014, 2015; Pérez-González, Cereijo-Blanco, & Carnerero, 2014; Pérez-González, García-Conde, & Carnerero, 2011). The emergence of each operant, with different objects or events, is determinant to consider that a person has acquired the naming capability. Related to the naming capability just described, Greer and Ross (2008) pointed out that a typically developing child can observe an adult saying the name of an object and after just this observation both the tact and the object selection emerge without further teaching. This form of naming has been called *pairing naming* by Carnerero and Pérez-González (2014) and Pérez-González, Cereijo-Blanco et al. (2014), *full naming* by Greer and Ross (2008, p. 149), and a *naturalistic naming experience* by Longano and Greer (2015). We consider tact-selection naming and pairing naming as two different capabilities (as, for example, Carnerero & Pérez-González, 2014, 2015). Many studies have demonstrated the emergence of tacts and selections after presenting two paired stimuli (Cahill & Greer, 2014; Carnerero & Pérez-González, 2014; Longano & Greer, 2015; Omori & Yamamoto, 2013; Pérez-González, Cereijo-Blanco et al., 2014; Pérez-González et al., 2011; Ramirez & Rehfeldt, 2009; Rosales, Rehfeldt, & Huffman, 2012; Takahashi, Yamamoto, & Noro, 2011).

Carnerero and Pérez-González's (2015) attempted to replicate and expand with just auditory stimuli the studies that had demonstrated pairing naming. In particular, they explored the emergence of intraverbals after listening to the sounds of musical instruments paired with the name or the country they belong to (i.e., the participant was required to listen, then the sound of the instruments were played while the experiment said their name). Notice that all the stimuli presented were auditory (no photos or other visual stimuli were used) and that the participant was not required to make any response other than attending to the stimuli. Experimental participants were randomly assigned to two conditions. In Part 1, the participants in one condition heard to the sound of an instrument and the name of the instrument spoken by the experimenter. Then, the tacts of the sound of the instruments were probed. When the tact emerged, the sound selection was also probed (it consisted of listening to the name of an instrument and pressing the button that had previously emitted the sound of that instrument instead of the buttons that had emitted the sounds of other instruments). In Part 2, the same pairing-probing procedure was repeated but with the name of the country instead of the name of the instrument. The participants in the other condition received Part 2 first and Part 1 thereafter. The experimenters found that the probed tacts emerged in all participants and the probed selections emerged in three out of the four participants assigned to each group. The second goal of that study was to explore the emergence of intraverbals after that experience. After acquiring the sound-name and the sound-country relations (even without reinforcement) the intraverbals can emerge because the two verbal stimuli are related to the sound, which works as a node (see Fig. 1). To that goal, the emergence of the two intraverbals that relate the name of the instrument and the country were probed. For instance, researchers probed if the participants would respond "Japan" in response to "Name the country of the *mukkuri*" and

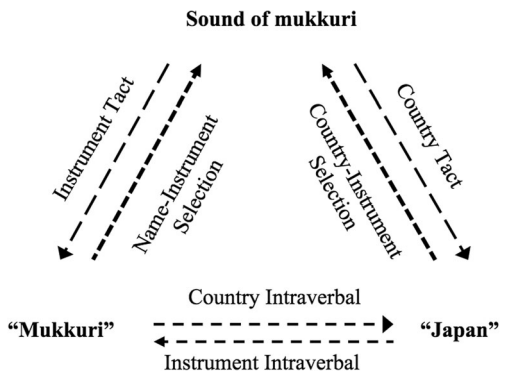

Fig. 1. Relations stimulus in tact, selection and intraverbal, and the name of the sound to the musical instrument and the name of the country of origin

would respond "Mukkuri" when they heard "Name a musical instrument of Japan" (in short, we describe these intraverbals as "Name the country of the *mukkuri*"—"Japan" and "Name a musical instrument of Japan"—"Mukkuri"). The intraverbals emerged fully in three of eight participants, emerged in four additional participants in some instances, and did not emerge in one participant. In summary, Carnerero and Pérez-González (2015) demonstrated the emergence of intraverbals after pairing the sounds of musical instruments with the names of the instruments and the countries they belong to. This experiment showed some interesting sequence effects, and replicated the effect that some intraverbals are more likely to emerge than others (i.e., the country intraverbals are more likely to emerge than in instrument intraverbals). Still, the results of emergence were not perfect in any group and the effects need additional replication.

Carnerero and Pérez-González (2015) probed first the naming relations after experiences of pairing naming. After each pairing phase, they first probed the tacts and repeated the probes until an emergence criterion was reached; thereafter, they probed the selections. It is possible that probing the selections first, rather than tacts, could have an effect in the further emergence of intraverbals. In fact, not all selections emerged at 100% correct in all participants and the lack of emergence correlated with the lack of emergence at 100% in the intraverbals.

The present study was designed as an extension of Carnerero and Pérez-González (2015), which also resulted in a systematic replication. The main goal was to find out whether probing the selection after each pairing phase, instead of the tacts, would affect the emergence of the intraverbals (see Fig. 2). It is possible that if the selections are probed first and tact emerges at a higher rate than if tacts are probed first (as in Carnerero and Pérez-González's study), then this outcome increases the likelihood of intraverbal emergence. That would be important because learning would be possible without the initial emergence of tacts, and therefore a new form of emergence would be demonstrated. The fact that the people demonstrate the emergence of selections after learning tacts earlier in development than the emergence of tacts after learning the selections (e.g., Gilic & Greer, 2011; Pérez-González & Williams, 2000) can result in that probing first the selections has a stronger effect than probing tacts on the further emergence of intraverbals. The results with children suggest that the rate of the emergence of tacts would be lower than that of selections. The results with adults, however, can be different from what this interpretation suggest, because the tact-selection naming and the pairing-naming capabilities are acquired around the third year of life (e.g., Cahill & Greer, 2014), and, as a result, adults demonstrate with great fluency the emergence of both operants.

The second and third goals of the present study were related to the outcome found by Carnerero and Pérez-González (2015) that first pairing the instrument sound with the name (as in the first group) produced more instances of the emergence of intraverbals than first pairing the instrument sound with the country (as in the second group). Moreover, intraverbals with the name of the country as response emerged better than intraverbals with the name of the instrument as response. This effect replicated those found in some studies on categorization (Belloso-Díaz & Pérez-González, 2015b, 2016). The next two goals of the present study were identical to those of Carnerero and Pérez-González's study and were intended to provide additional replications of the found processes. Thus, the second goal consisted of finding out whether first pairing the sound instrument with the name produces more instances of emergence of intraverbals than first pairing the sound with the country. Finally, the third goal consisted of finding out whether intraverbals with the name of the country as responses would emerge better than the intraverbals with the name of the instrument as responses.

Method

Participants

The participants were 11 bachelor's or master's students (5 women and 6 men; see Table 1). They participated voluntarily, were naïve to the goals of the study, and had not participated in similar experiments in the past.

Materials, Stimuli, and Relations

Stimuli The nonverbal auditory stimuli were sounds of eight musical instruments (see Table 2). Each sound was a 5-s recording downloaded from the internet. The verbal auditory stimuli were the names of the instruments and the countries of origin of the corresponding musical instruments, spoken by the experimenter (the first author).

Stimulus Relations The skills that relate the stimuli and the responses that were used in the present study were the tacts, selections, and intraverbals (see Fig. 1 and Table 3).

> ***Tacts.*** Tacts consisted of saying the name of the instrument or the country after hearing the sound of the instrument within 5 s following presentation of the instruction. In the *Instrument Tact,* the stimuli consisted of (1) the sound of the instrument and (2) listening, "What is the instrument?": the response was to say the name of the instrument. In the *Country Tact*, the stimuli consisted of (1) the sound of the instrument and (2) the question, "What is the country?": the response was to say the country of the instrument.

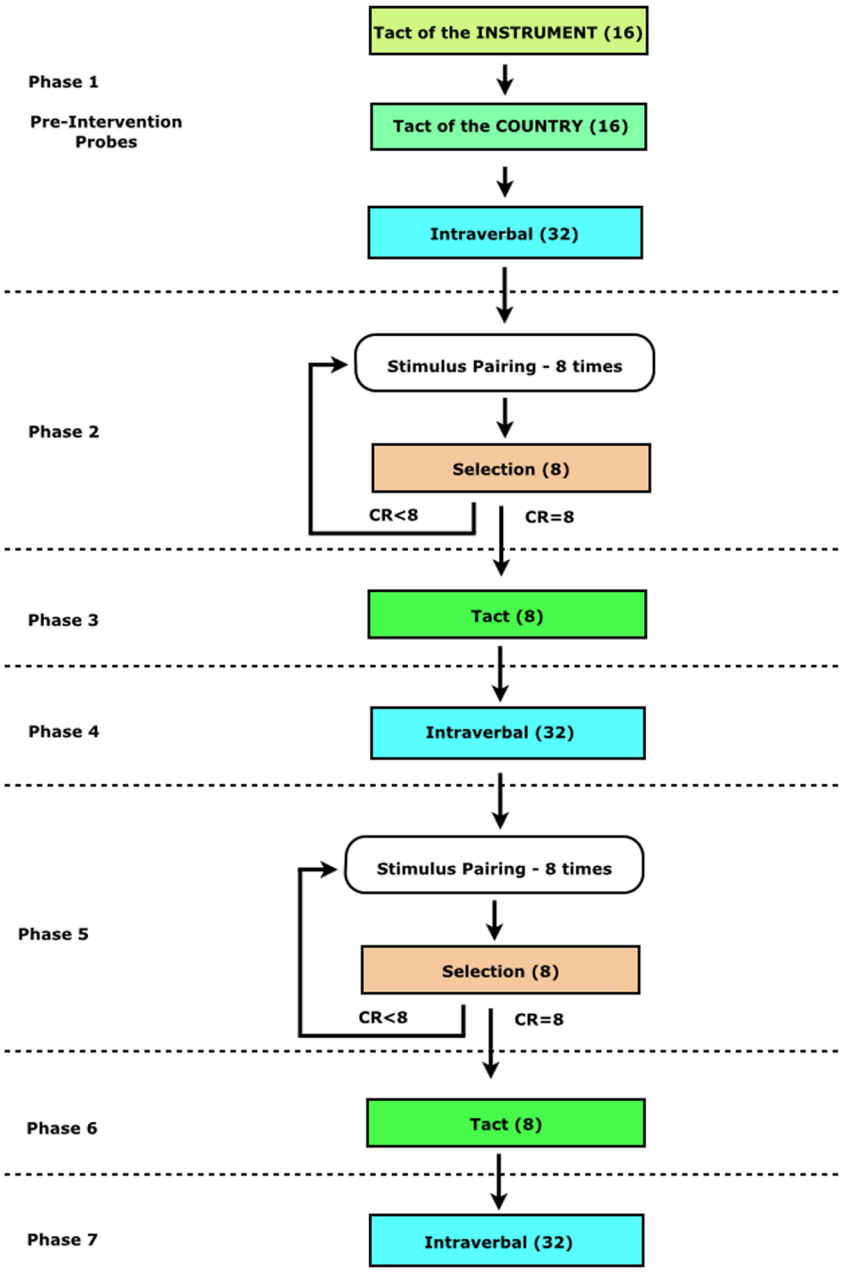

Fig. 2. Sequence of procedures. Colored boxes indicate probes. Numbers in parenthesis indicate trials presented. White boxes indicate pairing phases

Selections. Selections consisted of pointing to a visual stimulus (e.g., circles of different colors in the computer) that appeared together with the sound of an instrument corresponding to the heard instruction within 5 s following presentation of the instruction. They were conditional discriminations in which the sample was the name of the instrument or the country and the comparisons were the sounds of the instruments. In the *Name-Sound Selection*, the sample stimulus was hearing, "Point to [the instrument]" and the comparisons were the sounds of four instruments (see procedure below). The correct comparison was the sound of the heard instrument. In the *Country-Sound Selection*, the sample stimulus was hearing, "Point to [the country]" and the comparisons were the sounds of four instruments. The correct comparison was the sound of the instrument corresponding to the heard country.

Intraverbals. There were two intraverbals for each of the eight instruments (see Table 4): one intraverbal in which the response was to say the name of the country, "Name the country of the [instrument]"—[Country], called *Country Intraverbal*, and one intraverbal in which the response was to say the name of the instrument, "Name a musical instrument of [country]"—[Instrument], called *Instrument Intraverbal*. The 16 intraverbals were divided in two groups: the elements of eight intraverbals of four instruments were used for pairing; these intraverbals were

Table 1. Sex and age of the participants

Participant	Sex	Age
Condition 1		
1	Male	19
2	Male	19
3	Male	23
4	Female	19
Condition 2		
5	Male	21
6	Female	36
7	Male	21
8	Female	22
Control condition		
9	Female	23
10	Female	21
11	Male	18

called the *experimental intraverbals.* The elements of the other eight intraverbals corresponding to the other four instruments were not used in pairing; these intraverbals were called *control intraverbals.* Note than for these intraverbals, all the stimuli were verbal auditory (vocal),i.e., no nonverbal stimuli were presented.

Procedures

Setting and Sessions Sessions were conducted in a room at a private school. A portable computer was placed in front of the participant. The experimenter was seated beside the participant; thus, the participant could easily hear the experimenter but could not see his face nor guess what portion of the screen he was looking at. The instrument sounds were presented by the computer while a colored circle appeared on the screen. The colors were randomly assigned on each trial and were presented at random locations; therefore, colors and locations were different for successive presentations of each sound. Each session lasted about 1 hour, with a 10-min break between the first and second pairing (Phase 4 and Phase 5; see below) in which the participants waited in a room without the possibility of searching for information or talking with other people. All the sessions were conducted the same day.

Table 2. Names of the musical instrument and its respective countries

	Musical instrument	Country
Experimental	Mukkuri *(Mukkuri)*	Japón *(Japan)*
	Hang *(Hang)*	Suiza *(Switzerland)*
	Vibráfono *(Vibraphone)*	Estados Unidos *(United States)*
	Trembita *(Trembita)*	Ucrania *(Ukraine)*
Control	Bonang *(Bonang)*	Indonesia *(Indonesia)*
	Tanpura *(Tanpura)*	India *(India)*
	Diyiridú *(Didgeridoo)*	Australia *(Australian)*
	Kora *(Kora)*	Gambia *(Gambia)*

Tacts and intraverbals with all these eight musical instruments were probed in the Preintervention Probe. Thereafter, relations corresponding to four musical instruments were used for pairing and teaching (experimental), and the relations of the other four musical instruments were never paired or taught (control, see text for details). The names used, in Spanish, are shown in normal lettering and the names translated to English are shown in italics

Procedure Overview and Designs We conducted an initial probe with the sounds of all eight musical instruments. The sounds of four musical instruments were experimental and those of the other four musical instruments were control (see assignation criterion in *Partition of stimuli,* below). The experimental sounds were paired, and some of the relations of these stimuli were taught (see details below). The control sounds were never paired and the relations with these stimuli were never taught. These relations were, however, probed. Thus, these stimuli and relations served as control stimuli.

With the experimental sounds, the procedure was the following: first, (1) we paired the sounds with the name of the instrument and probed the emergence of the selections of the instrument and the tacts of the instruments; then, (2) we probed the emergence of the selections and tacts of the country after pairing the sound with the country of the instrument. Second, we explored whether the intraverbals emerged after the previous experiences. Therefore, the dependent variables were the emergence of the selections, tacts, and intraverbals. The main independent variable was the use of the pairing procedures.

The independent and dependent variables were related in several ways, which resulted in specific designs: first, the effect of the pairing procedure on the emergence of the selections was evaluated with a repeated probe design in which a pairing experience was followed by a probe of the selections. Second, once a criterion was reached in the probe of the selections, a probe of tacts was presented; we sought to explore the effects of the pairing experience and the emergence of the selections on the emergence of the tacts. This resulted in a pre/postintervention design. These procedures were conducted twice: once for the pairing of the sound and the name of instrument, and once for the pairing of the sound and the name of the country. Third, the effect of the two pairing procedures and their subsequent selection and tact probes on the emergence of the intraverbals was evaluated as well with a pre/postintervention design.

The effect of the two pairing procedures on the emergence of the intraverbals was controlled in two ways: first, by comparing the emergence of intraverbals with the stimuli used in pairing (the experimental intraverbals) with the emergence of intraverbals with stimuli that were not paired (the control

Table 3. Relations probed, stimuli, and responses of each operant

Relation	Stimuli	Response
Instrument tact	Sound of the instrument and "What is the instrument?"	Saying the name of the instrument
Name-sound selection	"Point to [instrument]"	Selected the circle that was presented when the sound corresponding to the instrument
Country tact	Sound of the instrument and "What is the country?"	Saying the name of the country
Country-sound selection	"Point to [country]"	Selected the circle that was presented when the sound corresponding to the country
Country intraverbal	"Name the country of the [instrument]"	Saying the name of the country
Instrument intraverbal	"Name a musical instrument of [country]"	Saying the name of the instrument

intraverbals). Second, by comparing the results in the postintervention probes of the participants who received the pairing procedure with those results of the participants of a control group who did not receive the pairing procedures (nor the subsequent selection and tact probes).

In addition, we explored whether pairing the sounds with the name of the instrument first and pairing the sounds with the country second would have an effect of the emergence of the intraverbals. Thus, we used a repeated probe design to evaluate whether the two pairing procedures (together with the selection probes and the tact probe that followed) had an effect on the emergence of the intraverbals.

Phases Overview The experiment consisted of the following phases (see Fig. 2): *Phase 1* consisted of probing the tacts of the instrument and the country, and the intraverbals with the sounds of the eight instruments. *Phase 2* consisted of pairing the experimental sounds with either the instrument names or the instrument countries (in Step 1) and probing the corresponding selection of the instrument sounds when the sample was the name of the instrument or the country (in Step 2). *Phase 3* consisted of probing the tacts of the experimental sounds. *Phase 4* consisted of probing the emergence of the intraverbals (with both the experimental and the control names). *Phase 5* consisted of repeating Phase 2 with the other stimulus (i.e., instrument country if instrument name was used in Phase 2 or instrument name if instrument country was used in Phase 2). *Phase 6* was analogous to Phase 3, but the stimuli were those used in Phase 5. *Phase 7* was identical to Phase 4.

Conditions There were two experimental conditions and one control condition. Four participants were randomly assigned to each experimental condition and three participants were assigned to the control condition (see Table 1). In Condition

Table 4. Experimental and control intraverbals probed

	Country intraverbal		Instrument intraverbal	
	Antecedent	Response	Antecedent	Response
Experimental intraverbals	Di el país del mukkuri	Japón	Di un instrumento musical de Japón	Mukkuri
	Name the country of mukkuri	*Japan*	*Name a musical instrument of Japan*	*Mukkuri*
	Di el país del hang	Suiza	Di un instrumento musical de Suiza	Hang
	Name the country of hang	*Switzerland*	*Name a musical instrument of Switzerland*	*Hang*
	Di el país del vibráfono	Estados Unidos	Di un instrumento musical de Estados Unidos	Vibráfono
	Name the country of vibraphone	*United States*	*Name a musical instrument of United States*	*Vibraphone*
	Di el país de la trembita	Ucrania	Di un instrumento musical de Ucrania	Trembita
	Name the country of trembita	*Ukraine*	*Name a musical instrument of Ukraine*	*Trembita*
Control intraverbals	Di el país del bonang	Indonesia	Di un instrumento musical de Indonesia	Bonang
	Name the country of bonang	*Indonesia*	*Name a musical instrument of Indonesia*	*Bonang*
	Di el país de la tanpura	India	Di un instrumento musical de India	Tanpura
	Name the country of tanpura	*India*	*Name a musical instrument of India*	*Tanpura*
	Di el país del diyiridú	Australia	Di un instrumento musical de Australia	Diyiridú
	Name the country of didgeridoo	*Australian*	*Name a musical instrument of Australian*	*Didgeridoo*
	Di el país de la kora	Gambia	Di un instrumento musical de Gambia	Kora
	Name the country of kora	*Gambia*	*Name a musical instrument of Gambia*	*Kora*

The intraverbals translated to English are shown in italics letters and the intraverbals used, in Spanish, are shown in normal lettering

1, the instrument sounds were first paired with their respective name, in Phase 2; then, the instrument sounds were paired with their respective country, in Phase 5. In Condition 2, the order was reversed: the instrument sounds were first paired with their respective country, in Phase 2; then the instrument sound was paired with their respective name, in Phase 5. In the Control Condition, the instrument sounds were not paired with the names or the countries. The purpose of this condition was to demonstrate that intraverbals do not emerge if the pairing procedures, coupled with the subsequent selection and tact probes, are not presented.

Phase 1. Preintervention Probes The participants received probes to verify that they had not acquired the tacts of the sound of the instrument (e.g., listening to the sound of a *mukkuri* and being asked, "What is the instrument?"), the tact of the country of the instrument (e.g., listening to the sound of a *mukkuri* and being asked, "What is the country of this instrument?"), the intraverbals that relate the name and the country of the instrument (e.g., "Name the country of the *mukkuri*"; the correct response is "Japan"), and the reverse intraverbal, "Name a musical instrument of Japan"; the correct response is *mukkuri*). No differential consequences were provided during probing and stimulus pairing blocks. In Phase 1, Preintervention Probes, conducted during the initial session, the experimenter gave the participants the following instructions: "Thanks for participating in this study. I will ask you some questions and you will have to respond by telling me names. After each response, I will not tell you anything. If you know the response, tell me that; if you do not know, you can say, 'I don't know.' If you don't tell me a response within 5 s, we will go on to the next. Please, try to say only one response. At the end of the session, we will answer your questions."

Tact of the instrument probe. At the start of the block, the experimenter told the participant, "Now you are going to listen to some sounds. After listening to the sound, tell me what instrument makes that sound." Then the experimenter presented the sound. Sixteen trials were presented a random sequence, corresponding to the eight instruments, with each instrument presented twice per trial block.

Tact of the country probe. The probe was identical to the tact of the instrument probe, except that the experimenter asked the participant to say the country of the instrument after hearing the sound of the instrument. Thus, the instruction was, "Now you are going to listen to some sounds. After listening to the sound, tell me what country this instrument comes from."

Intraverbal probe. The experimenter told the participants, "Now, I will ask you some questions. If you do not know the answer you can say 'I don't know.'" The experimenter then conducted 32 trials in which the eight experimental intraverbals and the eight control intraverbals were presented in a random sequence, twice each (no instrument sounds occurred).

Partition of stimuli into experimental and control. The stimuli corresponding to four instruments in which all participants gave zero or one correct responses in the tact and the intraverbal probes were the experimental sounds. The stimuli corresponding to the other four instruments were the control sounds.

Phases 2 and 5. Sound-Instrument and Sound-Country Pairing These consisted of two steps: stimulus pairing and post-pairing selection probe. These two steps were repeated (a cycle) until the participant reached criterion in Step 2 (see below).

Step 1. Stimulus pairing. The experimenter told the participant, "Now, some colored circles will appear on the screen, you will hear a sound, and I will say a name. You must remain silent looking at the screen while you listen." On each screen pairing presentation, the circle appeared (with a random color for each trial), the sound of the instrument was presented for 5 s and, just after the sound finished, the experimenter said the name of the instrument or country (the interstimulus interval was 0 s). Then, after a period of about 2 s, a new pairing was presented. Each of the four experimental sounds was presented with the instrument or the country name twice, with a random order, for a total of eight pairings.

Step 2. Post-pairing selection probe. On each trial, the computer presented four colored circles, positioned randomly in the upper left, upper right, bottom left, and bottom right portions of the screen. The sound of an instrument was played simultaneously with the presentation of each circle. All stimuli were equally presented in the four locations of the screen, and the correct sound also appeared with equal probability in each location. At the start of the probe, the experimenter showed a slide and gave the participant the following directions: "When I press each one of these circles, a sound will appear. I will tell you first the name of the [instrument or country]. Then, you will listen to the four sounds as I press the circles. Finally, I will tell you to 'point' and you have to point to the circle where the sound of the [instrument or country] that I said appeared." Correct and incorrect responses did not receive differential consequences. The criterion was to correct responding on at least seven of the eight trials. If the participant did not reach the criterion, the experiment continued in Step 1 (i.e., started a new cycle). After reaching

criterion, the experiment continued with the tact probe (either Phase 3 or Phase 6).

Phases 3 and 6. Tact Probe They were identical to the tact of the instrument or the tact of the country probes, but only eight trials with the stimuli presented in the Step 1 were presented (in random order). Thereafter, the experiment continued in the intraverbal probe (either Phase 4 or Phase 7).

Phases 4 and 7. Intraverbal Probe These phases were identical to the intraverbal probe of Phase 1.

Response Definition Responses in the selection probes were considered correct if the participant selected the circle that was presented when the sound corresponding to the instrument or the name of the country spoken by the experimenter had been presented, according to the pairing presented in the previous step. The moment of touching the circle was considered the selection. If the participant selected any other circle, the response was considered incorrect. We established 5 s as a criterion for selection, and all participants made all responses within that period. Responses in tact probes were considered correct if the participant said the name of the instrument or the country, according to the pairing presented in the previous step. If the participant said any other name, did not pronounce all sounds in Spanish, said "I don't know," or did not say anything within 5 s, the response was considered incorrect. Responses in the intraverbals were considered correct if the participant said the country or the instrument, pronouncing correctly the word with all its sounds. If the participant said any other name, did not pronounce all sounds, said "I don't know," or did not say anything in 5 s the response was considered incorrect.

Data Recording, Interobserver Agreement, and Procedural Fidelity The experimenter recorded all participants' responses on data sheets created for the purpose of the study (available from the authors upon request) of the experimental conditions. Correct responses were registered with a "+"; for the incorrect responses, a "-" and the response emitted by the participant (in tacts and intraverbals) or the location of the circle selected by the participant and the sound emitted when it was presented (in selections) was also recorded. A second observer recorded the responses from all participants of the experimental conditons and one particiant of the experimental condition. She recorded 1,408 responses out of a total of 1,632 responses produced (86% of the trials). Interobserver agreement (agreements/[agreements + disagreements] x 100) was 100%. The observer also registered the implementation of the procedures by the experimenter according to the plan. The observer was taught to evaluate experimenter´s performance in stimulus presentation and consequencing during all the experiment. We followed the procedure described in Ross, Singer-Dudek, and Greer (2005) to evaluate experimenter´s performance. The implementation of the procedure was correct in all trials and presentations.

Results

Preintervention Probe

Most participants demonstrated zero correct responses correct in the preintervention probes of the tacts and the intraverbals (see Figs. 3 and 4). Participants 1 and 3 demonstrated one correct response out of eight in the probes of the experimental country intraverbal (ECI).

Emergence of Selections after the Pairing Procedure

Participants in *Condition 1* received first cycles in which pairing of the sounds and the name of the instruments were followed by instrument selection probes. The four participants reached criterion in the instruction selection probes within one cycle. After the tacts were probed (see next section), they received cycles in which pairing of the sounds and the country of the instrument were followed by country selection probes. The four participants reached criterion in the country selection probes within one or two cycles.

Participants in *Condition 2* received the cycles in the reverse order than the participants in Condition 1. Three participants reached criterion in the country selection probes within one cycle and the fourth participant (Participant 8) did so within two cycles. They reached criterion in the instrument selection probes within one cycle.

Emergence of Tacts

Participants in Conditions 1 and 2 received the tact probes just after demonstrating the emergence of the selections. In Phase 3, three participants from each condition demonstrated the emergence of the tacts in all eight correct responses in the probe after the first pairing (Participants 1, 2, and 3 of Condition 1 and Participants 5, 7, and 8 of Condition 2), and the remaining participant of each condition demonstrated the emergence of six tacts out of 8 trials (Participant 4 of Condition 1 and Participant 6 of Condition 2). In Phase 6, all participants from Condition 1 and two participants from Condition 2 demonstrated the emergence of all eight tacts in the probe after the second pairing and the two remaining participants from Condition 2 demonstrated the emergence of six (Participant 6) and four (Participant 8) tacts out of eight responses.

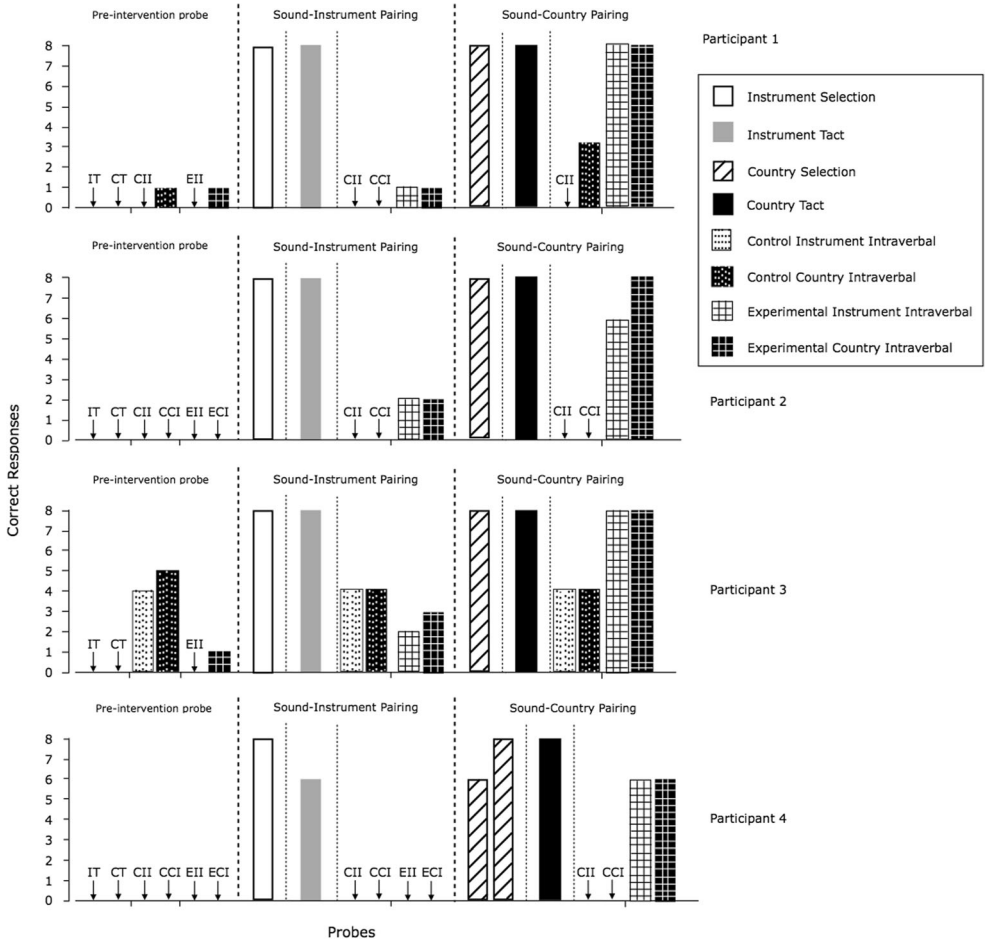

Fig. 3. Responding in the probes for the Instrument and Country Tacts (IT and CT, respectively), and the Control Instrument, Experimental Instrument, Control Country, and Experimental Country Intraverbals (CII, EII, CCI, & ECI, respectively) in Condition 1

Emergence of Intraverbals

Condition 1 In the experimental intraverbal probes conducted *after the first pairing procedure* was implemented (in Phase 4), two participants scored zero (Participant 4) or close to zero (Participant 1). Participants 2 and 3 demonstrated scores of two correct responses (out of eight responses) in the experimental instrument intraverbals and two and three correct responses (out of eight responses) in the experimental country intraverbals, respectively. Participant 3 had four correct responses for each of the instrument and country control intraverbals probes—he also had several correct responses in the preintervention probe. All three other participants scored zero in the control intraverbal probes. In the intraverbals probes conducted *after the second pairing procedure* (Phase 7), two of the four participants demonstrated the emergence of the instrument experimental intraverbals in all eight probe responses (Participants 1 and 3) and two participants demonstrated the emergence in six out of eight responses (Participants 2 and 4). Three of the four participants demonstrated the emergence of the experimental country intraverbals in eight out of eight responses and Participant 4 demonstrated the emergence in six out of eight responses. Therefore, all participants demonstrated the emergence of the instrument and country experimental intraverbals in 75% or more of the probe trials. In the control intraverbals, two participants emitted 0 correct responses (Participants 2 and 4), one participant emitted 3 correct responses out of 16 (Participant 1), and the fourth participant (Participant 3) maintained stable responding, in respect to the probes conducted after the first pairing procedure, of four correct for each type of intraverbal probe.

Condition 2 In the experimental intraverbal probes conducted *after the first pairing procedure* was implemented (in Phase 4), most participants scored zero or close to zero. Participant 7 demonstrated scores of three and four correct responses (out of eight responses) in the instrument and country experimental intraverbals, respectively. The remaining participants scored zero (Participants 5, 6, and 8). All participants scored zero in the control intraverbal probes. In the intraverbals probes conducted *after the second pairing procedure* (Phase 7), two of the four participants demonstrated the emergence of the instrument experimental intraverbals in all eight responses (Participants 5 and 7) and two participants demonstrated the emergence in six out of eight responses (Participants 6 and 8).

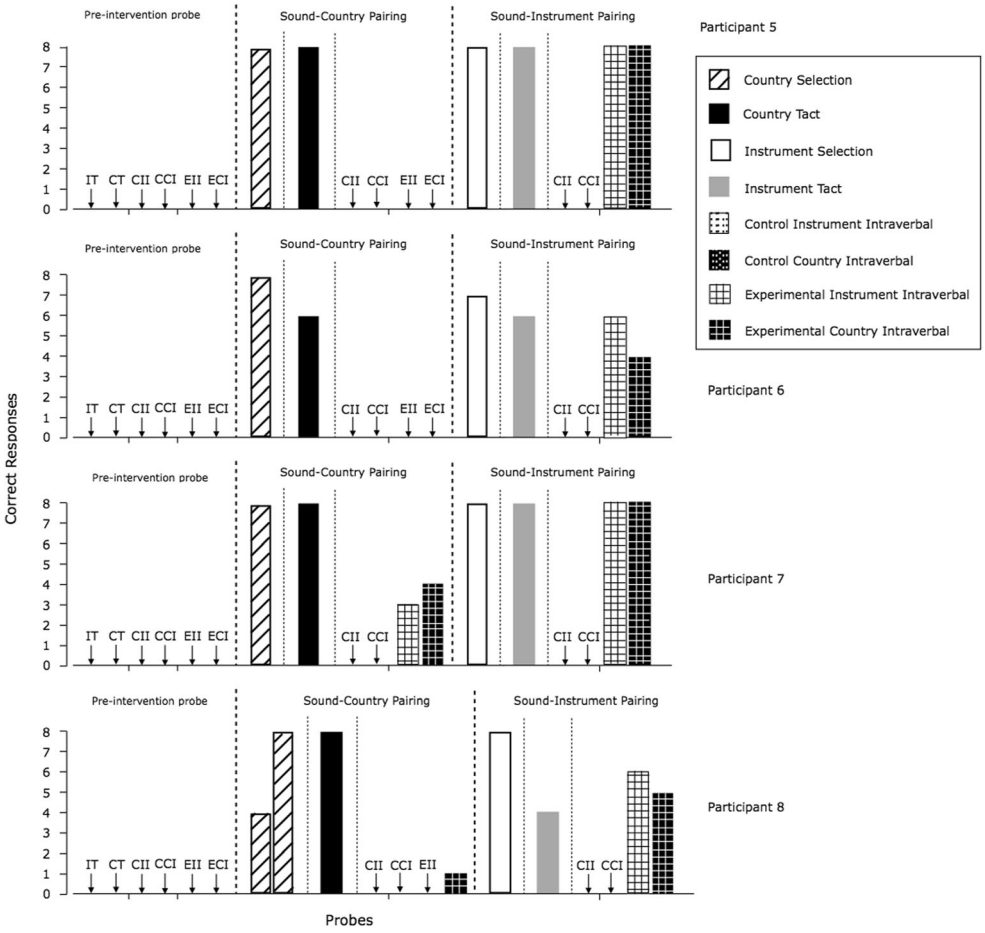

Fig. 4. Responding in the probes for the Instrument and Country Tacts (IT and CT, respectively), and the Control Instrument, Experimental Instrument, Control Country, and Experimental Country Intraverbals (CII, EII, CCI, & ECI, respectively) in Condition 2

Two of the four participants demonstrated the emergence of the country experimental intraverbals in all eight responses (again Participants 5 and 7) and the others two participants demonstrated the emergence in five and four out of eight responses (Participants 6 and 8, respectively). Thus, only two participants demonstrated the emergence of the instrument and country experimental intraverbals above 75% correct responding at the same time. In the control intraverbals, all participants scored zero in the instrument and country intraverbals. This is a clear example that without pairing procedure the intraverbal does not emerge.

Control Condition The three participants in this condition had zero correct responses in each eight trial probe.

Discussion

The main goal of the present study was to find out whether probing the selection after each pairing phase would affect the emergence of the intraverbals. The selections of the instrument emerged above criterion level after the first pairing presentation in all eight participants who experienced the pairing procedures. The selection of the country also emerged in all eight participants who experienced the pairing procedures. Six participants demonstrated emergence in the first probe session and the other two participants demonstrated emergence in the second probe. This was the first demonstration of the emergence of the selections after pairing auditory stimuli. Thus, a novel process involved in the emergence of intraverbals was demonstrated. The instrument tacts emerged to criterion in five participants. The remaining three participants also demonstrated instances of emergence. The country tacts emerged to criterion in seven participants. The instrument intraverbals emerged to criterion in four of the eight participants. The country intraverbals emerged to criterion in five of the eight participants. The remaining participants also demonstrated instances of emergence. Thus, the emergence of intraverbals after the experience with these two pairing procedures was demonstrated for the second time.

The second goal was to explore whether pairing the instrument sound with the name and then the instrument sound with the country would affect the emergence of intraverbals in relation to pairing the stimuli in the reverse order. The participants that experienced pairing in Condition 1 demonstrated more emergent responses in the intraverbal probes (a mean

of 7.25 correct responses out of 8) than the participants in Condition 2 (a mean of 6.62 correct responses). Therefore, it seems that pairing the sound with the instrument name first produces more instances of intraverbal emergence than pairing the sound with the country first, although this difference seems to be small.

The third goal was to explore whether intraverbals with the name of the instrument as responses emerged better than the intraverbals with the name of the country as responses (i.e., with more correct responses). Two participants demonstrated more correct responses in the instrument intraverbals than in the country intraverbals. One participant demonstrated more correct responses in reverse order. The remaining five participants emitted the same number of emergent responses (four of these participants responded to all intraverbals correctly; thus, there was a ceiling effect). The mean correct responses in the intraverbals with the name of the instrument as response was 7.00 (out of 8) whereas in the intraverbals with the country as response was 6.87. Thus, the difference in intraverbal emergence between the two types of intraverbals was very small.

The results of the present study regarding the emergence of intraverbals should be compared with those of our previous study (Carnerero & Pérez-González, 2015) because the procedures were identical except in the way to probe selections and tacts: in the present study the selection was probed first to criterion and thereafter the tact was probed, whereas in our previous study the probes were conducted in the reverse order. Moreover, the characteristics of the participants were similar: they were students or people with bachelor or master's degrees.

First, more participants demonstrated the emergence of the intraverbals in the present study than in the previous one: the instrument intraverbals emerged in four participants in the present study and in three participant of the previous study. The country intraverbals emerged in five participants in the present study and emerged in three participants of the previous study. Still, the difference was small. The difference appears greater when the overall correct responses are compared: the mean of correct responses in the instrument intraverbals was 7.00 in the present study and was 4.63 in the previous study. The mean of correct responses in the country intraverbals was 6.88 in the present study and it was 5.63 in the previous study. These results suggest that the procedures in the present study, in which the selections were probed first, produced more instances of emergence of intraverbals than the procedures of the previous study in which the tacts were probed first. This effect can be due to the fact that the adult participants have likely acquired the capacities of naming and pairing naming (Carnerero & Pérez-González, 2014; Greer & Ross, 2008; Pérez-González, Cereijo-Blanco, & Carnerero, 2014). Thus, after acquiring either the selection or the tacts, the other skill should immediately emerge (see also Petursdottir & Carr, 2011). The data in both studies indicates that this transfer was not perfect and that the participants who failed to show the emergence of all tacts or selections (i.e., produced fewer than seven correct responses) were the participants who failed the most to produce emergent intraverbal responses.

Second, the question regarding whether pairing first the instrument sound with the name and then the instrument sound with the country affects the emergence of intraverbals in relation to pairing the stimuli in the reverse order is answered in the following way: in the present and previous study, first pairing the sound with the name of the instrument produced more instances of emergence than the reverse order. Thus, this effect has been replicated in the present study. As explained by Carnerero and Pérez-González (2015, p. 519), this effect may be due to the fact that sound-country relations are relatively easier to learn (e.g., are learned with fewer trials) than the sound-instrument relations, as shown in that study, although that difference was not found in the present study.

Third, regarding whether intraverbals with the name of the instrument as responses emerged better than the intraverbals with the name of the country as responses was responded, the data show the following: in the previous study more instances of emergence were observed when the response in the intraverbal was to say the name of the country than when it was to say the name of the instrument. In contrast, in the present study that difference was very small (6.88 and 7 correct responses out of 8 on average in the country and the instrument intraverbals, respectively). Again, that small difference can be due mainly to a ceiling effect in the present study. For that reason, no clear comparison between the two studies is possible regarding this variable.

Finally, the emergence of selections after learning tacts with identical stimuli typically occurs before in development than the emergence of tacts after learning the corresponding selections (e.g., Gilic & Greer, 2011). For that reason, the emergence of selections should have been demonstrated immediately, as in Carnerero and Pérez-González's study. This did not happen with Participants 4 and 8. These results could be partially explained by the complexity of the selection task used, which employed buttons of several colors that were presented at random locations that varied across trials. The complexity of this task can explain the differences in the results between the previous study and the present one. Thus, it is likely that if the task is simplified (e.g., by placing the buttons of each sound at fixed locations) more instances of intraverbal emergence would be demonstrated with the procedure of the previous study, in which the tacts are probed first. An alternative procedure to improve the emergence of the intraverbals can be to repeat the probes of tacts and selections

(whatever the order they are presented) until reaching a high criterion before probing the intraverbals.

A correlation was observed in the present study between the emergence of tacts and the emergence of intraverbals. In fact, Participant 4 (who was exposed to the instrument sound paired with the name first) and Participants 6 and 8 (who were exposed to the instrument sound paired with the country first) had two errors out of eight in one or the two tact probes and they were the three participants who made fewer than seven correct responses in the two intraverbal probes. That correlation was not observed in the Carnerero and Pérez-González's (2015) study between the emergence of the selections and the emergence of intraverbals, but that correlation was impossible to find in that study (unless all intraverbals emerged in all participants) because the tacts were probed to criterion in that study, which produced high responding in the tact probes. Because pairing the instrument with the name first also correlated with the emergence of intraverbals, it is possible that the order of pairing (either with the name of the instrument or with the country) produced more emergence of tacts, and that the emergence of tacts had that effect on the emergence of the intraverbals. Thus, it is possible that both the order of pairing and the emergence of tacts may affect the emergence of intraverbals. In any case, the strong correlation found between the emergence of tacts and the emergence of intraverbals is worth exploring in further studies.

Participant 3 demonstrated 9 correct responses out of 16 in the preintervention probes of control intraverbals. He also made eight correct responses after the pairing phases with the experimental stimuli. The fact that this participant could have acquired some operants that could have facilitated the emergence of the experimental intraverbals due to an exclusion process similar to that observed when tacts are learned by exclusion, as shown by Greer and Du (2015). The remaining participants made zero correct responses after the pairing phases with the experimental stimuli, as expected because no pairing was presented with the stimuli of these intraverbals.

The correct responses expected in the intraverbal probe with the experimental intraverbals after the first phase procedure (Phase 4) would be close to zero, because the participants did not have yet experience with half of the verbal elements of the intraverbals. Participant 3 of Condition 1 had four correct responses for each of the instrument and country control intraverbals probes but he also had several correct responses in the preintervention probe. The remaining three participants of Condition 1 and the four participants of Condition 2 scored below 50%. Thus, the results in all eight participants of Conditions 1 and 2 were the expected ones. The present study had several limitations. The low number of participants per condition does not allow the observation of small differences when these are produced. The joint analysis of the results of the present study and those of the previous one allows, however, observing the primary effects, mainly those related to the order of presentation of the pairing phases. Another limitation is that the study was conducted with adults with sophisticated verbal skills. It is possible that the results with children may be different, especially in children who are at the developmental stage on which the capability of naming is acquired. Further studies that replicate the procedures of the present studies with children would provide interesting results regarding the emergence of these intraverbals after pairing. Finally, the experimenter presented the auditory stimuli himself, whereas it could be easily implemented by adding recording words to the computer presentation.

Selections were not probed prior to the intervention. We did so because we considered that probing tacts would suffice to explore the emergence of the intraverbals and we wanted to keep a procedure analogous to that used in Carnerero and Pérez-González (2015). In any case, the results indicate that intraverbals emerged as a result of the pairing experiences plus the tact and selection probes.

The processes shown in the acquisition of the categorization capabilities demonstrated in the present study, as well as in those by Belloso-Díaz and Pérez-González (2015b, 2016) and Carnerero and Pérez-González (2015), are very likely involved in what a child can learn after listening a demonstration in the classroom. The reasons for this is that demonstrations include the teacher presenting objects or facts—and naming them—without requiring a specific response by the student other than attending. The present results suggest procedures that could increase students' instances of emergence with intraverbals that relate names and the categories they belong to. That is, they suggest that a demonstration by a teacher may be learned better if the names of the specific instances (equivalent to the name of the instrument) are presented first and the category names (equivalent to the country) are presented thereafter. For example, it suggests that first presenting specific animals and naming them one at a time and then presenting the animals again and categorizing them as mammals (and doing that intermixed with animals of other category or categories) is more efficient than categorizing them as mammals first and then naming them one by one. Of course, if other skills are involved, the outcome could differ. This hypothesis, however, should be tested in further applied research.

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Compliance with Ethical Standards

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

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

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

I confirm that the information provided is accurate.

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