Psychol Rec
DOI 10.1007/s40732-015-0123-6

A|B|A|I Association for Behavior Analysis International

ORIGINAL ARTICLE

Emergent Relations with Compound Stimuli in Conditional and Simple Discriminations: an Experimental Application in Children

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Abstract The aim of this research was to examine the effect of discrimination training in the emergence of six new stimuli relations: two conditional discriminations and four simple discriminations (intraverbals). To do so, two experiments comprising a pretest, a training session, and a posttest were performed with twelve typically developing children randomized into two groups of six participants each. Using four sets of stimuli, A, B, C, and D, the children were trained in different sets of stimuli relations between flags, countries, and capitals. The stimuli relations were A1B1-C1, A1B2-D1, A2B1-C2, and A2B2-D2. In the first experiment, participants received conditional discrimination training, while in the second they received simple discrimination training. Emergent relations were evaluated using simple and compound stimuli in both experiments. The results showed that conditional and simple discrimination procedures are equally effective in the training stage. However, differences were found in the number of emergent relations between the two training procedures. Children who were trained using the simple discriminations procedure produced a greater number of relations in which they were not explicitly trained.

Keywords Compound stimuli · Conditional discriminations · Intraverbals · Emergent relations · Children

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Published online: 17 April 2015

Procedures using conditional and simple discriminations have been implemented for years to teach language to the disabled in an effective manner. In the scientific literature, in-depth behavioural analyses have been performed to dissect each component of the different contexts in which the children were trained. However, verbal behaviour includes much more complex situations than those described by simple stimuli. Due to the complex and combined nature of stimuli, the description of simple discriminations including various antecedent stimuli is continually being developed (see Eikeseth and Smith 2013; Sundberg and Sundberg 2011). According to Skinner (1957, p. 227), "(1) the strength of a single response may be, and usually is, a function of more than one variable and (2) a single variable usually affects more than one response." In this way, various variables or stimuli would control a response (convergent multiple control) or one variable or stimulus could control various responses (control) (Axe 2008; Michael et al. 2011). Nevertheless, the appropriate combinations of compound stimuli and the similarities and differences between them are yet to be determined.

A vast amount of research has been carried out on conditional discriminations using samples comprised of two stimuli (Carpentier et al. 2002; Debert et al. 2007, 2009; Grisante, et al. 2013). Although these studies use the terms "complex stimuli" and "compound stimuli" indistinctly, the stimuli relations that emerge are different. In some studies, subjects learn the stimuli combinations A1B1-C1 and A2B2-C2 (Groskreutz et al. 2010; Lane and Critchfield 1998; Maguire et al. 1994; Strommer and Strommer 1990a, b), while in others they learn several classes of stimuli (Augustson et al. 2000; Barnes et al. 1997; Markham and Dougher 1993; Markham et al. 2002; Ruiz and Luciano 2011). In these cases, similarities or differences can be established between the sample and the comparison stimulus. Alonso-Álvarez and Pérez-González (2006) and Pérez-González and Alonso-Álvarez (2008), used the stimuli relations A1B1-C1, A1B2-D1, A2B1-C2, and A2B2-D2, thus

allowing for a greater variety of stimuli combinations. The complexity of compound stimuli appears to more closely represent a natural environment. For this reason, it is of interest to investigate how different combinations of stimuli promote effective training procedures in order to achieve the goal of facilitating successful interventions for children with language disorders or autism.

Several recent studies have examined the effect of simple and conditional discrimination training using auditory stimuli and/or verbal responses in the production of new discriminations (Alós et al. 2013; Groskreutz et al. 2010; Petursdottir et al. 2008). Petursdottir et al. (2008) determined the effect of expressive language (simple discriminations) and receptive language (conditional discriminations) training on intraverbal relations (Michael 1982, 1984; Skinner 1957). In their experiment, four children were taught a small amount of vocabulary in a foreign language (Spanish) with a one-to-one equivalent to words in their native language (Icelandic). They evaluated the effect of training using two tests for bidirectional intraverbal relations on two sets of stimuli (fruits and animals). The authors concluded that both types of discriminations increased intraverbal responses, although these emerging relations were not always bidirectional. They also found that the procedure using simple discriminations was more effective for the emergence of bidirectional intraverbal relations than the procedure using conditional discriminations.

Groskreutz et al. (2010) carried out a study involving six children diagnosed with autism. They used a training sample consisting of conditional discriminations that included two stimuli (auditory and visual). The procedure enabled the authors to evaluate the children's performance in simple discriminations (tact and textual) that were not explicitly taught. The results showed acquisition of conditional discriminations and the emergence of simple discriminations.

In their review of the literature on instructions, Petursdottir and Carr (2011) recommended teaching children with and without disabilities expressive language (simple discriminations) rather than receptive language (conditional discriminations). However, no research has yet been carried out on the influence of both discriminations on the emergence of a greater number of relations with compound stimuli.

Given that natural contexts include multiple complex relations, it is necessary to investigate how to teach functional relations which include compound stimuli. It is also important to develop further procedures to achieve more relations in less time. Comparing procedures with experimental and systematic structures has proven to be an effective option for determining the most accurate procedure for evaluating relations and emergent relations. Thus, the purpose of the present research is to provide a systematic analysis of the level of accuracy in emergent relations depending on the procedure implemented: conditional discriminations or simple discriminations. It is also necessary to study how the inclusion and implementation of compound stimuli affect accuracy during the training procedure.

Our hypothesis is derived from the findings of Petursdottir et al. (2008) that simple discrimination training seems to facilitate the emergence of new relations to a greater degree than conditional discriminations, and that simple discriminations may be more efficient to acquire the trained relations with fewer trials. Therefore, we attempt to test that relations trained under conditions of verbal response are better established than relations with only selection answers. Compound stimuli could contribute to producing both trained and new relations.

Experiment 1

Method

Participants

Six typically developing children (three boys and three girls) attending a public elementary school in Spain participated in the experiment: Peter, John, Susan, Bruce, Mary, and Lisa. The participants were aged from 8 years 1 month old to 10 years 0 months old at the time they entered the study and were equally distributed in each group by sex to prevent gender bias.

Setting, materials, and stimuli

The experimental sessions were carried out in a school classroom. A child and the experimenter were seated at opposite sides of a table. An independent observer sat at a 90 degree angle to the right of the child at a distance of two metres. Another table with reinforcers, such as stickers, toys, and other objects, was placed in the room at a distance of five metres. The experiment was run over six sessions, which lasted approximately one hour each. Both experiments were carried out in the same week. Although no time limit was set for the experiments (the duration of the experiments was not a study variable), each experiment lasted approximately 45 minutes.

Two types of stimuli were used as follows:

- Three pictures displaying the flags of Qatar, Syria, and Ruanda. The pictures measured 3.3×2.1 inches (8.5×5.5 cm) in size and were presented on cards 4.7×3.5 inches (12×9 cm) in size. In the two pretests (phases 1 and 2), none of the children associated the flags with the names of the countries or their capitals.
- Six words divided into countries and capitals. The countries were Qatar, Syria, and Ruanda, and the capitals were Doha, Damascus, and Kigali. In some phases of the experiment, the participants were shown the words on cards, while in others, they were said out loud by the experimenter.

A capital letter and a number were used to designate each single stimulus, while the set of stimuli was labelled with capital letters. The compound stimuli were labelled with two letters (AB) and numbers in brackets (1, 2, 3). When the discrimination included a verbal response, the letter "R" was added. When stimuli C1, C2 and D1, D2 appeared in the same phase, both the stimuli and the responses were labelled with an "X". The stimuli are shown in Fig. 1.

Stimuli A3, B3, C3, and D3 functioned as distractor stimuli in the trials. However, the participants were not required to respond to these stimuli in either the pretest or the posttest. These stimuli were always presented as response options. Thus, the participants had to select from between three options, one of which was a distractor stimulus. These stimuli were not included in the training phases.

Procedure

Instructions

At the beginning of the experiment, the experimenter read the following instructions to the child:

> We are going to play a series of games. I am going to ask you some questions. It will be quick and when you finish you can choose one of these things (reinforcers), whichever one you want. Do not worry if you do not know the answers. I cannot tell you if they are correct or not. Just try to do the best you can.

In addition, at the beginning of each phase, the participants were told which type of answer was required: to say the answer or to point at it, as well as the possible response options. In the training session, the experimenter said the following:

A1	A2	A3
Country	Capital	State
B1	B2	B3
Qatar	Syria	Ruanda
C1	C2	C3
Doha	Damascus	Kigali
D1	D2	D3

Fig. 1 Stimuli used in Experiments 1 and 2

"Okay, now I can tell you when you are right, and I will help you when you need to improve." Social reinforcement such as "very good" or "great" was given when the participants provided correct answers in these phases. When the training session had concluded, the child was told: "Now, I cannot tell you if they are correct or not. You just try to do the best you can."

The stimuli were presented after eye contact had been established between the experimenter and the child.

Phases

The procedure was structured around a total of 21 phases that were grouped as follows: pretests (phases 1 to 8), training (phases 9 to 13), and posttests (phases 14 to 21). The acquisition criterion was defined as 90 % correct trials in both the pretest and posttest. Training consisted in the learning of conditional discriminations that included compound stimuli ([AB]-X). The criterion for advancing to the next phase was to give 10 consecutive correct responses in phases 9 to 12, and 12 consecutive correct responses in phase 13. The stimuli relations are shown in Fig. 2.

The stimuli were consistently randomized in all phases of the entire procedure. The phases are described as follows:

> *Phase 1. Test (AB)-RX.* Before the first test was presented, the participants were told that they should say one of four possible words: "Qatar," "Doha," "Syria," or "Damascus." The discriminations were presented in the following way. The experimenter presented a compound stimulus (AB) comprised of a stimulus A (flag) and a stimulus B (word) and the participant had to give a verbal response (RX). The flag was placed at the participant's eye level at a distance of approximately 19.5 inches (50 centimeters) while the experimenter said the corresponding word (country or capital). The trial concluded when the child responded. No deliberate consequences were administered during the pretest or posttest phases. The phases, the possible stimuli relations, and the acquisition criterion for all the phases are shown in Table 1.
>
> *Phase 2. Test (AB)-X.* The stimuli, the evaluation tests, and the acquisition criterion were the same as those in the first phase. However, the children now had to select a stimulus. The comparisons (X) were presented on an A4-sized sheet of paper placed on a table. Four words were printed in 22-point font capital letters in each corner of the sheet. A total of four sheets were used on which each stimulus was displayed in one of the four corners. A different sheet was used for each trial.
>
> *Phase 3. Test C-A.* The experimenter provided one of two possible oral stimuli (C1 or C2) and the child had to select one of the three comparisons on the table: flag A1, A2, or A3.

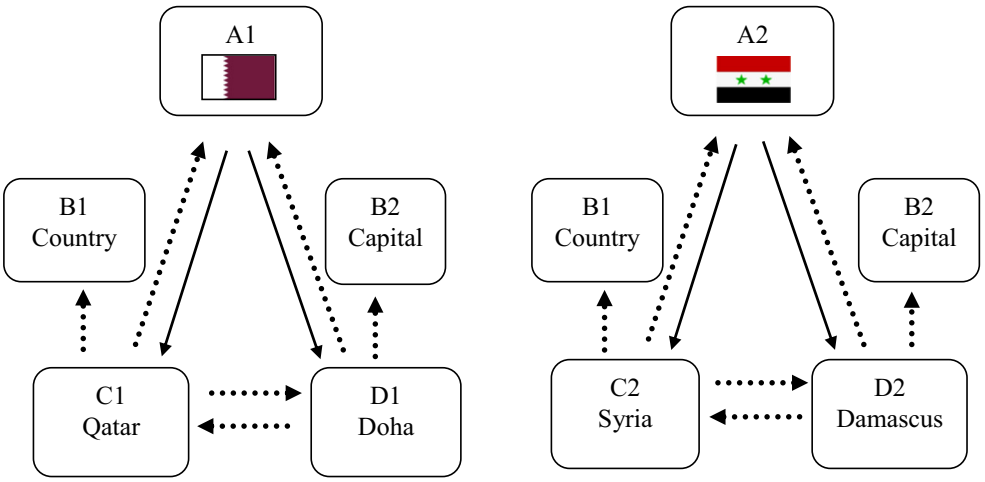

Fig. 2 Stimuli relations

Phase 4. Test D-A. The experimenter provided one of two possible oral stimuli (D1 or D2) and the child had to select one of the three comparisons on the table: flag A1, A2, or A3.

Phase 5. Test C-RD. Prior to the first trial, the participants were told that they should say one of the following words: "Doha," "Damascus," or "Kigali." These discriminations were presented in the following way. The experimenter provided one of two possible oral stimuli (C1 or C2) and the child had to provide one of the three verbal responses: RD1, RD2, or RD3.

Phase 6. Test D-RC. Prior to the first trial, the participants were told that they should say one of the following words: "Qatar," "Syria," or "Ruanda." The experimenter then provided one of two possible oral stimuli (D1 or D2) and the child had to say one of three verbal responses: RC1, RC2, or RC3.

Table 1 Phases, stimuli relations, and acquisition criterion (correct consecutive responses)

Phases	Stimuli relations	Acquisition criterion
1. Test (AB)-RX	(A1B1)-RC1; (A1B2)-RD1; (A2B1)-RC2; (A2B2)-RD2	10 or more trials
2. Test (AB)-RX	(A1B1)-C1; (A1B2)-D1; (A2B1)-C2; (A2B2)-D2	10 or more trials
3. Test C-A	C1-D1; C2-D2	9 or more trials
4. Test D-A	D1-A1; D2-A2	9 or more trials
5. Test C-RD	C1-RD1; C2-RD2	9 or more trials
6. Test D-RC	D1-RC1; D2-RC2	9 or more trials
7. Test X1-RB	C1-RB1; D1-RB2	9 or more trials
8. Test X2-RB	C2-RB1; D2-RB2	9 or more trials
9. Teaching A-C	A1-C1; A2-C2	10 trials
10. Teaching A-D	A1-D1; A2-D2	10 trials
11. Teaching (A1B)-X1	A1B1-C1; A1B2-D1	10 trials
12. Teaching (A2B)-X2	(A2B1)-C2; (A2B2)-D2	10 trials
13. Teaching (AB)-X	(A1B1)-C1; (A1B2)-D1; (A2B1)-C2 (A2B2)-D2	12 trials
14. Test (AB)-RX	(A1B1)-RC1; (A1B2)-RD1 (A2B1)-RC2; (A2B2)-RD2	10 or more trials
15. Test (AB)-RX	(A1B1)-C1; (A1B2)-D1 (A2B1)-C2; (A2B2)-D2	10 or more trials
16. Test C-A	C1-D1; C2-D2	9 or more trials
17. Test D-A	D1-A1; D2-A2	9 or more trials
18. Test C-RD	C1-RD1; C2-RD2	9 or more trials
19. Test D-RC	D1-RC1; D2-RC2	9 or more trials
20. Test X1-RB	C1-RB1; D1-RB2	9 or more trials
21. Test X2-RB	C2-RB1; D2-RB2	9 or more trials

Phase 7. Test X1-RB. Prior to the first trial, the participants were told that they should say one of the following words: "country," "capital," or "state." The experimenter then provided one of two possible stimuli (C1 or D1) and the child had to say one of the three verbal responses: RB1, RB2, or RB3.

Phase 8. Test X2-RB. Prior to the first trial, the participants were told that they should say one of the following words: "country," "capital," or "state." The experimenter then provided one of two possible oral stimuli (C2 or D2) and the child had to say one of the three verbal responses: RB1, RB2, or RB3.

Phase 9. Training A-C. The experimenter presented a visual stimulus (A1 or A2) and the child had to point to C1 or C2. In the first two trials, one for each stimuli relation of phases 9, 10, 11, and 12, the following prompt was provided: The experimenter presented the flag and said a word and immediately afterwards pointed to the appropriate word. In each phase, and in the remaining training phases, contingent verbal consequences were given, such as "very good" or "great." When a mistake was made, a correction was provided. The experimenter pointed to the correct answer so that the child could imitate that response. The trial concluded when the child gave the answer and the experimenter applied the consequence. The trials were randomized.

Phase 10. Training A-D. The experimenter presented a stimulus (A1 or A2) and the child had to point to D1 or D2.

Phase 11. Training (A1B)-X1. The experimenter presented two stimuli, A1 and B1 or B2, depending on the trial. The child then had to point to the printed answer, C1 or D1, accordingly. More specifically, the experimenter showed a flag (A1) while saying "country" or "capital" (B1 or B2) and the child had to point to "Qatar" or "Doha" (C1 or D1). In the first two trials, the following prompt was provided. The experimenter presented the flag and said either "country" or "capital," and then pointed to the appropriate word. The trials concluded when the child gave the answer and the experimenter applied the consequence. The trials were randomized.

Phase 12. Training (A2B)-X2. The experimenter presented two stimuli, A2 and B1 or B2, depending on the trial. The child had to point to C2 or D2, accordingly. The experimenter showed a flag (A2) while saying "country" or "capital" (B1 or B2) and the child had to point to "Syria" or "Damascus" (C2 or D2).

Phase 13. Training (AB)-X. Two stimuli were presented, A1 or A2 and B1 or B2, depending on the trial. The child had to select C1, C2, D1, or D2. More specifically, the experimenter showed a flag (A1 or A2) while saying "country" or "capital (B1 or B2). The child then had to point to "Qatar," "Doha," "Syria," or "Damascus," accordingly. No prompted trials were provided.

The posttest (phases 14 to 21) was carried out under the same conditions as the pretest. Phases 14 and 15, corresponding to (AB)-RX and (AB)-X, evaluated if the child had acquired the trained relations. These phases only evaluated the relations in which the participants had been trained. The next six phases, corresponding to C-A, D-A, C-RD, D-RC, X1-RB, and X2-RB, evaluated untrained relations. As a result, eight conditional discriminations were tested, of which the following six were emergent relations: 1) when the child was shown the words (Qatar or Syria) to choose the appropriate flag (CD); 2) when the child was shown the words (Doha or Damascus) to choose the correct flag (CD); 3) when the child said that Qatar was related to Doha and Syria was related to Damascus (intraverbal); 4) when the child said that Doha was related to Qatar and Damascus was related to Syria; 5) when the child said that Qatar and Syria are countries (intraverbal); and 6) when the child said that Doha and Damascus are capitals (intraverbal).

The structure of the phases, the stimuli relations presented in each phase, and the acquisition criterion are shown in Table 1.

Interobserver agreement

An independent observer recorded 100 % of the trials. The observer could not see the data obtained by the experimenter during the session. In order to calculate the agreements, the following formula was used: agreements divided by agreements plus disagreements multiplied by 100. The observers reached 98 % agreement for all trials.

Results

Peter did not meet the acquisition criterion in any of the pretest discriminations. To learn the conditional discriminations that included compound stimuli, he required a total of 92 trials. In the posttest, the acquisition criterion was reached in five discriminations: (AB)-RX, (AB)-X, C-A, X1-RB, X2-RB. Therefore, *Peter* met the acquisition criterion in the two phases that evaluated the acquisition of training: (AB) –RX and (AB) -X. However, he only reached this criterion in three of the six possible emerging relations: C-A, X1-RB, X2-RB.

John met the acquisition criterion for D-A in the pretest. To perform the pertinent discriminations, he required 85 trials. In the posttest, the correct criterion was met in eight discriminations: (AB)-RX, (AB)-X, C-A, D-A, C-RD, D-RC, X1-RB, X2-RB. Therefore, he achieved the six possible emergent relations.

Susan did not perform correctly in any of the pretest phases. To learn the pertinent discriminations, she needed 67 trials. In the posttest, she met the acquisition criterion in six discriminations: (AB)-RX, (AB)-X, C-A, D-A, D-RC, X2-RB. Consequently, she produced all the emergent relations tested.

Bruce and Mary did not met the acquisition criterion in any of the pretests. To learn the pertinent discriminations, *Bruce* required 67 trials and *Mary* needed 62 trials. In the posttest, *Bruce* met the acquisition criterion in discriminations (AB)-RX, (AB)-X, C-RD, and X1-RB, and *Mary* met them in discriminations: (AB)-RX, (AB)-X, C-A, D-A, C-RD, and D-RC. Both *Bruce* and *Mary* reached the acquisition criterion in the training phases. Therefore, *Bruce* demonstrated the emergence of two transfers of learning, while *Mary* produced four emergent relations.

Lisa did not meet the acquisition criterion in any of the pretest phases. To acquire the pertinent discriminations, she needed 62 trials. In the posttest, she reached the acquisition criterion in eight discriminations. Specifically, *Lisa* met the acquisition criterion in the training phases and produced the six possible emergent relations.

Therefore, not all participants produced the same number of emergent relations. Specifically, only two of the participants produced the six emerging relations (*John* and *Lisa*), two girls produced four emergent relationships each (Susan and Mary), one participant produced three emergent relations (*Peter*), and another met the acquisition criterion in only two emergent relations (*Bruce*).

A detailed description of the results is shown in Table 2. A graphic representation of the results for the pretest and posttest phases and the specific score for the emergent relations are displayed in Fig. 3.

Discussion

The procedure described above enabled us to evaluate the acquisition of the trained stimuli relations (AB)-RX and (AB)-X, and the emergence of six new relations: C-A, D-A, C-RD, D-RC, X1-RB, and X2-RB. Although the participants were observed to improve in most of the test phases, we cannot say that the procedure was completely effective regarding the emergence of all possible relations. However, the procedure was found to be effective for learning the trained relations.

The data seem to indicate that conditional discriminations with compound stimuli are effective in training phases, although their effect favours, to some degree, the emergence of new stimuli relations that are not explicitly trained. These results are in line with Petursdottir et al. (2008) as the participants' performance did not show high levels of accuracy following listener training. Although all the participants performed successfully in the training phases, training with conditional discriminations was insufficient to produce a greater number of emergent relations. Therefore, our data are consistent with those obtained by Peturdottir et al. and confirmed in a larger sample. Hence, it was necessary to study these effects using simple discriminations with compound stimuli to determine whether the verbal responses had any differential effect on the acquisition and transfer of learning.

Experiment 2

Method

Participants

Another group comprising six Spanish-speaking children participated in this experiment (three boys and three girls): *Nancy*, *Karen*, *Robert*, *Steven*, *Daniel*, and *Julia*.

Setting, materials, and stimuli

The experiment was conducted in the same location and under the same conditions as Experiment 1. The same stimuli with the same coding were also used. Moreover, it took the participants approximately the same amount of time to do Experiment 1 and Experiment 2.

Procedure

Both procedures (Experiment 1 and Experiment 2) shared some elements in common. For example, the pretest and posttest were implemented under the same conditions and the trials were randomized in both experiments. Moreover, both experiments included a five-phase training session. As in the previous experiment, a prompt was provided for each possible relation in the first two trials of phases 9, 10, 11, and 12. In addition, contingent verbal consequences were delivered in each training phase as in the previous experiment.

Unlike Experiment 1, the training session in Experiment 2 was carried out with simple discriminations that included compound stimuli (Alós et al. 2011, 2013) in phases 11, 12, and 13. Thus, the responses in these types of discriminations were verbal (oral) as opposed to the selection responses in the previous experiment. In what follows, we will only describe the training phases since they were implemented using different procedures than in Experiment 1 (see Experiment 1 for further information about the pretest and posttest phases) as they were implemented with different procedures.

Phase 9. Training A-RC. The experimenter presented stimulus A1 or A2 (flags) and the child had to deliver the verbal responses RC1 ("Qatar") or RC2 ("Syria").

Table 2 Experiment 1. Conditional discriminations. Results and phases

	Phases	Prompt	Conseq.	Trials	Participants					
					Peter	John	Susan	Bruce	Mary	Lisa
Pretests										
1	(AB)-RX	No	No	12	2/12	3/12	7/12	5/12	3/12	5/12
2	(AB)-X	No	No	12	0/12	2/12	3/12	5/12	4/12	4/12
3	C-A	No	No	10	5/10	0/10	6/10	5/10	0/10	5/10
4	D-A	No	No	10	8/10	10/ 10	0/10	5/10	2/10	4/10
5	C-RD	No	No	10	5/10	0/10	1/10	4/10	2/10	8/10
6	D-RC	No	No	10	8/10	0/10	3/10	5/10	7/10	6/10
7	X1-RB	No	No	10	6/10	5/10	2/10	5/10	4/10	3/10
8	X2-RB	No	No	10	5/10	5/10	4/10	5/10	4/10	0/10
Training										
9	A-C	Yes	Yes	10	12	15	12	12	12	12
10	A-D	Yes	Yes	10	12	17	12	12	12	12
11	(A1B)-X1	Yes	Yes	10	18	12	14	18	12	12
12	(A2B)-X2	Yes	Yes	10	13	16	12	13	12	12
13	(AB)-X	No	Yes	12	37	25	17	20	14	14
Post-tests										
14	(AB)-RX	No	No	12	11/12	12/12	11/12	12/12	12/12	12/12
15	(AB)-X	No	No	12	12/12	12/12	12/12	12/12	11/12	12/12
16	C-A	No	No	10	9/10	10/10	10/10	5/10	10/10	10/10
17	D-A	No	No	10	6/10	10/10	9/10	5/10	10/10	10/10
18	C-RD	No	No	10	1/10	10/10	5/10	10/10	10/10	10/10
19	D-RC	No	No	10	0/10	10/10	9/10	7/10	10/10	10/10
20	X1-RB	No	No	10	10/10	10/10	5/10	10/10	4/10	9/10
21	X2-RB	No	No	10	10/10	10/10	10/10	0/10	1/10	10/10
Total					260	253	235	243	230	230

Note: The first four columns show the phases, the prompt, consequences (Conseq.) and trials. In the second column, "yes" or "no" specifies if there was prompt or not depending on its appearance. The third column shows the probability of reinforcement in tests in which no differential consequences were administered (No), and in training phases where each trial included a consequence (Yes). The next six columns show the correct responses and the number of trials in each phase.

A1-RC1 and A2-RC2 were the possible correct stimuli combinations. More specifically, the experimenter presented the flag and said the appropriate word immediately afterwards. When a mistake was made, a correction was provided. The experimenter told the child the correct answer so that the child could imitate the response. The trial concluded when the child provided the correct answer and the experimenter applied the consequence. The trials

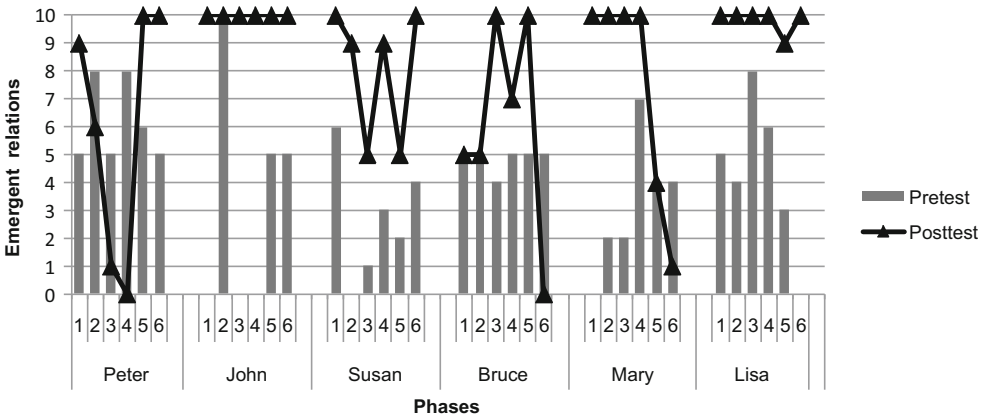

Fig. 3 Experiment 1. Punctuations of emergent relations in the pre- and posttest using the conditional discrimination procedure

were randomized. The acquisition criterion was defined as ten consecutive correct trials.

Phase 10. Training A-RD. The experimenter presented stimulus A1 or A2 (flags) and the child had to deliver the verbal responses RD1 ("Doha") or RD2 ("Damascus"). The acquisition criterion was defined as ten consecutive correct trials.

Phase 11. Training (AB)-RX1. The experimenter presented a compound stimulus comprised of A1 and B1 or B2, depending on the trial. The child had to deliver RC1 ("Qatar") or RD1 ("Doha"), accordingly. More specifically, the experimenter showed a flag (A1) while saying "country" or "capital" (B1 or B2) and the child had to say "Qatar" or "Doha" (RC1 or RD1). To provide prompt trials, the experimenter presented the flag (A1) and said the appropriate word as a model of imitation. Possible combinations were A1B1-RC1 and A1B2-RD1. The acquisition criterion was ten consecutive correct trials.

Phase 12. Training (AB)-RX2. The experimenter presented two stimuli, A2 and B1 or B2. The child had to say RC2 ("Syria") or RD2 ("Damascus"), accordingly. Possible combinations were A2B1-RC2 and A2B2-RD2. The acquisition criterion was ten consecutive correct trials.

Phase 13. Training (AB)-RX. The experimenter presented two stimuli, A1 or A2 and B1 or B2. The child had to say RC1 ("Qatar"), RC2 ("Syria), RD1 ("Doha"), or RD2 ("Damascus"), accordingly. Possible combinations were A1B1-RC1, A1B2-RD1, A2B1-RC2, and A2B2-RD2. The acquisition criterion was defined as twelve consecutive correct trials. No prompted trials were provided.

Interobserver agreement

An independent observer recorded 100 % of the trials under the same conditions as in Experiment 1. Agreement among observers was 98 % for all the trials.

Results

Nancy met the acquisition criterion in the D-A pretest phase. To acquire the simple discriminations that included compound stimuli, she needed a total of 88 trials. In the posttest, she met the acquisition criterion in seven of the eight discriminations: (AB)-RX, (AB)-X, C-A, D-A, C-RD, D-RC, and X2-RB. Therefore, *Nancy* produced five of the six possible learning transfers.

Karen met the correct criterion in the D-RC pretest phase. To learn the discriminations, she required 79 trials. *Karen* made no errors in any of the posttest phases. Hence, *Karen* performed successfully in the two evaluation phases of the training session and produced the six possible emergent relations.

Robert met the acquisition criterion in the C-A pretest trial. To acquire the discriminations, *Robert* required 68 trials. He also met the acquisition criterion in all the phases of the posttest as he produced six emergent relations.

Steven, *Daniel,* and *Julia* did not reach the acquisition criterion in any of the pretest phases. To learn the discriminations, *Steven* needed 97 trials, *Daniel*, 62, and *Julia,* 66. *Steven* met the acquisition criterion in seven of the posttest trials, but did not meet the criterion in the posttest trial (AB)-X used to evaluate training. However, he produced the six possible emergent relations. *Daniel* and *Julia* met the acquisition criterion in the eight relations evaluated in the posttest. Thus, both participants produced the six emergent relations.

Four of the six children met the acquisition criterion for all the discriminations in the posttest: (AB)-RX, (AB)-X, C-A, D-A, C-RD, D-RC, X1-RB, and X2-RB. Therefore, all the participants reached the acquisition criterion of 90 % or more correct trials in all the discriminations. They demonstrated an accurate acquisition of trained relations (test [AB]-RX and [AB]-X) and all of them produced the six possible emergent relations. Moreover, five of the six children produced the six emergent relations (*Karen, Robert, Steven, Daniel,* and *Julia*), while only one produced five instead of six emergent relations (*Nancy*).

A description of the results is shown in Table 3. A graphic representation of the pretest and posttest results as well as the specific scores obtained in the six emergent relations are displayed in Fig. 4.

Discussion

In comparing the pretest and posttests, the results reveal that the training procedure was effective for the acquisition of the stimuli relations ([AB]-RX, [AB]-X) and facilitated the transfer of all the new stimuli relations: C-A, D-A, C-RD, D-RC, X1-RB, and X2-RB. Specifically, the procedure produced two new conditional discriminations and four simple discriminations or intraverbals with a high level of accuracy. Until now, compound stimuli have been shown in conditional discriminations (Alonso-Álvarez and Pérez-González 2006; Pérez-González and Alonso-Álvarez 2008) and in simple discriminations (Alós et al. 2011, 2013). However, the inclusion of compound stimuli in simple discriminations has enabled us to study two specific types of verbal behaviour: abstract tacts and intraverbals. In relation to the first, Skinner (1957) stated that:

Table 3 Experiment 2. Simple discriminations. Results and phases

	Phases	Prompt	Conseq.	Trials	Participants					
					Nancy	Karen	Robert	Steven	Daniel	Julia
Pretests										
1	(AB)-RX	No	No	12	4/12	5/12	2/12	2/12	3/12	2/12
2	(AB)-X	No	No	12	5/12	4/12	4/12	1/12	1/12	1/12
3	C-A	No	No	10	0/10	5/10	9/10	6/10	8/10	0/10
4	D-A	No	No	10	10/ 10	1/10	1/10	5/10	0/10	3/10
5	C-RD	No	No	10	5/10	8/10	1/10	3/10	5/10	3/10
6	D-RC	No	No	10	5/10	9/10	1/10	3/10	2/10	4/10
7	X1-RB	No	No	10	8/10	3/10	4/10	3/10	3/10	5/10
8	X2-RB	No	No	10	5/10	0/10	7/10	0/10	2/10	5/10
Training										
9	A-RC	Yes	Yes	10	12	12	12	12	12	12
10	A-RD	Yes	Yes	10	12	12	12	12	12	12
11	(A1B)-RX1	Yes	Yes	10	28	19	12	12	12	12
12	(A2B)-RX2	Yes	Yes	10	12	12	12	12	12	12
13	(AB)-RX	No	Yes	12	24	24	20	49	14	18
Posttests										
14	(AB)-RX	No	No	12	12/12	12/12	12/12	12/12	12/12	12/12
15	(AB)-X	No	No	12	12/12	12/12	12/12	9/12	12/12	12/12
16	C-A	No	No	10	10/10	10/10	10/10	10/10	10/10	10/10
17	D-A	No	No	10	10/10	10/10	10/10	10/10	10/10	10/10
18	C-RD	No	No	10	10/10	10/10	10/10	10/10	10/10	10/10
19	D-RC	No	No	10	10/10	10/10	10/10	10/10	10/10	10/10
20	X1-RB	No	No	10	8/10	10/10	9/10	10/10	10/10	10/10
21	X2-RB	No	No	10	10/10	10/10	10/10	10/10	10/10	10/10
Total					237	198	236	265	230	234

To evoke a response which is under the control of a single property of an object it is necessary not only to present the object but to "specify the property to be reacted to." Thus, to get the response *red*, one must present a red object as well as a verbal occasion on which color responses are especially reinforced—for example, by saying *Tell me what color this is*. (pp. 113-114)

This appears to be similar to what occurred in our research when a flag was presented and the child was asked whether it was a "capital" or a "country."

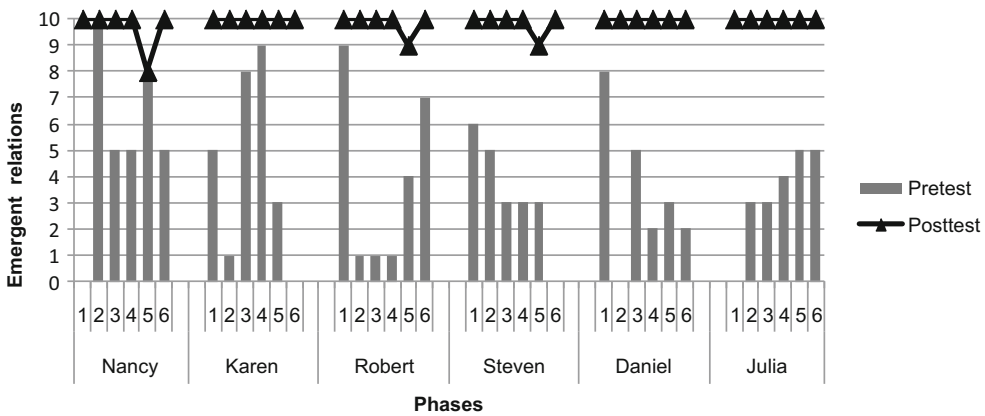

Fig. 4 Experiment 2. Punctuations of emergent relations for each participant in the pre- and posttest using the conditional discrimination procedure

Petursdottir et al. (2008) found that children performed better in bidirectional intraverbal relations when tacts were shown (simple discriminations) as opposed to listener training (conditional discriminations). The results obtained in our experiment indicate that, in the behavioural training of children, the use of expressive language not only facilitates the transfer to comprehensive language (Petursdottir and Carr 2011), but also facilitates new stimuli relations in expressive language.

General Discussion

No differences were observed between the pretests and the training in Experiment 1 and Experiment 2. In the posttests, however, the results were consistently better for the simple discriminations (Experiment 2) than for the conditional discriminations (Experiment 1). Specifically, the mean percentage of correct responses in the conditional discrimination procedure was 79 %, while it was 99 % in the simple discrimination procedure, thus suggesting that the simple discrimination procedure was the most effective.

It is also interesting to note that the children's performance varied substantially in the same phase depending on the procedure used (see Figs. 1 and 2). For example, the posttest results for the C-A trial and the D-A trial were 10 % and 17 % better, respectively, in the simple discrimination procedure than in the conditional discrimination procedure. The level of accuracy reached in phases C-RD and D-RC was 23 % higher in Experiment 2 than in Experiment 1, while phase X1-RB showed a 15 % higher level of accuracy in Experiment 2 compared to Experiment 1. Phase X2-RB showed the largest difference, with 32 % better results in Experiment 2.

The data, therefore, seem to suggest that training in simple discriminations with compound stimuli (Alós et al. 2011, 2013) facilitates more emergent relations than conditional discriminations with compound stimuli (Alonso-Álvarez and Pérez-González 2006; Pérez-González and Alonso-Álvarez 2008). These findings coincide with those of Petursdottir et al. (2008), who reported that training in expressive language (simple discriminations) as opposed to receptive language (conditional discriminations) favours the emergence of bidirectional intraverbal relations in children. However, the inclusion of compound stimuli in the discrimination procedures seems to favour the emergence of a greater number of stimuli relations.

In the procedures described in this article, the children who were presented a flag (A1 and A2) and one of two words, country (B1) or capital (B2) had to point to (Experiment 1) or say (Experiment 2) one of the following response options: Qatar (C1), Doha (D1), Syria (C2), or Damascus (D2). Thus, given the emergent stimuli relations, we could discuss compound samples or compound stimuli (Alonso-Álvarez and Pérez-González 2006; Alós et al. 2011, 2013; Eikeseth and Smith 2013; Pérez-González and Alonso-Álvarez 2008) irrespective of whether the discriminations are simple or conditional. In a specific way, the simple discriminations with compound stimuli could also be named as abstract tacts (Skinner 1957), in which two stimuli control a response, a form of multiple convergent control (Axe 2008; Michael et al. 2011). However, the use of a descriptor, compound stimuli in simple discriminations, differentiates this work from the descriptions of stimuli combination given by Axe (2008). The relations between the stimuli in those studies are different from the relations shown in the current research.

In our study, once the four possible relations of stimuli were acquired (A1B1-C1, A1B2-D1, A2B1-C2, A2B2-D2), six emergent relations were evaluated. The results of our experiments in children have shown that procedures using simple discriminations with compound stimuli produce a greater number of emergent relations than conditional discriminations with compound stimuli.

Petursdottir et al. (2008) found that children perform better in bidirectional intraverbal relations when simple discriminations were taught rather than conditional ones. The results of our study seem to support the notion that behavioural training in children using expressive language not only facilitates a transfer to comprehensive language (Petursdottir and Carr 2011), but also facilitates new relations of expressive language.

It should be pointed out that several children performed correctly in some of the pretest trials. This could be due to a variety of causes. Firstly, the children may have exhibited a response pattern from the beginning of the pretest and then systematically used the pattern throughout the pretest, even though the stimuli relations had not been established previously. Secondly, the combined presentation of several stimuli may have favoured acquisition of new relations even without the explicit use of consequences (Tonneau and González 2004). Therefore, in future research, the procedures should eliminate the possibility that some children reach the acquisition criterion in some of the pretest trials. However, for the purposes of this article, it should be pointed out that these correct pretests were equally distributed in both experiments. Moreover, the data drawn from the pretests and posttests, as well as the statistical analysis, enabled us to determine the effect that the training sessions had on the posttests.

In conclusion, this article provides no evidence of differences in the acquisition phase of discriminations with compound stimuli depending on the procedure used (conditional or simple discrimination). However, differences regarding the number of emergent relations without explicit training do exist. All the children who were trained using the simple discrimination procedure with compound stimuli performed better than in the conditional discrimination procedure.

Specifically, they produced six new stimuli relations: two conditional discriminations and four intraverbals. The results show that children acquire the trained relations and produce emergent relations in both the pre- and posttests and the training sessions when two procedures with compound stimuli are used. The use of compound stimuli has fostered acquisition and emergent relations in fewer trials and has shown a high level of accuracy in the posttests, particularly in the simple discrimination procedure.

The adaptations of verbal behavior procedures that include these findings, as well as replications to validate them, could be a possible approach to intervention in children with disabilities. It would be necessary to adapt these procedures with compound stimuli in order to assess their efficiency within a sample of children with autism or other specific disabilities. Due to the greater complexity of the stimuli to be acquired, further research on training is needed due to their presence in natural contexts. In future research, the number of stimuli relations could be increased and, hence, also the possible response options, which would, in turn, allow for a greater number of interrelated stimuli relations. It would also be interesting to increase the number of participants with a view to conducting more reliable statistical studies. Although the use of statistical analysis in single case studies cases is not unanimously accepted (Kazdin 2002), we believe that it would be of interest to conduct a deeper statistical analysis in the future in order to provide additional support and complement our results. Moreover, it would be interesting to investigate if these differences between procedures also occur in samples of children with disabilities or autism.

Acknowledgments We would like to thank the teachers of the Colegio Ferroviario for facilitating this research. In particular, we would like to express recognition to the children who participated in the experiments. Furthermore, we want to thank the Centro de Atención Infantil Temprana (CAIT, University of Cordoba) for their professional and financial contribution to the research.

We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. Also, there is no conflict of interest with any that may be affected by the publication of this article. All authors have approved the manuscript and agree with its submission to The Psychological Record.

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