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Derived control by compound and single stimuli in a matching-to-sample task in children

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A matching-to-sample procedure was used to investigate whether 9-year-old children would demonstrate the emergence of a derived compound-sample conditional discrimination following training in four interrelated single-sample conditional discriminations and vice versa, as adults did in previous studies. In Experiment 1, three out of three children demonstrated the emergence of a compound-sample conditional discrimination following training in four single-sample conditional discriminations. In Experiment 2, two out of three children acquired a compound-sample conditional discrimination and they demonstrated the emergence of four single-sample conditional discriminations; one of them did so only after being exposed to a remediation training and testing procedure. Training variables that facilitated discrimination emergence in both directions are discussed. In general, results showed that the sophisticated learning skills that are supposedly possessed by adults are not required to demonstrate the two types of derived control under study.

Control derivado ejercido por estímulos compuestos y simples en una tarea de igualación a la muestra en niños. Se empleó un procedimiento de igualación a la muestra para investigar si niños de 9 años mostrarían la emergencia de una discriminación condicional de muestra compuesta a partir del entrenamiento de cuatro discriminaciones condicionales de muestra simple interrelacionadas, y viceversa, tal como hicieron participantes adultos en investigaciones previas. En el Experimento 1, tres de tres niños mostraron la emergencia de una discriminación condicional de muestra compuesta tras ser entrenados en cuatro discriminaciones condicionales de muestra simple. En el Experimento 2, dos de tres niños adquirieron una discriminación condicional de muestra compuesta y a continuación ambos mostraron la emergencia de cuatro discriminaciones condicionales de muestra simple; uno de ellos solo lo hizo tras haber sido expuesto a un procedimiento de entrenamiento y prueba específicamente diseñado para ello. Las características del entrenamiento que facilitaron la emergencia de discriminaciones en ambas direcciones son discutidas. En general, los resultados demostraron que las sofisticadas habilidades de aprendizaje que supuestamente poseen los adultos no son necesarias para mostrar el tipo de control de estímulos derivado que se estudió.

Research on the emergence of derived stimulus control in matching-to-sample tasks (i.e., the emergence of conditional discrimination performances that were not directly trained) may contribute to the understanding of complex human behavior like creative thinking, problem solving or linguistic productivity, as it shows how humans can behave systematically in contexts in which they do not have any previous experience (e.g., Hayes, Barnes-Holmes, & Roche, 2001; Sidman, 1994). To that end, it is particularly relevant to study the emergence of derived stimulus control in increasingly complex matching-to-sample tasks (e.g., Sidman, 1986), such as those in which compound stimuli are presented as samples or as comparisons (e.g., Stromer, McIlvane, & Serna, 1993). Following this line of research, Alonso-Álvarez and Pérez-González (2006) and Pérez-González and Alonso-Álvarez (2008) showed that humans may demonstrate the emergence of a compound-sample conditional discrimination after been trained in four interrelated single-sample conditional discriminations and vice versa. Such discrimination training and emergence (see Figure 1) was parallel to a hypothetical categorization task in which participants were taugh to separately categorize exemplars as members of two intersecting categories (e.g., categorizing *Cervantes* as both *Spanish* and a *Writer*), and then they were able to relate those exemplars to the appropriate combination of categories, without further training (e.g., correctly identifying *Cervantes* as a *Spanish writer*), and vice versa. More specifically, during the referred single-sample conditional discrimination training, each one of four A and B comparisons was matched to two different P and Q single samples (e.g., A1 was matched to P1 and Q1, A2 was matched to P2 and Q1, etc.), and the emergence of the PQ-A/B compound-sample conditional discrimination consisted of selecting, in each probe trial, that comparison matched during training to both elements of the PQ compound presented as sample (e.g., selecting A1 in the presence of P1Q1, A2 in the

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presence of P2Q1, etc.). Conversely, the emergence of the single-sample conditional discriminations consisted of selecting in each probe trial the comparison matched, during training, to the PQ compound of whom the single sample presented was an element (e.g., selecting A1 in the presence of P1, because A1 was matched during training to P1Q1, etc.).

The results of Alonso-Álvarez and Pérez-González (2006) and Pérez-González and Alonso-Álvarez (2008) are limited, however, because all of the participants in their studies were adults and all but one were college students. Hence, it is not possible to determine whether the training and testing procedures employed in their studies were sufficient to produce the types of discrimination emergence observed or some of the complex learning abilities that are supposedly possessed by college students were also required. If the latter case was true, then the significance of the results found in the cited studies would be greatly diminished because it would mean that those types of discrimination emergence would be a function, not only of the training and testing procedures employed, but also of other variables that remain unknown.

In order to fully comprehend the conditions under which compound-sample conditional discriminations emerge from interrelated single-sample conditional discriminations training and vice versa, the previous studies should be replicated with participants whose learning abilities were much lower than those of college students, for example, with populations with learning disabilities or even with non-human animals. However, before attempting such replication, it seems convenient to try first to replicate those studies with participants whose learning abilities are lower, but not so different, to those possessed by college students; for example, with verbal school-aged children (see examples of this research strategy applied to the study of compound-sample conditional discriminations in Carpentier, Smeets, & Barnes-Holmes, 2002a, 2002b; Rodríguez García, García García, Gutiérrez Domínguez, Pérez Fernández, & Bohórquez Zayas, 2009). This was the main objective of the present study.

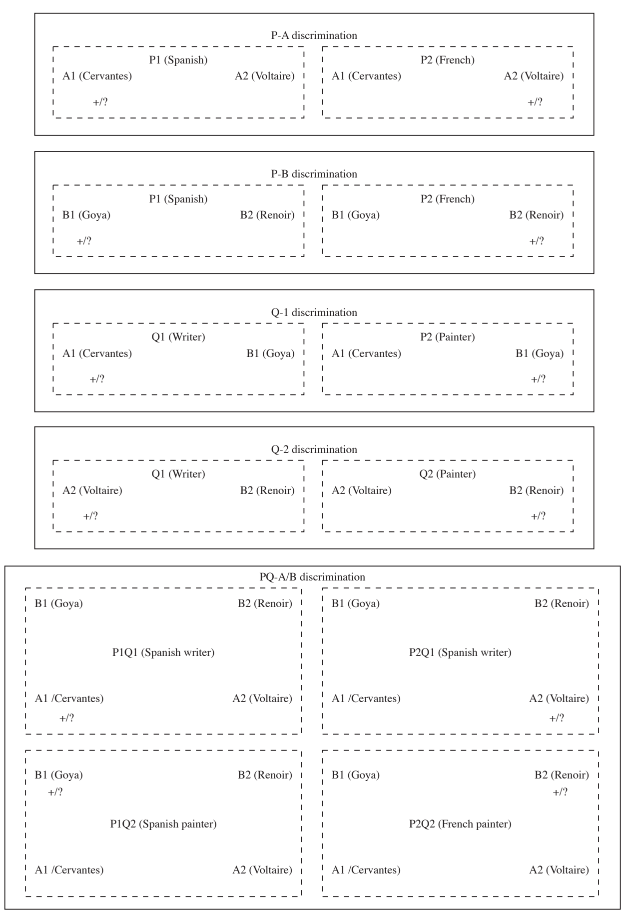

Figure 1. *Discriminations trained and tested. The codes located in the center of the square represent samples; the codes in the corners of the square represent comparisons. In parenthesis are presented examples that could help the reader to understand the stimulus relations trained and tested. The plus signs and the interrogation marks indicate the correct comparisons in training (+) and in test trials (?)*

Experiment 1

In Experiment 1, participants were trained in four single-sample conditional discriminations and were presented with the probe of a compound-sample conditional discrimination.

Method

Participants

Three typically developing 9-year-old children, two boys and one girl, participated. They were randomly selected from a public school and were rewarded with their choice of stickers after each of several sessions.

Apparatus and stimuli

Experimental sessions were individually conducted in an empty, quiet room at the participants' school. They sat at a desk with a Macintosh Color Classic® computer programmed in MTS (v. 9.32) software that presented the eight black abstract forms, measuring approximately 2 cm × 2 cm that served as stimuli (see Figure 2). Each form was displayed in the center of one of the five white background squares which measured 5 cm × 5 cm and were located in the center and in each of the screen corners on a gray background. The distance between the center of the screen and the center of each of the corner squares was 7 cm. The participants responded to the stimuli by touching the screen within the squares where the stimuli were presented. The experimenter sat behind and to one side of the participant and used the 1, 3, 5, 7 and 9 keys on the computer keyboard to record the responses.

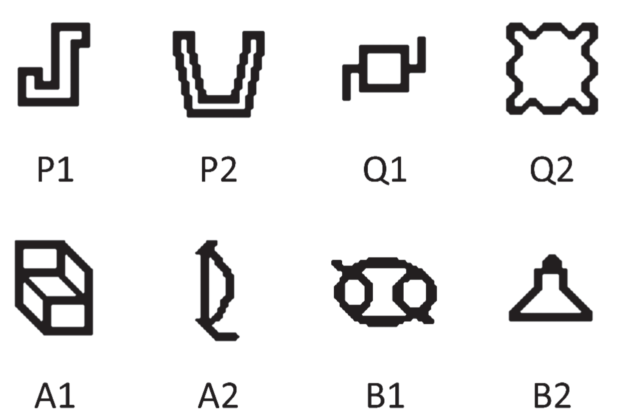

Figure 2. *Stimuli and their alphanumeric code*

Procedure

Trials. Training trials began when a *sample* stimulus appeared in the center of the computer screen. After the participants touched the sample, two *comparison* stimuli appeared in two corners of the screen. Then, the participants selected one of the comparisons. When the comparison defined as *correct* was selected, the computer displayed a dartboard-like image on the screen and played a short melody. However, when the comparison defined as an *incorrect* was selected, the computer screen went blank for 3 s. The inter-trial interval was 1.5 s. Probe trials were similar to training trials except that (a) the sample presented in each trial consisted of two stimuli (the Q stimuli were presented above the P stimuli, with no separation between them), (b) four comparisons were presented in each trial and (c) comparison-selection responses were only followed by the next trial.

Phases. The experiment consisted of a sequence of 13 phases (see Table 1). In Phases 1-12, participants were trained in the P-A, P-B, Q-1, and Q-2 single-sample conditional discriminations. To facilitate discrimination learning, those four discriminations were first separately trained and then progressively intermixed. In addition, a prompting procedure (see below) was used every time that a new discrimination was presented. To ensure the maintenance of the trained discriminations in the absence of differential consequences, the consequences that followed participants' responses in Phases 1-11 were absent in Phase 12. Across Phases 1-12, trials were presented until participants achieved a learning criterion of 8 or 16 correct consecutive responses (Phases 1-11) or a minimum number of 15 correct responses in 16 trials (Phase 12). Alternatively, those phases ended when 48 trials were presented and the participants did not achieve the learning criterion (the experiment was interrupted in the latter case, see below). In Phase 13, participants were presented with the probe of the PQ-A/B compound-sample conditional discrimination. Their responses were never followed by differential consequences and 24 trials were presented regardless of their performance. For analytic purposes, it was considered that participants demonstrated the emergence of the PQ-A/B discrimination when they *correctly* responded to at least 21 trials in a probe. The randomization criteria used to determine the presentation order of the samples and the comparisons' location in each trial was the same as in Alonso-Álvarez and Pérez-González (2006).

Sessions. The presentation of all of the training phases and the final probe had been programmed for each session. However, some sessions were interrupted at some point during the training phases because participants did not achieved the learning criterion established for a phase after 48 trials or the time available for the experiment was over. In such cases, the next session re-started depending on performance in the previous one. If the participant made less than 3 errors, the experiment began at the point at which it was interrupted. If the participant made more that 3 errors throughout Phases 1 to 5, the experiment restarted at Phase 1. If the participant made more than 3 errors throughout Phases 6 to10 and less than 3 errors in the previous ones, the experiment restarted at Phase 6. Finally, when the participant made more than 3 errors in Phase 11 and/or 12 and less than 3 errors in the previous ones, the experiment was reset to the a brief version of the training; that version consisted of eliminating the phases in which the prompting had been used in the original training procedure and reducing the learning criterion of Phases 2, 4, 7 and 9 to half.

Prompting procedure. In order to minimize training errors, a prompting procedure was used in some phases (see Table 1) that consisted of displaying the sentence «IF THIS IS HERE» above the sample and the sentence «PICK THIS» above the correct comparison (both written in English). The participants were instructed to select the figures that had a sentence on top (see below).

Instructions. Before each session began, the experimenter asked the participants not to talk to the other participants about the experiment and read the following instructions to them (in Spanish):

> *When you see a figure in the center of the screen, point to it. Following that, two figures will appear in any of the four corners of the screen and you will have to point to the one that has a sentence written above it. If you respond correctly, the monitor will display a bright light and a soft musical tone. If you fail, the screen will be blank. Sometimes, the sentence displayed above the figure will not appear but you still have to select one of the figures. Sometimes, the monitor will not indicate if you are right or not but you still have to try to respond correctly.*

The participants were also instructed to look only at the computer screen during the sessions and not to look back at the experimenter.

Table 1
Procedure overview of Experiment 1. The table shows the presentation order of the phases, the discriminations presented in each phase, the phases in which differential consequences and prompts were presented (indicated by an asterisk) and the learning and emergence criteria (correct consecutive responses, c.c.r., or minimum number of correct responses/trials)

Phases	Discriminations	Consequences	Prompts	Criteria
1	P-A	*	*	8 c.c.r.
2	P-A	*		8 c.c.r.
3	P-B	*	*	8 c.c.r.
4	P-B	*		8 c.c.r.
5	P-A, P-B	*		8 c.c.r.
6	Q-1	*	*	8 c.c.r.
7	Q-1	*		8 c.c.r.
8	Q-2	*	*	8 c.c.r.
9	Q-2	*		8 c.c.r.
10	Q-1, Q-2	*		8 c.c.r.
11	P-A, P-B,Q-1, Q-2	*		16 c.c.r.
12	P-A, P-B, Q-1, Q-2			15/16
13	PQ-A/B			21/24

Results

Each participant completed three to seven sessions; the mean session duration was about 13 minutes. The first sessions of each participant were interrupted before the presentation of the final probe and in such sessions participants made a significant number of training errors. The cumulative number of correct responses across trials in these sessions was calculated and plotted (see Figure 3); the resulting graphs help to identify the phases in which participants made the highest number of errors. These errors

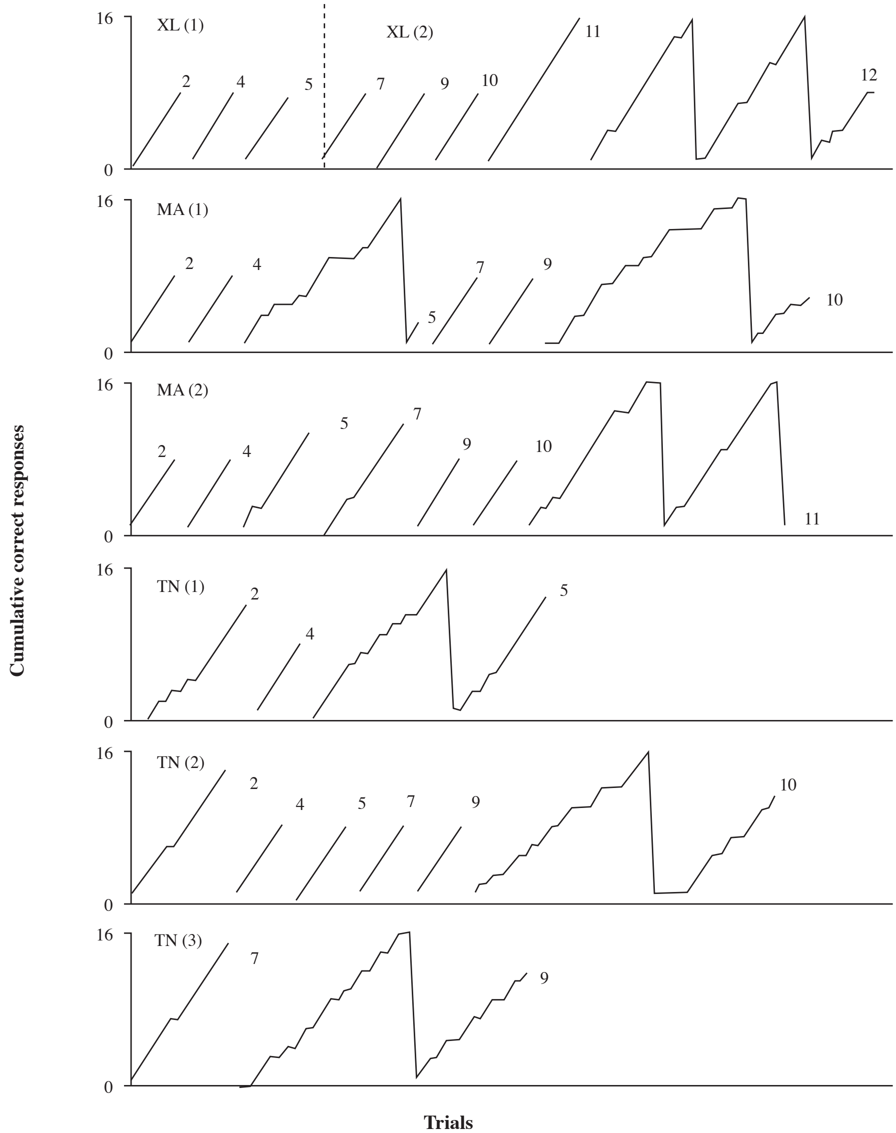

Figure 3. *Results of the first sessions of Experiment 1. In each graph, a line was added for each training phase of the PQ-A/B discrimination (excluding the phases in which the prompting procedure was used). The numbers placed in the upper side of each line correspond with the presentation order of the phases (see Table 1). In parentheses are presented the number of the sessions in which the phases were presented*

were concentrated on Phases 5, 10 and 11, in which two or four discriminations were intermixed, and on Phase 12, in which the differential consequences were absent (the only exception to this rule was the Phase 9 of the TN's third session). The relevance of these data will be discussed in the following section.

The last sessions of each participant ended with the presentation of the probe and participants made a low number of training errors in them. For these sessions, the global percentage of correct responses in all of the training phases of each session and in each probe was calculated and plotted (see Figure 4). As the resulting graphs shows, the percentages of correct responses during training were high and increased across sessions and, in the probe, the three participants finally achieved the emergence criterion (88%) of the PQ-A/B discrimination.

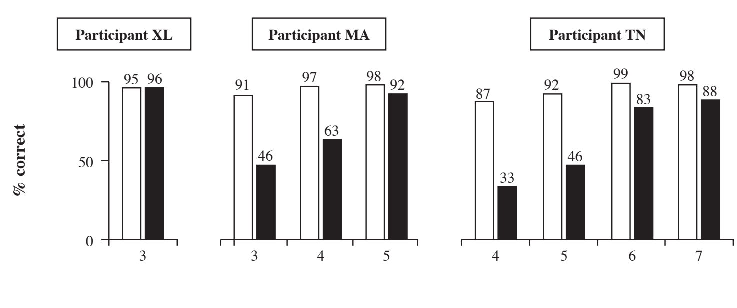

Figure 4. *Results in last sessions of Experiment 1. The graph bars show the accuracy percentages in all of the training phases (white bars) and in the probe phase (black bars) presented in several sessions of Experiment 1*

Discussion

Three typically developing, 9-year-old children demonstrated the emergence of a PQ-A/B compound-sample conditional discrimination following training in four P-A, P-B, Q-1, and Q-2 single-sample conditional discriminations. These results demonstrate that the emergence of the PQ-A/B discrimination does not require the complex learning skills that are possessed by adults in general and by college students in particular; until now, these participants were the only ones who have demonstrated such emergence. Hence, the present experiment results open the door to a possible replication of this experiment with younger children or even with populations with learning disabilities. Such replication would permit a more complete understanding of the conditions under which the PQ-A/B discrimination emerges.

Moreover, the results of the present experiment, together with the results of previous experiments (Alonso-Álvarez & Pérez-González, 2006; Pérez-González & Alonso-Álvarez, 2008), show the reliability of a training procedure in which (a) a prompting procedure is used, (b) the P-A, P-B, Q-1, and Q-2 discriminations are progressively intermixed and (c) the differential consequences are faded out before the probe, to produce the emergence of the PQ-A/B discrimination. In the referred studies, six out of seven adults demonstrated the emergence of the PQ-A/B discrimination after been trained in the P-A, P-B, Q-1, and Q-2 discriminations with such procedure. In contrast, only three out of seven adults demonstrated that emergence after been trained with a procedure in which (a) no prompting procedure was used, (b) the four P-A, P-B, Q-1, and Q-2 discriminations were separately trained, and (c) differential consequences were presented in all training phases. Thus the procedure that reliably produced the emergence of the PQ-A/B discrimination in adults (the first one described) also reliably produced such emergence in children, during the present experiment.

Alonso-Álvarez and Pérez-González (2006, pp. 459-460) discussed whether all of the three differences between the two training procedures employed with adults, or only any of them, were responsible of the different yields obtained in the PQ-A/B discrimination probe. The results of the present experiment are relevant in relation to that question because unlike the adults (whose performance during training was usually almost error free) children made a significant number of errors that were, besides, concentrated in some phases, specifically in those phases in which several discriminations were intermixed and/or differential consequences were absent (see Figure 3). These results suggest that children had difficulties to maintain the four trained discriminations simultaneously and/or in the absence of differential consequences; therefore, both the progressive intermixing of the trained discriminations as well as the fading out of the differential consequences before the probe could have helped them to maintain the trained discriminations and hence to demonstrate the emergence of the PQ-A/B discrimination. That could also have been also the case in previous studies with adults. However, the prompting procedure could also have been relevant, because participants demonstrated the emergence of the PQ-A/B discrimination in sessions in which they achieved a high percentage of correct responses during training (see Figure 4), an outcome apparently facilitated by the prompting procedure. In conclusion, it is probable that using a prompting procedure, the intermixing of the trained discriminations, and the fading out of the differential consequences were all relevant factors that contributed to increase the likelihood of the PQ-A/B discrimination emergence. Such possibility is not surprising as the effective use of these three procedures is common in the literature about derived stimulus control (e.g., Haimson, Wilkinson, Rosenquist, Ouimet, & McIlvane, 2009) and thus it seems that they are generally effective to facilitate the emergence of derived discriminations. Some reasons for it could be that (a) the use of prompts helps to avoid unwanted sources of stimulus control that could compete with the sources defined by the experimenter precluding the expected derived stimulus control to emerge (e.g., McIlvane & Dube, 2003); (b) the intermixing of the trained discriminations could help to maintain those discriminations at the moment of the probe; and (c) the fading out of the differential consequences increase the similarity between the training and testing conditions, hence facilitating the transfer of learning from one condition to another.

A possible limitation of these results is that the training and testing cycle was repeated until participants achieved the defined emergence criterion; hence, it could be claimed that participants could have guessed, on the basis of this repetition, that they were not responding as the experimenters were expecting from them so they changed their responses to try to meet those expectations. In other words, they could have learned during the probes even in the absence of differential consequences (e.g., Pérez Fernández & García García, 2010). This possibility is unlikely, however, as the mere repetition of unreinforced probes in the studies by Alonso-Álvarez and Pérez-González (2006), and by Pérez-González and Alonso-Álvarez (2008) did not lead, in most cases, to the emergence of the probed discriminations.

Experiment 2

The original aim of Experiment 2 was to replicate the Experiments 3 and 4 of Pérez-González and Alonso-Álvarez (2008). Those experiments studied whether the training of a PQ-A/B discrimination alone or in combination with emergence of four P-A, P-B, Q-1, and Q-2 derived discriminations would facilitate discrimination emergence in the opposite direction; that is to say, the emergence of a PQ-A/B discrimination following P-A, P-B, Q-1, and Q-2 discrimination training, with another set of stimuli. Regarding that question, the data obtained was inconclusive, but the data corresponding to the emergence of the P-A, P-B, Q-1, and Q-2 discriminations following PQ-A/B discrimination training is useful and will be reported here (the complete data are available from the authors).

Method

Participants, apparatus and stimuli

Three typically developing 9-year-old children, two boys and one girl, participated. They were selected and rewarded as in Experiment 1. The apparatus were also the same as in Experiment 1. Eight new figures were presented as stimuli (see Figure 5).

Procedure

Overview. The data reported here correspond to sessions in which participants were trained in a PQ-A/B discrimination or in which that discrimination was reviewed and the P-A, P-B, Q-1, and Q-2 discriminations were probed. Initially, the PQ-A/B discrimination training procedure consisted of 12 phases, but a brief version of that procedure was used in most of the sessions due to time constrains (see below). Moreover, one participant failed to show the emergence of the probed discriminations with the original training and testing procedure and was submitted to a remediation procedure that is also described below. A brief version of this procedure was also used in some sessions.

Original procedure. It consisted of a sequence of 13 phases (see Table 2). In Phases 1-12, participants were trained in the PQ-A/B compound-sample conditional discrimination. For descriptive purposes, the four sample-correct comparison combinations presented in that discrimination (P1Q1-A1, P1Q2-A2, P2Q1-B1, and P2Q2-B2) are conceptualized here as simple discriminations. Those simple discriminations were intermixed, a prompting procedure was used, and the differential consequences were faded out similarly as in Experiment 1. In Phase 13, participants were presented with the probe of the P-A, P-B, Q-1, and Q-2 discriminations. The learning and emergence criteria were also similar to those of Experiment 1. The presentation order of the samples and the comparisons' location was determined as in Pérez-González and Alonso-Álvarez (2008). Some sessions were interrupted in Phases 11 or 12 (see results section); in those cases, the experiment in the next session was re-started in Phase 1 or was reset to the brief version of the original procedure. The brief version consisted of eliminating the phases in which the prompting procedure had been used and reducing the learning criterion of Phases 2, 4, 7, and 9 to half.

Remediation procedure. This procedure was based on the assumption that control by *non-separable* PQ compound samples (e.g., Stromer et al., 1993) during the PQ-A/B discrimination training precluded the emergence of the P-A, P-B, Q-1, and Q-2 discriminations (in which control by single P and Q samples is required), in the case of DR. Hence, this

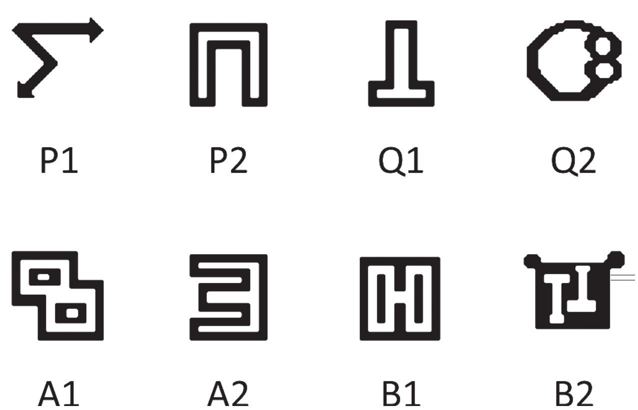

Figure 5. *Stimuli and their alphanumeric code*

Table 2
Original procedure overview of Experiment 2. See note to Table 1

Phases	Discriminations	Consequences	Prompts	Criteria
1	P1Q1-A1	*	*	8 c.c.r.
2	P1Q1-A1	*		8 c.c.r.
3	P2Q1-A2	*	*	8 c.c.r.
4	P2Q1-A2	*		8 c.c.r.
5	P1Q1-A1 P2Q1-A2	*		8 c.c.r.
6	P1Q2-B1	*	*	8 c.c.r.
7	P1Q2-B1	*		8 c.c.r.
8	P2Q2-B2	*	*	8 c.c.r.
9	P2Q2-B2	*		8 c.c.r.
10	P1Q2-B1 P2Q2-B2	*		8 c.c.r.
11	PQ-A/B	*		15/16
12	PQ-A/B			15/16
13	P-A, P-B, Q-1, Q-2			21/24

Table 3
Remediation procedure overview of Experiment 2. See note to Table 1

Phase	Discriminations	Consequences	Criteria
1	P1Q1-A1	*	4 c.c.r.
2	P2Q1-A2	*	4 c.c.r.
3	P1Q1-A1 P1Q2-A2	*	8 c.c.r.
4	P1Q1-A1 P2Q1-A2		4 c.c.r.
5	P-A		4 c.c.r.
6	P1Q2-B1	*	4 c.c.r.
7	P2Q2-B2	*	4 c.c.r.
8	P1Q2-B1 P2Q2-B2	*	8 c.c.r.
9	P1Q2-B1 P2Q2-B2		4 c.c.r.
10	P-B		4 c.c.r.
11	P1Q1-A1	*	4 c.c.r.
12	P1Q2-B1	*	4 c.c.r.
13	P1Q1-A1 P1Q2-B1	*	8 c.c.r.
14	P1Q1-A1 P1Q2-B1		4 c.c.r.
15	Q-1		4 c.c.r.
16	P2Q1-A2	*	4 c.c.r.
17	P2Q2-B2	*	4 c.c.r.
18	P2Q1-A2 P2Q2-B2	*	8 c.c.r.
19	P2Q1-A2 P2Q2-B2		4 c.c.r.
20	Q-2		4 c.c.r.
21	PQ-A/B	*	16 c.c.r.
22	PQ-A/B		8 c.c.r.
23	P-A, P-B, Q-1, Q-2		22/24

procedure was intended to break the supposed non-separable compound samples, encouraging stimulus control by the P and Q elements of the compound samples. The procedure consisted of a sequence of 23 phases (see Table 3), with a total of 18 training phases and five probe phases (see Table 3). All pairs of simple discriminations with a compound-sample element in common (e.g., P1Q1-A1 & P2Q1-A2, P1Q2-B1 & P2Q2-B2, etc.) were first trained separately, then intermixed, and finally presented without differential consequences. During that training, only one element of each compound sample was relevant, while the other one was redundant (e.g., in P1Q1-A1 & P2Q1-A2 training, P1 and P2 were relevant and Q1 redundant), thus participant's responses during that training likely were only controlled by the two relevant elements. Because of that, immediately after the training of each pair of simple discriminations, a probe of the single-sample conditional discrimination in which those relevant elements served as single-samples was presented (e.g., after P1Q1-A1 & P2Q1-A2 training, a P-A probe was presented). Finally, the PQ-A/B discrimination was trained in a single phase, the differential consequences were faded out, and a simultaneous probe of the P-A, P-B, Q-1, and Q-2 was presented. A brief version of this procedure was used in some sessions due to time constrains (see below); that version consisted of eliminating the phases in which the simple discriminations were separately trained.

Specific procedures. Trials were as in Experiment 1, but in the present experiment, the differential consequences were used in those trials in which a compound sample and four comparisons were presented. The prompting procedure and the instructions were identical to those of Experiment 1.

Results

Participant DR

DR completed seven sessions (average duration: 14 minutes). In Sessions 1-4, the original procedure was used (see Table 2), although its complete version was only used in Session 1. In

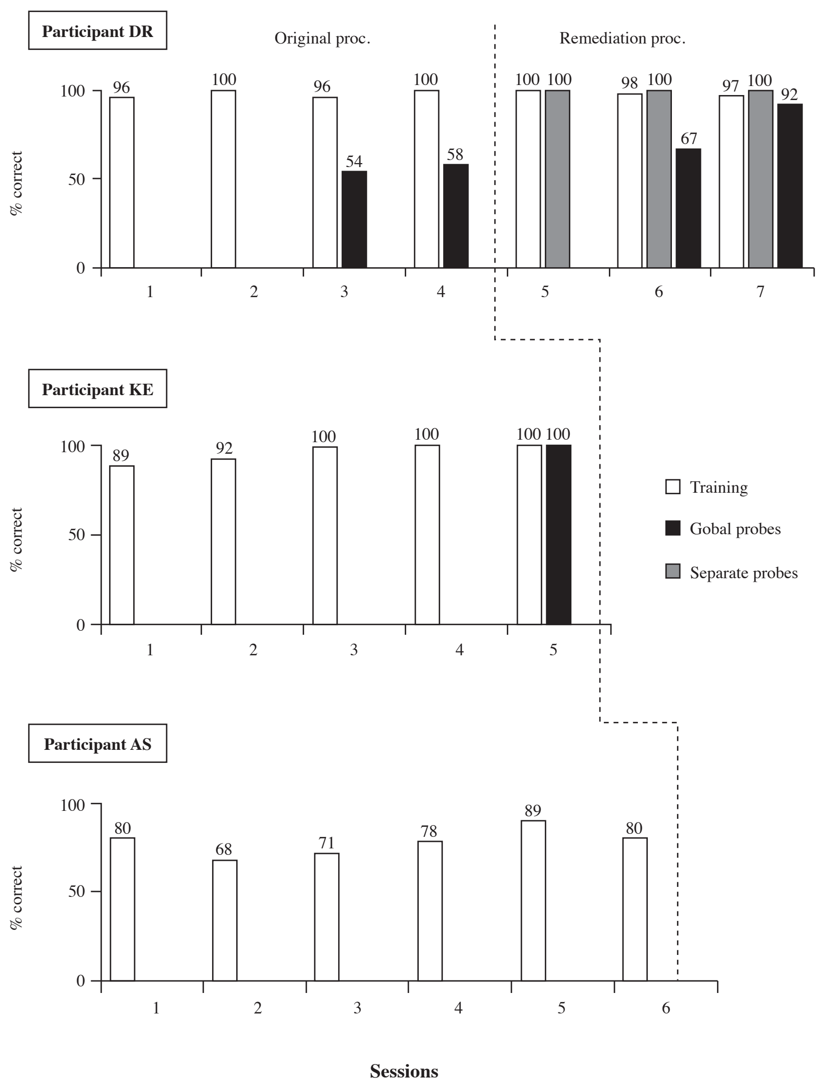

Figure 6. *Results of Experiment 2. The graph bars show the accuracy percentages in all of the training phases (white bars), separate probe phases (grey bars) and global probes phases (black bars) presented in each session of Experiment 2. The graphs also indicates the sessions in which the original and the remediation procedure (proc.) were used*

Sessions 1 and 2, the final probe (Phase 13 in Table 2; see Figure 6) was not presented because its presentation had not been scheduled in the context of the original aim of the study (as explained in the introduction to this study). In Sessions 5-7 the remediation procedure was used (see Table 3), although its complete version was only used in Session 5. Across sessions, DR maintained a high accuracy during the training phases. In the final probes of the original procedure (the Phase 13 of Table 2, also called here *global* probes), DR correctly responded in about half of the trials. In the *separate* probes of the remediation procedure (the Phases 5, 10, 15 and 20 of Table 3), DR correctly responded to all trials. In the global probes of the remediation procedure (Phase 23 of Table 3), DR's percentage of correct responses increased in comparison with previous sessions and finally achieved the emergence criterion for that phase.

Participant KE

KE completed five sessions (average duration: 11 minutes). In Session 1 the complete version of the original training was used (see Table 2); that session was interrupted during Phase 11, due to time constrains. In the remaining sessions, the brief version of the original procedure was used. Sessions 2-4 ended in Phase 12, so the final probe (Phase 13) was presented only in Session 5, as it had been scheduled in the context of the original aim of the study. Across sessions (see Figure 6), KE achieved and maintained a 100% correct responses during training; in the final probe, she correctly responded to all trials.

Participant AS

AS completed six sessions (average duration: 18 minutes); all of them were interrupted during some of the PQ-A/B discrimination training phases (Phase 1-12, see Table 2) and thus, before the presentation of the final probe (Phase 13, see Table 2). Sessions 1, 3 and 5 were interrupted during Phase 11 due to time constrains. Session 2 was interrupted during Phase 12 after 48 trials in which AS made a total of 37 errors and did not achieve the training criterion. Sessions 4 and 6 were also interrupted during Phase 12, but in those cases, the sessions were interrupted by the experimenter before the presentation of the scheduled 48 trials (after 43 trials and 24 errors, and after 11 trials and 7 errors, respectively) as it seemed obvious that AS was unable to maintain the PQ-A/B discrimination in the absence of differential consequences. AS dropped out the study at that point.

In Session 1, the complete version of the original procedure was used, but in Sessions 2 and 3 the brief version was introduced to save time. However, as in those sessions the percentage of training errors increased as compared with Session 1 (see Figure 6), in Sessions 4 and 5 the complete version was re-introduced and the percentage of errors reduced. In Session 6, the brief training was used again; the percentage of training errors remained stable.

Discussion

Two out of three 9-year-old children acquired a PQ-A/B compound-sample conditional discrimination and showed the emergence of four P-A, P-B, Q-1, and Q-2 single-sample conditional discriminations. One child (KE) readily demonstrated that emergence, as five adults have done in a previous study (Pérez-González & Alonso-Álvarez, 2008); the other child (DR), however, initially failed to show that emergence and he was only able to show it after receiving a remediation procedure. The emergence of the P-A, P-B, Q-1, and Q-2 discriminations after acquiring the PQ-A/B discriminations seems easy to explain and because of that DR's initial failure to show that emergence becomes puzzling. If, for example, a participant during training correctly selected A1 in the presence of P1Q1 and A2 in the presence of P2Q1, how could he fail to correctly select A1 in the presence of P1 and A2 in the presence of P2, during the probes? Consider that participants must *pay attention* to both elements of each compound sample to correctly respond during training (see Figure 1). A possible explanation to it is that the compounds functioned as unitary, non separable stimuli during training (see Stromer et al., 1993). The remediation procedure used with DR was aimed to promote control by the compound-sample elements by training pairs of discriminations in which only one element of each compound sample was relevant and inserting separate probes of the discriminations tested. Such procedure was immediately effective, as DR showed the emergence of the discriminations tested in the separate probes and increased his percentage of correct responses during the global probes. Thus, DR's results support the hypothesis of control by non-separable compounds.

On the other hand, the failure of the third child (AS) to maintain the PQ-A/B discrimination in the absence of differential consequences indicates the importance of evaluating whether participants are able to maintain trained discriminations in the absence of differential consequences, before probing the emergence of new discriminations. In the case of AS, the progressive reduction of the density of the differential consequences (a procedure commonly used in studies about discrimination emergence) could have helped him to maintain the PQ-A/B discrimination.

General discussion

The aim of the present experiments was to evaluate whether 9-year-old children could demonstrate the emergence of a compound-sample conditional discrimination following training in single-sample conditional discriminations and vice versa. The answer to both questions was affirmative. In the course of the experiments, it was also demonstrated that a training procedure consisting of (a) using a prompting procedure, (b) intermixing the trained single-sample conditional discriminations and (c) fading out the differential consequences, which reliably produce the emergence of a compound-sample conditional discrimination in adults, also produce that emergence in children. In addition, it was demonstrated that when a similar training procedure does not produce the emergence of single-sample conditional discriminations following training in a compound-sample conditional discrimination, intermixing pairs of simple discriminations in which only one element of each compound sample are relevant (e.g., P1Q1-A1 and P2Q1-A2) and inserting separate probes of the single-sample conditional discriminations may produce that emergence.

Finally, as the training procedures used were effective to produce the emergence of the discriminations probed in 9-year-old children and thus sophisticated learning skills are apparently not required to show that emergence, it seems now appropriate to replicate these experiments with younger school children as well as with people with learning disabilities. Such replications may contribute to increase our understanding of the variables that determine the types of discriminations emergence under study; but also, given the ubiquitous presence in every day life of discriminations analogous to those trained and tested here (see, for instance, the example of Figure 1), those replications could eventually lead to the design of effective procedures to teach adaptive discrimination skills to people with learning disabilities.

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