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TRANSFER OF SPECIFIC CONTEXTUAL FUNCTIONS TO NOVEL CONDITIONAL DISCRIMINATIONS

LUIS ANTONIO PÉREZ-GONZÁLEZ AND RICHARD W. SERNA

UNIVERSITY OF OVIEDO, SPAIN AND UNIVERSITY OF MASSACHUSETTS MEDICAL SCHOOL–SHRIVER CENTER

Three adolescents and 4 children participated in studies designed to examine contextually controlled conditional discrimination performance. In Study 1, participants selected Comparison B1 in the presence one stimulus (A1) and Comparison B2 in the presence of another stimulus (A2) using a matching-to-sample procedure. Next, contextual stimuli X1 or X2 were presented, such that in the presence of X1, selection of B1 given A1 and selection of B2 given A2 were reinforced; and in the presence of X2, selection of B2 given A1 and selection of B1 given A2 were reinforced. Then, new conditional discriminations were taught with Stimuli E and F. When the contextual Stimuli X1 and X2 were presented, participants selected the same comparisons as previously established in the EF relations in the presence of X1, but the opposite comparison as in the EF relations in the presence of X2. The results then were replicated with new Stimuli G and H. In Study 2, a new conditional discrimination, CD, was taught. Then, four combinations of two-element samples—C1 and D1, C2 and D2, C1 and D2, or C2 and D1—were presented with X1 and X2 as comparisons. Five of 6 participants selected X1 in the presence of C1 and D1 or C2 and D2, and selected X2 in the presence of C1 and D2 or C2 and D1. Finally, in Study 3, two new discriminations IJ and JK were taught. Then, the transitive IK relations were tested with X1 and X2 as contextual stimuli. The 4 participants selected K1 in the presence of I1 and K2 in the presence of I2 when the contextual stimulus was X1—demonstrating class formation—and selected the other comparisons when the contextual stimulus was X2. These results suggest that the contextual control functions of X1 and X2 transferred even to relations that had not been directly taught. These results extend those demonstrating generalized contextual control by showing transfer of functions of the contextual stimuli in transitivity tests and when the former contextual stimuli were presented as comparisons.

Key words: contextual control, transfer of functions, conditional discriminations, stimulus equivalence, stimulus relations, adults, children

After humans learn conditional discriminations, they often can perform other novel conditional discriminations such as stimulus equivalence outcomes (e.g., Sidman, 1971; Sidman & Tailby, 1982; Spradlin, Cotter, & Baxley, 1973; see Sidman, 1994, for a review). Conditional discriminations may themselves come under conditional control. In a two-choice, experimental *contextual control* task (Sidman, 1986), the selection of comparisons in the presence of specific samples are reinforced only in the presence of a specific contextual stimulus X1; however, in the presence of another contextual stimulus X2, the opposite sample-comparison selections are reinforced. Thus, each contextual stimulus establishes specific sample-comparison relations. Many studies have reported contextual control (e.g., Bush, Sidman, & de Rose, 1989; Dymond & Barnes, 1995; Gatch & Osborne, 1989; Hayes, Kohlenberg, & Hayes, 1991; Kennedy & Laitinen, 1988; Lynch & Green, 1991; Markham & Dougher, 1993; Meehan & Fields, 1995; Pérez-González, Spradlin, & Saunders, 2000; Roche & Barnes, 1996, 1997; Wulfert & Hayes, 1988). These studies, however, have not yet completely answered questions such as the potential of contextual stimuli to control novel relations. Because the contextual stimuli control the sample-comparisons relations (the comparison selected

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Address correspondence to Luis A. Pérez-González, La Granja, 33720 Boal, Asturias, Spain (e-mail: laperez@sci.cpd.uniovi.es), or to Richard W. Serna, E. K. Shriver Center, 200 Trapelo Road, Waltham, Massachusetts 02452 (e-mail: richard.serna@umassmed.edu).

in the presence of a given sample), it is possible that these stimuli may control novel sample-comparison relations.

Pérez-González (1994) demonstrated the transfer of stimulus functions to novel relations. In that study, the functions of *comparison stimuli* transferred to novel relations established by conditional discriminations. Participants first learned an AB conditional discrimination (select B1 given A1, B2 given A2, and B3 given A3). Next, they were presented with trials containing two-stimulus samples with either the former sample/correct-comparison relations (A1 and B1, A2 and B2, or A3 and B3) or the former sample/incorrect-comparison relations (e.g., A1 and B2, and A2 and B1). The comparison stimuli were X1 and X2. Selecting X1 was reinforced in the presence of the samples with the sample/correct-comparison relations, and selecting X2 was reinforced in the presence of the samples with the sample/incorrect-comparison relations. To test transfer of functions of Stimuli X1 and X2, participants next learned a conditional discrimination with new stimuli, P and Q. Finally, they were tested with P and Q stimuli as samples and X1 and X2 as comparisons. Participants selected X1 in the presence of P1 and Q1, P2 and Q2, and P3 and Q3, and selected X2 in the presence of the other combinations (e.g., P1 and Q2). This performance can be characterized as selecting X1 in the presence of any two stimuli having a sample/correct-comparison relation, and selecting X2 in the presence of any two stimuli having a sample/incorrect-comparison relation. Thus, the functions of X1 and X2 as comparisons transferred to relations established independently from these stimuli. Pérez-González's findings are relevant for studying contextual control because the functions of X1 and X2 as comparisons are similar to the functions of the contextual stimuli. In typical studies of contextual control, one contextual stimulus, C1, controls the sample/correct-comparison relation (i.e., selecting the former correct comparison given the sample) and the other contextual stimulus, C2, controls the sample/incorrect-comparison relation (i.e., selecting the incorrect comparison given the sample). Thus, the functions of contextual stimulus C1 are similar to the functions of comparison X1, and the functions of contextual stimulus C2 are similar to the functions of comparison X2. For that reason, Pérez-González's results raise the possibility that the functions of contextual stimuli may transfer to relations that have never appeared with contextual stimuli or with other conditional discriminations, which we will describe as novel conditional discriminations.

The contextual stimuli and the comparisons, however, serve different functions in a conditional discrimination. When one stimulus is the contextual stimulus in a conditional discrimination, one sample and two or more comparisons are presented. Conversely, Stimulus X1 as comparison is the selected stimulus when two stimuli are presented as the sample. Thus, the processes derived from the transfer of functions of contextual stimuli could be noticeably different from those derived from Pérez-González's (1994) procedure. Thus, it was of interest to study whether the contextual stimulus that controls sample/correct-comparison selections and the contextual stimulus that controls sample/incorrect-comparison selections would transfer such functions when presented to novel conditional discriminations.

The functions of each contextual stimulus are specific to control the relations between the remaining stimuli in the taught and tested conditional discriminations. For example, in the presence of contextual stimulus X1, the selection of one comparison is correct, and the selection of the other comparison is incorrect. The same phenomenon occurs with contextual stimulus X2, but this stimulus controls alternative sample-comparison relations. Given that the contextual stimuli specify the relations established among the other stimuli in conditional discriminations, it is possible that these functions transfer to a variety of novel conditional discriminations. Thus, we conducted three studies to explore the extent of the generalization of contextual stimulus functions. Study 1 explored whether humans demonstrate transfer of contextual stimuli to novel conditional discriminations. Study 2 examined whether the contextual-control functions established in Study 1 were sufficient to establish X1 and X2 as comparisons, responses to which would be controlled by the presentation of two-sample stimuli with the sample/correct-comparison or the sample/incorrect-comparison relations acquired in a previous conditional discrimination.

Study 3 examined whether the contextual functions of X1 and X2 would transfer to conditional discriminations derived from stimulus-equivalence teaching procedures. A second goal of the third study was to analyze further whether the contextual stimuli change preestablished classes or just comparison responding. We analyze a more generalized case of contextual control in a related article (Serna & Pérez-González, 2003).

STUDY 1

This study examined whether the functions of contextual stimuli taught to control a conditional discrimination would transfer to other conditional discriminations involving novel stimuli.

METHOD

Participants

To examine the possible effect of age difference on outcomes, three 17-year-old adolescents (Marina, Marta, and Pablo), and three 10- to 11-year-old children (Gema, Nora, and Tamara), were recruited as participants. All volunteered to participate on the basis of personal contacts. They were not given information concerning the goals or the nature of the study prior to completing it, nor did they receive payment for serving in it.

Apparatus

The study was conducted in a quiet room. A microcomputer using a DOS-based operating system presented the stimuli on a 22 cm by 20 cm screen and recorded responses automatically. The stimuli were arbitrary visual forms (approximately 1.5 cm by 2 cm). The shapes and the relations appear in Figure 1.

Procedure

Instructions. After the participant was seated in front of the computer, the following instructions appeared in Spanish on the screen:

> Thank you for playing this game.
> Some pictures are going to appear on the screen, which may be accompanied by music.
> You can move this shape: "Ь". To do this, use the B, N and H keys.
> By moving this you can choose a picture.
> Most of the time, music will play, which will indicate you are correct.
> If a pitch sounds, that means the selection was incorrect.
> The game consists of responding correctly as much as possible.
> (Press the space bar when you wish to start.)

Only questions strictly related to the instructions were answered. The experimenter waited until the participant responded to the first two or three trials and then left the room. After the first session, the experimenter was not in the room with the participant.

The task was matching to sample. There were two types of trials. In the single-sample trials, two forms were presented randomly over trials as samples (e.g., A1 or A2), and another two (e.g., B1 and B2) served as comparisons. In the presence of A1, B1 was the correct stimulus; in the presence of A2, B2 was the correct stimulus.

The second trial type was a two-choice conditional discrimination with two conditional stimuli (either the contextual stimulus and the sample or two samples). As diagrammed in Figure 1 for the XAB discriminations, X1 or X2 was the contextual stimulus, A1 or A2 was the sample, and B1 and B2 were the comparisons. The presence of X1 or X2 determined the selection of which comparison would be reinforced in the presence of each sample.

Presentation of stimuli, selections, and consequences. The sample or samples shown in Figure 1 appeared in the center of the screen. During the trials with a contextual stimulus or two samples, the two stimuli were displayed one on top of the other. The two comparisons appeared below the sample, from left to right. A cursor appeared in the bottom left-hand corner of the screen. The position for each comparison varied randomly throughout the trials of all sessions. On each trial, the sample or samples and the comparisons were presented simultaneously; no observing response was required. The two or four possible combinations of contextual stimuli and sample or two samples were randomly presented in each block of two or four consecutive trials. For example, Combination X1 and A1 and Combination X1 and A2 were randomly presented every two trials in some phases; also, Combinations X1 and A1, X1 and A2, X2 and A1, and X2 and A2 were randomly presented every four trials in other phases.

An initial selection of the B key moved the

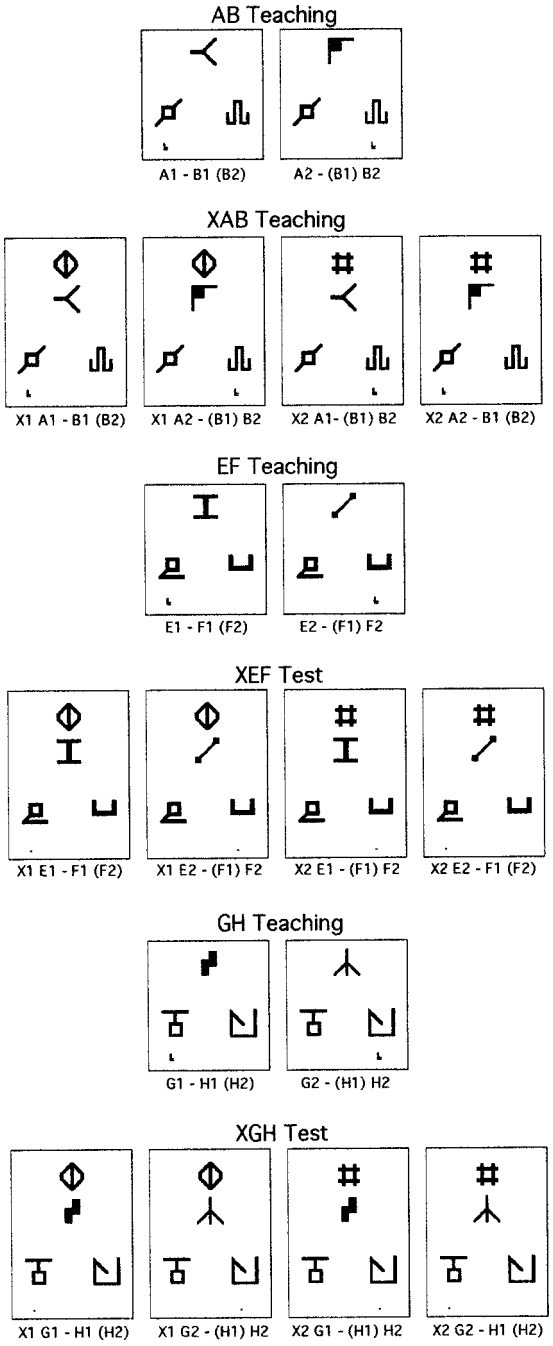

Fig. 1. Stimuli and stimuli relations of Study 1. Each panel displays the conditional discriminations of each relation. Each frame contains a conditional discrimination, as it was presented, plus its alphanumeric notation. The simple conditional discriminations show the sample (top) and the comparisons (bottom). The contextual stimuli appeared above the sample in the second-order conditional discriminations. A symbol below a comparison indicates that selections of it were reinforced. A point

cursor to a position below the left comparison. A selection of the N key moved the cursor to a position below the right comparison. After the first selection, selections of either the B or N key moved the cursor to a position below the opposite comparison. Pressing the H key moved the cursor upward toward the comparison; delivered the consequence programmed for that trial; advanced to the next trial; and recorded the selection. During the initial teaching phase of a conditional discrimination (see the *Succession of trials* section), every correct selection resulted in a sequence of four musical notes and each incorrect selection resulted in a low tone. Subsequent responding showed that the sequence of musical notes functioned as a reinforcer and the low tone decreased behavior. After the presentation of the consequence, the screen was blank for 2 s, after which the next trial was presented.

Delayed prompt procedure. A delayed-prompt procedure (e.g., McIlvane & Dube, 1992; Touchette, 1971) was used in which the incorrect comparisons disappeared after being presented for 1 s during the first trial. A correct selection increased the interval during which the incorrect comparison was present by 1.3 times. An incorrect selection decreased this interval by an identical amount. Correct selections made after the incorrect comparison disappeared increased the interval for the next trial, but they were counted as incorrect in relation to advancing to the next phase of the study.

Succession of trials. Successive series of trials are described below as phases. Each phase contained all the possible combinations of samples corresponding to a conditional discrimination. There were two types of phases: teaching and test phases. Teaching phases were designed to teach or to review conditional discriminations. Test phases were designed to test the emergence of a novel conditional discrimination. In teaching phases, the same series of 16 or 24 trials was repeated

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(°) indicates that selections of that comparison were considered correct in probe trials. The notation below each conditional discrimination indicates the contextual stimulus (in XAB, XEF, and XGH), the sample, and the comparisons (the incorrect comparison is in parentheses). Comparisons were presented at random positions.

until the participant responded correctly on several consecutive trials (the number of specific correct trials depended on the phase, see below). Once the participant reached this criterion, a new phase followed. Each teaching phase also varied in terms of the proportion of selections reinforced (1, 0.5, or 0.25). Test phases ended after 24 unreinforced trials, regardless of performance. Sessions ended after the final programmed phase or after 25 minutes. When a session finished before reaching the end of the last programmed phase, the next session started with the phase the participant was performing at the moment of the interruption.

One or more phases were designed to teach or to test the conditional discriminations. Table 1 summarizes the specific procedures used in each phase, as described below. Conditional discrimination AB was taught in Phases 2 through 4, XAB was taught in Phases 5 through 12, and EF was taught in Phases 13 through 15. The XEF conditional discrimination probed the transfer of functions of contextual stimuli in Phase 16. A new conditional discrimination GH was taught in Phases 17 through 19, and XGH probed the transfer of functions of contextual stimuli in Phase 20.

Phase 1: BB identity matching. Because identity matching to sample may facilitate learning of arbitrary matching to sample, prior to AB teaching the B1 and B2 stimuli were presented in a two-choice identity matching-to-sample task. Selections of B1 in the presence of B1 and selections of B2 in the presence of B2 were reinforced. As shown in Table 1, the delayed prompt procedure was used and the participants received the consequences described above on each trial. This procedure continued until the participant made eight consecutive correct selections when both the correct choice and the incorrect choice were present. The program then automatically advanced to the first AB teaching phase.

Phases 2, 3, and 4: AB teaching. During Phase 2 (see Table 1), Stimuli A1 and A2 were presented randomly as samples across trials; Stimuli B1 and B2 served as comparisons. Selections of B1 in the presence of A1 and selections of B2 in the presence of A2 were reinforced. The remaining procedures were as in Phase 1 except that correct responses in 16 consecutive trials were required to advance to Phase 3. Phases 3 and 4 were conducted to gradually reduce the differential consequences provided along trials in preparation for the test phases, in which there were no differential consequences for responding. Phases 3 and 4 presented the same discriminations as in Phase 2 and the criterion of correct responses to advance to the next phase was the same. The delayed prompt procedure, however, was not in effect and the probability of reinforcement decreased to .5 (Phase 3), and to .25 (Phase 4).

Table 1

Relations used in each phase of Study 1. The relations, whether the delayed prompt procedure was used, the probability of reinforcement, and the criterion of correct trials to advance to the next phase are shown. Letters followed by a number in the Relations column indicates that only the stimulus cited (X1 or X2) was presented as contextual in these phases. The asterisks in Phases 16 and 20 indicate that the program finished after 24 unreinforced trials, irrespective of the performance.

Phase	Relations	Delayed prompt	Probability of reinforcement	Trials
1	B-B	YES	1	8
2	A-B	YES	1	16
3	A-B	NO	.5	16
4	A-B	NO	.25	16
5	X1-A-B	NO	1	24
6	A-B	NO	.25	16
7	X2-A-B	NO	1	24
8	A-B	NO	.25	16
9	A-B	NO	.25	16
10	X-A-B	NO	1	24
11	X-A-B	NO	.5	24
12	X-A-B	NO	.25	24
13	E-F	YES	1	16
14	E-F	NO	.5	16
15	E-F	NO	.25	16
16	X-E-F	NO	0	24*
17	G-H	YES	1	16
18	G-H	NO	.5	16
19	G-H	NO	.25	16
20	X-G-H	NO	0	24*

Phase 5: X1AB teaching. During this phase, Contextual Stimulus X1 and Sample A1 or A2 were presented in each trial. The procedure was identical to the procedure of the previous phase except that 24 consecutive correct trials were required to advance to the next phase and all correct responses were reinforced.

Phase 6: AB review. This phase was identical to AB teaching Phase 4. This phase, as well as Phases 8 and 9, were introduced because

pilot experiments showed that it was more likely that the functions of contextual stimuli transferred to the new conditional discriminations when these phases were inserted in this way.

Phase 7: X2AB teaching. This phase was identical to X1AB teaching phase (Phase 5) except that the contextual stimulus was always X2 instead of X1. Also, selections of B2 in the presence of A1 and selections of B1 in the presence of A2 were reinforced.

Phases 8 and 9: AB review. Phases 8 and 9 were identical to each other and to the former AB phases (Phases 4 and 6); thus, they provided additional review.

Phases 10, 11, and 12: XAB teaching. During the first phase of the XAB teaching (Phase 10) the four combinations of stimuli shown in Figure 1 were presented randomly over trials. As in the X1AB and X2AB teaching phases, selections of B1 in the presence of A1 and selections of B2 in the presence of A2 were reinforced in the trials with X1; selections of B2 in the presence of A1 and selections of B1 in the presence of A2 were reinforced in the trials with X2. After 24 consecutive correct selections, participants advanced to the next phase. In Phases 11 and 12, the probability of reinforcement decreased to .5 and then to .25, respectively.

Phases 13, 14, and 15: EF teaching. EF conditional discrimination teaching was the same as for the AB conditional discriminations, except that stimuli E1 and E2 were presented as samples and stimuli F1 and F2 were presented as comparisons.

Phase 16: XEF test. The XEF test consisted of randomly presenting the four stimulus combinations of XEF (X1-E1, X1-E2, X2-E1, or X2-E2) with stimuli F1 and F2 as comparisons (see Figure 1). No differential consequences occurred and the session ended after 24 trials. For descriptive purposes, in accordance with the teaching of XAB, the selections of F1 in the presence of X1 and E1, or in the presence of X2 and E2, and selections of F2 in the presence of X1 and E2, or in the presence of X2 and E1, were defined as correct.

Phases 17, 18, and 19: GH teaching. The next session started with the teaching of a new conditional discrimination. It was conducted in three phases exactly as the AB teaching, except that stimuli G1 and G2 were presented as samples and stimuli H1 and H2 were presented as comparisons.

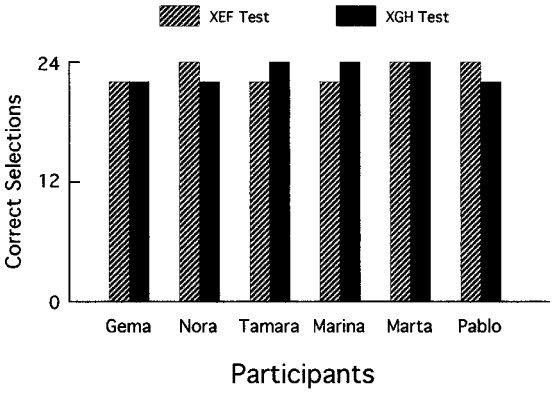

Fig. 2. Performance of children Gema, Nora, and Tamara, and adolescents Marina, Marta, and Pablo in the XEF and EGH tests of Study 1. Each bar represents correct selections in a block of 24 trials.

Phase 20: XGH test. The XGH was also identical to the XEF test except for the stimuli involved in the discrimination. The X1-G1, X1-G2, X2-G1, or X2-G2 stimulus combinations were presented with H1 and H2 as comparisons; the selections of H1 in the presence of X1 and G1, or in the presence of X2 and G2, and selections of H2 in the presence of X1 and G2, or in the presence of X2 and G1, were defined as correct. The session ended after 24 trials.

RESULTS

Conditional Discriminations Taught

The teaching procedure resulted in a low number of errors and relatively rapid acquisition. For example, Tamara responded to a total of 1,525 teaching trials over seven sessions, of which 1,302 were correct (85.4% of the total of selections). Teaching trials from the other participants ranged from 357 (Pablo) to 544 (Gema). Percentage correct ranged from 90.9% (Marina) to 98.3% (Pablo). Even when all participants met criteria with no errors in most phases, all participants made an error in the first trial of the X2AB teaching phase (Phase 7).

XEF and XGH Tests

Figure 2 shows that the 6 participants made 23 to 24 correct responses during 24 trials in the XEF and the XGH tests; that is, they selected F1 in the presence of X1 and E1 or in

the presence of X2 and E2, and they selected F2 in the presence of X1 and E2 or in the presence of X1 and E2. Adolescent Marta and Child Gema responded to 10 and 11 trials of the XEF test, respectively, in the first session with this test. Then, the assigned time for the session ended. Both participants were tested again during the next session and they responded correctly to the test. In summary, all 6 participants showed transfer of the contextual control functions from the taught to the tested conditional discriminations. They learned a conditional discrimination; then, they learned to respond to that conditional discrimination according to contextual stimuli; then, they learned a second conditional discrimination; finally, the participants demonstrated transfer of the contextual control functions to the second conditional discrimination by responding according to the contextual stimuli without reinforcement.

The adolescents and the children showed the emergence of the tested conditional discriminations with few errors. During the tests of the novel conditional discriminations, the children responded correctly to all but four trials (see Figure 2) and the adolescents responded correctly to all but two trials. Thus, the response pattern was virtually identical in both groups.

Discussion

These results demonstrated transfer of specific contextual control functions by showing that the functions of the contextual stimuli transferred to novel conditional discriminations with the same functions among its stimuli. That type of transfer occurred even though the contextual stimuli had never appeared in the presence of the stimuli of the tested conditional discriminations. Moreover, the stimuli presented with the contextual stimuli in the taught conditional discriminations were not taught to be in the same stimulus class as the stimuli of the tested conditional discriminations. The only features the stimuli in the taught and tested conditional discriminations had in common were that each functioned as both sample-correct comparison relations and sample-incorrect comparison relations.

One child made more errors and needed more teaching trials than the other participants. Even so, the remaining children and the adolescents learned the taught conditional discriminations with small differences among them, and all participants learned the conditional discriminations needed for receiving testing. Given that the purpose of the study was to explore possible differences in the outcomes, the test results are more relevant for comparing the two participant groups. Both groups responded with one or zero errors in each test. Thus, the outcome differences between the two participant groups were minimal.

STUDY 2

Pérez-González (1994) demonstrated transfer of stimuli taught as comparisons in a conditional discrimination to the function of comparisons in novel conditional discriminations. Study 2 examined transfer from the functions of stimuli taught as contextual, as in Study 1, directly to the function of comparison stimuli. Specifically, given that each contextual stimulus X controlled the selection of a particular comparison in the presence of a sample (e.g., the selection of F1 in the presence of E1 and contextual stimulus X1 in Study 1), we examined whether that X stimulus would be selected when the other two stimuli were presented as a two-stimuli sample (e.g., whether X1 would be selected in the presence of C1 and D1) without the previous teaching or testing of those stimuli with the X stimuli as contextual.

Method

Participants

The participants were the same as in Study 1.

Apparatus

The apparatus was the same as in Study 1. New stimuli were used to teach novel conditional discriminations (see Figure 3).

Procedures

This study was conducted immediately following Study 1. The phases were as follows:

Phases 1, 2, and 3: CD teaching. The teaching of CD was identical to that for the AB relations in Study 1 (Phases 2 through 4). In Phase 1, Stimuli C1 and C2 were presented

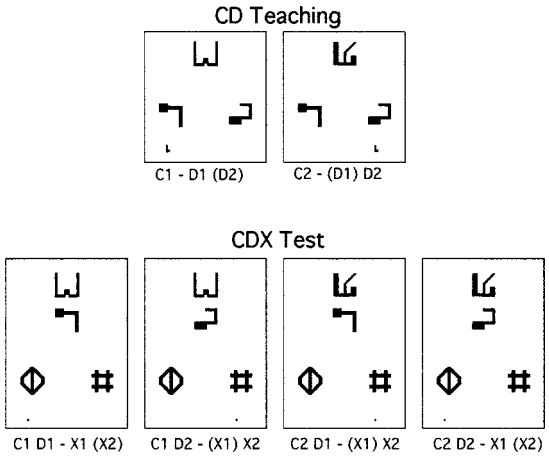

Fig. 3. Stimuli and stimuli relations of Study 2. In two-sample conditional discriminations, the two samples appear above the comparisons. See caption of Figure 1.

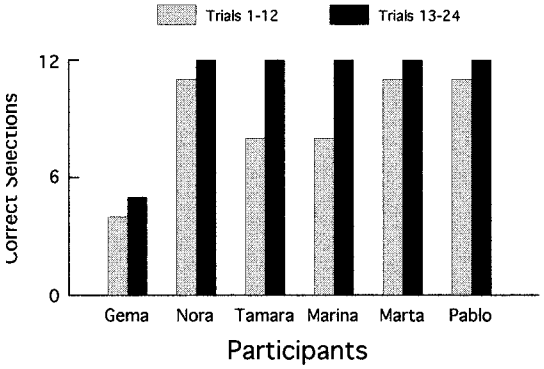

Fig. 4. Performance in the CDX test of Study 2. Each bar represents correct selections in a block of 12 trials.

randomly as samples across trials; Stimuli D1 and D2 served as comparisons. Selection of D1 in the presence of C1 and selection of D2 in the presence of C2 were reinforced. A delayed prompt procedure was used. After 16 correct consecutive responses, Phase 2 was introduced. Phases 2 and 3 were like Phase 1 except that the delayed prompt procedure was not in effect and the probability of reinforcement was decreased to .5 (Phase 2), and to .25 (Phase 3).

Phase 4: CDX test. Two stimuli with the previously established sample-correct comparison (C1D1 and C2D2) or sample-incorrect comparison (C1D2 and C2D1) relations appeared as samples, whereas X1 and X2 appeared as comparisons. As diagrammed in Figure 3, C1 or C2 and D1 and D2 appeared in the upper part of the screen, and X1 and X2 appeared in the lower part of the screen. Twenty-four trials without feedback were presented. Selections of X1 in the presence of C1 and D1 or C2 and D2 were defined as correct; selections of X2 in the presence of C1 and D2 or C2 and D1 were also defined as correct.

Results

CD teaching. All participants learned the CD conditional discriminations virtually without errors. No participant made more than seven total errors across phases.

CDX test. Figure 4 shows the number of correct responses of the test for all participants. The results are displayed in two 12-trial halves to more clearly show the gradual transfer of functions of the X stimuli. Nora, Marta, and Pablo showed transfer immediately by selecting correctly in 11 of the 12 first trials. Five of the 6 participants correctly selected X1 or X2 when presented as comparisons in the last 12 trials of the CD test. Gema responded correctly to 9 of 24 trials (37.5%). Her selection pattern did not show any apparent regularity—she made errors to all four types of conditional discriminations. Tamara made three errors in the first three trials with C2 and D2 in the sample; however, she responded correctly to the remaining three trials of this type. Marina made three errors in the first four trials of the test.

Discussion

All but 1 participant selected between Stimuli X1 and X2 in a precise way when they were presented as comparisons with novel stimuli after learning conditional discriminations with the X stimuli taught as contextual in Study 1. Thus, the performance occurred when two operations were made simultaneously, changing the functions of the X stimuli from contextual to comparisons and presenting them with novel stimuli. Markham and Dougher (1993), Pérez-González (1992), and Serna (1991) showed that elements of contextual control arrangements were interchangeable. These researchers taught comparison selection in the presence of two-stimulus samples, such as XAB. Then, in unreinforced test trials, stimuli were interchanged, resulting in two-stimulus-comparison arrangements such as ABX, AXB, and

BXA. Participants continued to respond in a manner consistent with the originally taught XAB relations. For example, if in the presence of X1 and A1, selections of B1 (but not B2) were reinforced, then when B1 and A1 were presented in a test, X1 (but not X2) was the selected comparison. The present study also showed interchangeability: Stimuli that had served a contextual function were shown in testing to serve a comparison function. The present study is distinguished, however, from Markham and Dougher, Pérez-González, and Serna by the fact that X1 and X2 were successfully interchanged to become comparisons, but in the presence of two-stimuli samples with which they had never been explicitly taught.

The final performance was identical to that of Pérez-González (1994), although four combinations of samples were used in the present study whereas nine combinations were used in Pérez-González's. The procedure was different, however, for here, Stimuli X1 and X2 were taught as contextual stimuli, whereas Pérez-González used these two stimuli as comparisons. The basic process of transfer, however, was identical: In both studies X1 and X2 were taught with some stimulus pairs and were tested with novel stimuli.

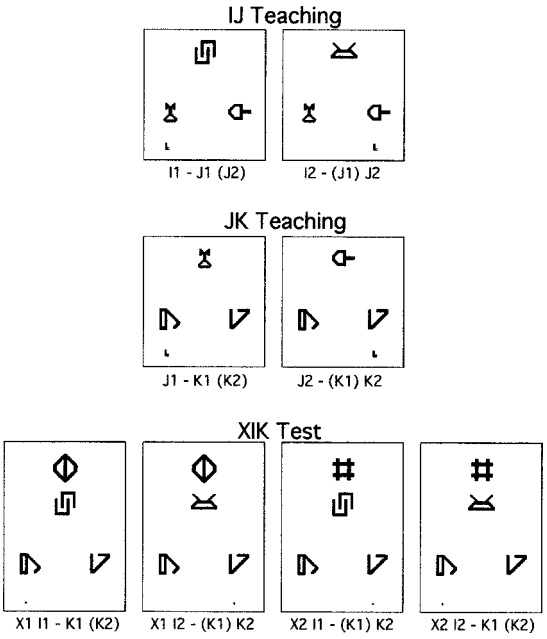

Fig. 5. Stimuli and stimuli relations of Study 3. See caption of Figure 1.

STUDY 3

As in the previous studies, in Study 3 we asked whether contextual control functions would transfer to new conditional discriminations. In the present study, however, we asked whether the transfer would occur to novel, rather than taught, sample-comparison pairs. Thus, we taught two new conditional discriminations and we presented the contextual stimuli during transitivity probes (e.g., Sidman & Tailby, 1982). We examined whether the X stimuli would determine comparison selections.

METHOD

Participants

The participants were Pablo, Marta, and Nora, who participated in Studies 1 and 2, and Eulalia (a 10-year-old girl). Eulalia was taught with the same conditional discriminations (Phases 1 through 20 of Figure 1) and responded correctly in the XEF and the XGH test, as did the participants in Studies 1 and 2. The experimenter, however, mistakenly programmed the computer to teach the CD and test the XCD conditional discriminations before teaching the GH conditional discrimination. She also responded correctly to the XCD test. Thus, this child had two replications of EF teaching and the XEF test.

Apparatus

The apparatus was the same as in Study 1. New stimuli were used to teach novel conditional discriminations (see Figure 5).

Procedure

Phases 1 through 6: IJ teaching and JK teaching. Participants were given conditional discrimination teaching with new stimuli. The IJ teaching was identical to that for teaching the AB and other relations in the previous studies (e.g., Phases 2 through 4 of Study 1). During Phase 1, Stimuli I1 and I2 were presented randomly as samples across trials; Stimuli J1 and J2 served as comparisons. Selections of J1 in the presence of I1 and selections of J2 in the presence of I2 were reinforced. The delayed prompt procedure was used. The participant moved to Phase 2 after making 16 consecutive correct responses. Phases 2 and 3 presented the same discriminations as in

Phase 1, and the criterion of correct responses to advance to the next phase was the same. The delayed prompt procedure, however, was not in effect. The differential consequences provided along trials were gradually reduced in preparation for the test phases; thus, the probability of reinforcement decreased to .5 (Phase 2), and to .25 (Phase 3).

The JK teaching was conducted during Phases 4 to 6 exactly as that for IJ relation, except for the stimuli presented. Stimuli J1 and J2 appeared randomly as samples across trials; Stimuli K1 and K2 served as comparisons. Selections of K1 in the presence of J1 and selections of K2 in the presence of K2 were reinforced.

Phase 7: XIK test. As with the tests in Studies 1 and 2, X1 and X2 were randomly presented as contextual stimuli during 24 trials. In Study 3, either I1 or I2, randomly selected, was presented as sample and K1 and K2 were the comparisons. Consistent with predicted performance, selections of the transitive relations (selections of K1 when I1 was the sample and selections of K2 when I2 was the sample) in the presence of X1 were defined as correct; selections of the opposite relations (selections of K2 when I1 was the sample and selections of K1 when I2 was the sample) in the presence of X2 were also defined as correct.

Results

IJ teaching and JK teaching. All participants made one or zero errors in each teaching phase, with the exception of participants Nora, who made 7 errors in the first phase of the IJ teaching and 4 in the JK teaching, and Marta, who made 4 four errors in the first phase of the JK teaching.

XIK test. The results are displayed in Figure 6. They appear in two 12-trials halves to show the gradual transfer of functions of the X stimuli. Nora, Eulalia, and Pablo made 11 correct selections in the first 12 trials and Marta made eight. Finally, in the last 12 trials of the XIJ test, Nora, Eulalia, and Pablo selected correctly in the 12 trials. Marta selected correctly on 11 of the 12 trials.

Discussion

The 4 participants demonstrated transfer of the contextual stimulus functions of X1 and X2 from the AB relations to novel stimuli

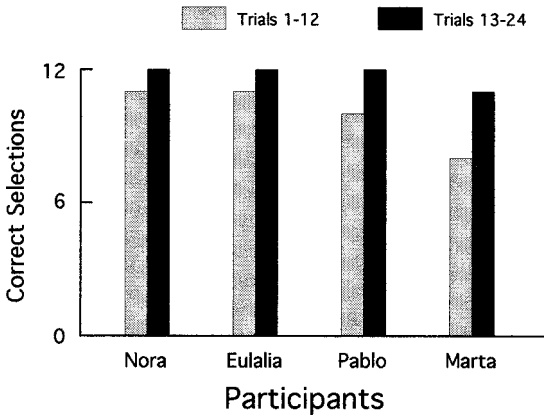

Fig. 6. Performance in the XIK test of Study 3. Each bar represents the correct selections in a block of 12 trials.

I and K when those were tested for transitivity. Three participants immediately selected the comparison predicted by the transitive performance when X1 was the contextual stimulus and selected the alternative comparison when X2 was the contextual stimulus. The 4th participant (Marta) ultimately demonstrated XIK performance after failing the first few trials of the test. The results are unique in that the transitivity test was conducted for the first time with a contextual stimulus that had never been presented with I or K (or even with J). Moreover, the I and K stimuli themselves had never been presented together, even though the specific functions of X1 and X2, acquired in previous conditional discriminations (in Study 1), transferred to the IK conditional discrimination.

GENERAL DISCUSSION

Participants were first taught AB conditional discriminations. Then, contextual control was established such that participants made the original AB conditional selections in the presence of X1, but the opposite conditional selections in the presence of X2. Across three studies, the specific functions of X1 and X2 established during the XAB teaching transferred to novel conditional discriminations: None of the stimuli in the conditional discriminations presented during testing had been previously presented with X1 and X2, or with A and B stimuli. The transfer of control of X1 and X2 functions, established dur-

ing teaching, was demonstrated in three ways. In Study 1, the specific functions of X1 and of X2 transferred to novel previously established conditional discriminations (EF and GH) during testing. In Study 2, the participants first learned CD conditional discriminations. During testing, participants were presented with CD compound samples that consisted of either related (C1D1 and C2D2) or unrelated (C1D2 and C2D1) stimuli; X1 and X2 served as comparisons. If the compound sample consisted of related stimuli, participants selected X1; if the compound sample was not related, participants selected X2. Finally, in Study 3, the participants were taught IJ and JK conditional discriminations. The contextual functions established during teaching transferred to a test of IK transitivity: Participants selected K1 to I1 and K2 to I2 in the presence of X1; but the opposite stimuli, K2 to I1 and K2 to I1, in the presence X2.

Transfer of Specific Functions

The initial XAB teaching appeared to establish specific functions for X1 and X2. Once criterion was met with XAB, at least two stimulus control bases could have accounted for accurate performance. First, responding could have been based on four separate if–then ''rules:'' (a) if X1 and A1, select B1; (b) if X1 and A2, select B2; (c) if X2 and A1, select B2; and (d) if X2 and A2, select B2. Second, responding could have been based on the more efficient and general contextual control rule: if X1, select the same sample-comparison relations as previously reinforced, and if X2, select the opposite sample-comparison relations as were previously reinforced. Participants' responses in Study 1, EF and GH test performance in the presence of X1 and X2, suggest that the latter stimulus control basis was operative by the end of teaching. Had participants based XAB responding on four separate if–then rules during teaching, the obtained XEF and XGH performances of Study 1 and CDX performance in Study 2 would have been unlikely. This is so because the learned rules (e.g., if X1 and A1, select B1) could not be applied to the novel conditional discrimination given that some stimuli specified by the rule were not present (i.e., A1 is not present in the XEF conditional discrimination).

The control exerted by the specific functions of X1 and X2 were robust, especially in Study 2 where participants showed transfer of control when the taught contextual stimuli X1 and X2 appeared as comparisons (teach CD, test CDX). Examination of the teaching and testing may shed light on the interaction between the contextual stimuli and the conditional discriminations that allowed CDX performance in Study 2. In addition to the specific functions of X as contextual stimuli, as explained above, CDX performance in Study 2 appeared to require previously established relations among the C and D stimuli. Once taught, participants then selected X1 or X2 according to the relations established between C and D stimuli in the CD teaching. For example, given C1D1 or C2D2 as compound stimuli, participants selected the stimulus (X1) that had a history of contextually controlling these previously reinforced sample-comparison relations during the taught and the tested conditional discriminations (Study 1). Given C1D2 or C2D1 as compound stimuli, participants selected the stimulus (X2) that had controlled selection of the opposite relations to those explicitly taught. In effect, the CDX test functioned as a yes–no task: select X1 if the compound stimuli are related to one another, select X2 if they are not. As noted earlier, other studies have also demonstrated interchangeability of terms in contextual control arrangements (e.g., contextual and comparison stimuli: Markham and Dougher, 1993; Pérez-González, 1992; Serna, 1991), but with stimuli that were previously presented in the same configuration. Other studies demonstrated generalization of X stimuli as contextual stimuli to novel conditional discriminations (Study 1 here) and generalization of X stimuli as comparisons to novel conditional discriminations (Pérez-González, 1994). Study 2 combined the tasks of these studies in one.

The results of Study 3 extended the findings of Study 1 by showing that the functions of the X stimuli transferred to a novel conditional discrimination in which the samples and the comparisons appeared together for the first time. The findings of Serna and Pérez-González (2003) also extended the present findings by showing that the specific functions of the X stimuli also transfer to conditional discriminations in which comparison selections are unreinforced and, therefore,

each participant selects the comparison of his or her will in the presence of each sample.

The present findings combined with those of Pérez-González (1994) and Serna and Pérez-González (2003) provide evidence that stimuli X1 and X2 acquired functions separate from the conditional discriminations they controlled when they were presented as contextual stimuli as well as when they were comparisons. Moreover, the functions of the contextual stimuli may extend to a potentially infinite number of novel relations.

Contextual Control of Transitivity

Sidman (1986) discussed the function of contextual stimuli within the framework of classes of equivalent stimuli. For example, one contextual stimulus might control the formation of a stimulus class (e.g., X1 controls the formation of A1B1C1 and A2B2C2) whereas another contextual stimulus might control the formation of an alternate stimulus class (e.g., X2 controls the formation of A1B2C2 and A2B1C1). Is it possible that in previous experiments the contextual control demonstrated was merely of the type demonstrated in the present experiments? Lynch and Green (1991) explored contextual control in a test for transitivity involving two sets of four stimuli by teaching the contextual stimuli with two members of each pair and testing for transitivity with the other two members. They suggested that two stimulus control bases could have accounted for the results. First, each contextual stimulus could have determined the formation of a stimulus class. Second, one contextual stimulus might have merely controlled selections of the same comparisons as in the previous no-contextual-stimulus teaching, and the other contextual stimulus controlled selections of nonequivalent comparisons. Although Lynch and Green did not conduct tests that would separate these accounts, the results of the present studies suggest that the stimulus control basis of the contextual stimuli is consistent with the second hypothesis proposed by Lynch and Green. Consider the results of the present Study 3. Had X1 and X2 controlled class formation, classes would have appeared as I1J1K1 and I2J2K2 under the control of X1 and I1J2K1 and I2J1K2 classes under the control of X2. This would result in selections of K1 in the presence of I1 and K2 in the presence of I2 regardless of whether X1 or X2 were present. Instead, the participants responded to I1K1 and I2K2 in the presence of X1, but I1K2 and I2K1 in the presence of X2. The results indicated that participants selected the comparison of the same class as the sample in the presence of X1 and the alternative comparison in the presence of X2 (Lynch and Green's second hypothesis). Therefore, it appears more parsimonious to consider that the classes established among the noncontextual stimuli remained the same throughout the experiment. Contextual control of this type can also account for Lynch and Green's outcomes.

In addition, for the reasons noted above, the stimulus classes were always the same, independent from the contextual stimulus. The comparison selections varied across trials according to the contextual stimuli. Therefore, the contextual stimuli had functions different from those of the remaining stimuli, and they were not part of the classes established among the remaining stimuli.

True Contextual Control

Bush et al. (1989) and Lynch and Green (1991) argue that a demonstration of ''true'' contextual control requires the contextual stimuli be shown to function independently of the other stimuli; that is, that selections cannot be accounted for by a compound between the contextual and sample stimuli. As such, they considered that most previous studies had not provided demonstrations of true contextual control. To demonstrate true contextual control, Bush et al. and Lynch and Green taught and tested participants in ways that experimentally separated the contextual and sample stimuli. For example, in Lynch and Green's tests for transitivity, the samples and comparisons had never before been presented with the contextual stimuli. Thus, contextual and sample stimulus compounds could not account for ''contextual'' responding. For Lynch and Green, then, the conditional selection of samples and comparisons that depended on the presence of the contextual stimulus provided a demonstration of true contextual control. Similarly, during testing in the present study, neither the sample nor the comparisons had been presented before with the contextual stimuli, and thus an account of the results based on compound

stimuli control is not warranted. Therefore, one might characterize the present tests (e.g., XEF and XIK) as another means by which true contextual control can be demonstrated.

Contextual Control and Verbal Behavior

Several investigators have noted the importance of stimulus-class research to study basic processes of verbal behavior (e.g., de Rose, de Souza, & Hanna, 1996; Pérez-González et al., 2000; Stromer, Mackay, & Stoddard, 1992). One characteristic of verbal stimuli is that they may also control behavior even when presented in novel combinations with other stimuli (Bush et al., 1989; Hayes, 1994; Hayes et al., 1991; Hayes & Wilson, 1993; Sidman, 1986). In the example by Bush et al., ''Kennedy'' is related to ''de Gaulle'' and not ''Twain'' in the presence of the contextual stimulus ''discipline''; however, Kennedy is related to Twain and not de Gaulle in the presence of the contextual stimulus ''nationality.'' Here, Kennedy has the function of a sample, de Gaulle and Twain have the functions of comparisons, and discipline and nationality have the functions of contextual stimuli in conditional discriminations. In Bush et al.'s example and in their demonstration, the contextual stimuli control only relations specific to the noncontextual stimuli; hence, these stimuli accomplish relatively narrow functions.

In contrast, the control established in the present studies was much broader. Suppose we verbally instruct a child as follows: ''Select the one that goes with the other.'' Kennedy is presented as a sample and de Gaulle (the correct selection) and ''Renoir'' are comparisons. In a different trial with the same samples and comparisons, the instruction might be ''select the one that does not go with the other.'' In this case, the phrases ''goes with'' and ''does not go with'' have the functions of contextual stimuli, like the functions of X1 and X2, respectively, in the present studies. Those stimuli can apply to a virtually infinite number of relations. For example, when a person hears ''Select the one that goes with the other'' in the presence of a guitar, and that person can select between a piano and an orange. Most people in everyday life appropriately select piano—even though Kennedy and de Gaulle do not have any relation with a guitar and a piano. They respond in the same way as the participants responded in the present studies. Thus, the present research has demonstrated some processes that likely can be involved in those verbal episodes. Pérez-González (1994) made a similar case for the generalized transfer of the ''yes'' and ''no'' functions established in his study. Therefore, the studies reported here provide an account of generalized contextual control that has much potential for understanding the factors that produce this type of generalized verbal behavior.

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