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Richard W. Serna
University of Massachusetts Medical School

Luis Antonio Perez-Gonzalez
University of Massachusetts Medical School

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AN ANALYSIS OF GENERALIZED CONTEXTUAL CONTROL OF CONDITIONAL DISCRIMINATIONS

RICHARD W. SERNA AND LUIS ANTONIO PÉREZ-GONZÁLEZ

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

This research asked whether performance engendered by contextual control procedures would generalize to novel matching-to-sample stimulus arrangements. Two studies were conducted with young adult participants. In Study 1, participants first were trained to perform the contextually controlled conditional discrimination, X-AB, where the sample-comparison relations A1B1 and A2B2 were reinforced in the presence of contextual stimulus X1, but the relations A1B2 and A2B1 were reinforced in the presence of X2. Then, a new conditional discrimination, CD, was established via an unreinforced-conditional-selection procedure. Next, participants were tested for X-CD contextual control performance. Participants selected the originally established CD relations in the presence of X1, but the opposite relations in the presence of X2. Next, an additional conditional relation, EF, was established. Then, participants received trials consisting of entirely novel contextual stimuli, Z1 and Z2, and EF samples and comparisons. Selections were consistent with contextual control; that is, participants selected the originally established EF relations in the presence of one of the novel contextual Z stimuli, but selected the opposite EF relations in the presence of the other contextual Z stimulus. Study 2 systematically replicated these results with naive participants and demonstrated the necessity of first establishing a conditional discrimination prior to tests for generalized contextual control. The findings are discussed in terms of unreinforced conditional selection, stimulus classes, and new ways in which contextual control performances can emerge.

Key words: stimulus control, generalized contextual control, unreinforced conditional selection, five-term control, conditional discriminations, matching-to-sample, human participants

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Over the past several years, stimulus control researchers have demonstrated that the composition of stimulus equivalence classes can be controlled conditionally by the presence of other stimuli (e.g., Bush, Sidman, & de Rose, 1989; Gatch & Osborne, 1989; Kennedy & Laitinen, 1988; Lynch & Green, 1991; Markham & Dougher, 1993; Serna, 1987, 1991; Steele & Hayes, 1991; Wulfert & Hayes, 1988). For example, Lynch and Green showed that a participant who demonstrated 2 four-member stimulus equivalence classes, A1B1C1D1 and A2B2C2D2, in the presence of the spoken word ''Bem'' (contextual stimulus) also demonstrated different classes, A1B2C2D1 and A2B1C1D2, in the presence of another spoken word ''Zut.''

Essential to such stimulus control demonstrations has been a conceptual extension of the three-term contingency (Sidman, 1986). This analysis posits that the three-term contingency ''unit'' (discriminative stimulus-response-consequence) can be controlled by additional stimuli: the fourth terms. For example, in an arbitrary matching-to-sample (MTS) task, a response to Comparison Stimulus B1 and not B2 will be reinforced in the presence of Sample A1; in the presence of Sample A2, a response to B2 and not B1 will be reinforced. Sidman further extended the analysis to include conditional control over the four-term unit. Thus, five-term contingencies include antecedent stimuli that control entire four-term units. For example, under the minimal conditions for such control, in the presence of Stimulus X1, responses to Comparison B1 given Sample A1, and B2 given Sample A2 are reinforced; but in the presence of X2, responses to B2 given Sample A1, and B1 given Sample A2 are reinforced. This five-term (stimulus-stimulus-stimulus-response-con-

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Address correspondence to Richard W. Serna, University of Massachusetts Medical School–Shriver Center, Psychological Sciences Division, 200 Trapelo Road, Waltham, Massachusetts 02452 (e-mail: Richard.Serna@umassmed.edu.), or to Luis A. Pérez-González, La Granja, 33720 Boal, Asturias, Spain (e-mail: laperez@sci.cpd.uniovi.es).

sequence) contingency describes an "X-AB" task, where X stimuli are fifth-term stimuli, A stimuli are samples, and B stimuli are comparisons. Performance under five-term contingencies is most often referred to as contextual control of conditional discriminations, and the fifth-term stimuli as contextual stimuli. This analysis, and the accompanying MTS procedures, have provided the basic framework from which analyses of contextual control of equivalence relations have been conducted.

Although many studies have demonstrated contextual control of equivalence relations, these and other studies have also extended our understanding of the nature of the five-term contingency, per se. Many investigators have attempted to show that participants' performances represent more than just responses to the absolute stimulus configurations in the MTS task. Their studies have shown that stimulus functions within the five-term contingency are substitutable and interchangeable. For example, Gatch and Osborne (1989) and Lynch and Green (1991) showed that new stimuli conditionally related to the contextual stimuli via MTS procedures could substitute for the original contextual stimuli (e.g., after X-AB training, then XY training, participants could perform Y-AB without additional training). Markham and Dougher's (1993) findings demonstrate that substitutability is not restricted to the contextual stimulus in a five-term contingency. In their study, after X-AB training, then BC training, participants performed X-AC without additional training. Further, Serna (1991) and Markham and Dougher have shown that, after contextual control training, the contextual, sample, and comparison stimuli are interchangeable with one another. For example, after X-AB matching has been established, participants may demonstrate A-BX, A-XB, B-XA, and so forth, without additional training.

More recently, stimulus control researchers have documented an additional characteristic of contextual control performance: Contextual stimulus functions will transfer to newly trained conditional discriminations; that is, conditional discriminations that have not been related procedurally to the contextual stimuli. This possibility was first suggested in a control condition of Hayes, Kohlenberg, and Hayes (1991). Hayes et al. investigated contextually controlled transfer of conditioned reinforcing and punishing functions through equivalence classes. The equivalence classes consisted of nonrepresentational form stimuli, and the contextual stimuli were colored backgrounds. Equivalence classes A1B1C1, A2B2C2, and A3B3C3 were established in the presence of a red background (X1), and classes A1B1C3, A2B2C2, and A3B3C1 in the presence of a green background (X2). Participants also performed a sorting task, and Stimuli B1 and B3 were established as a conditioned reinforcer and punisher, respectively, for sorting. Note that B1 and B3 were procedurally related to C1 and C3, respectively, when the contextual cue was red, but to C3 and C1 (the opposite) when the contextual cue was green. On transfer tests with the sorting task, in general, (a) the C stimuli, by virtue of their equivalence relations with the B stimuli, also functioned as consequences, and (b) these functions changed with changing contextual cues. Of primary relevance to the present discussion was a control condition in which participants were given novel stimuli instead of C stimuli during the sorting test. For most of the control participants, the novel stimuli functioned as differential consequences even though these stimuli had never been procedurally related to the B stimuli or any other members of the ABC equivalence classes. Further, participants' idiosyncratic consequential assignments reversed with changing color (contextual) stimuli. The control participants' performances suggest not only transfer of consequential stimulus functions, but also transfer of contextual control to novel stimuli. Similar findings by Pérez-González (1994) also suggest this possibility of transfer of contextual control to novel stimuli.

Pérez-González and Serna (2003) more directly demonstrated transfer of contextual control of novel conditional discriminations. In their Study 1, participants were trained first with the minimal conditions necessary for establishing contextual control: X-AB. Participants were then trained to respond to two new conditional discriminations, CD and EF. Finally, tests showed that the contextual control established during X-AB training transferred to the trained conditional discriminations resulting in X-CD and X-EF. CD and EF stimuli had never been directly related to X stimuli.

Pérez-González and Serna (2003) showed that contextual control of specific stimuli over positive and negative sample-comparison relations also transferred to new positive and negative sample-comparison relations. In their study, however, test trials always contained one or more stimuli from the original training (e.g., train X-AB, test X-CD, where CD was an established conditional discrimination). Does the transferred contextual control shown in these studies depend on the inclusion of one of the original training stimuli? The present studies examined whether training with contextual-control procedures would result in a broader, more generalized contextual control of conditional discriminations; for example, train X-AB, test Z-EF. We term such performance *generalized contextual control.* Two studies asked the following: Given a minimal training history for contextual control, will control by the originally trained contextual stimuli transfer to new conditional discriminations? Will contextual control performance generalize to new configurations in which all stimuli are novel? What features of the training and testing conditions affect the likelihood of generalized contextual control?

STUDY 1

Study 1 had two purposes: First, it was designed to systematically replicate the essential findings of Pérez-González and Serna (2003) across laboratories. Thus, Study 1 asked whether contextual functions would transfer to new conditional discriminations. Unlike Pérez-González and Serna, however, new conditional discriminations in this and Study 2 of the present article were established via the *unreinforced-conditional-selection procedure.* Unreinforced conditional selection is demonstrated when participants are presented with a novel arbitrary conditional discrimination task and make consistent conditional selections in the absence of differential consequences (R. Saunders, K. Saunders, Kirby, & Spradlin, 1988; Stromer, 1986, 1989; Williams, K. Saunders, R. Saunders, & Spradlin, 1995). Unreinforced conditional selection plays both a conceptual and procedural role in the present studies: Establishing conditional discriminations via the unreinforced-conditional-selection procedure verified that participants were at least capable of conditional selection performance at the four-term (Sidman, 1986) conditional discrimination level.

The second purpose of Study 1 was to examine generalization of contextual control performance. Emergent contextual control performance would appear to depend on conditional control functions specific to the individual contextual stimuli presented during training. It is possible, however, that any visual stimulus presented in the same physical and temporal relation to new samples and comparisons as the trained contextual stimuli would exert the same control. Study 1 examined this possibility.

Method

Participants

Participants D.E. (male [m], chronological age 19) and J.S. (m, 19) were college students recruited from an introductory psychology course at a local university. Both participants were experimentally naive.

Apparatus

Sessions were conducted in a quiet room. Participants completed all sessions alone, other than the first few trials during initial instructions (see below). Participants sat at a table where an Apple Macintosh® Plus computer was located. The computer contained a built-in 22.9 cm black-and-white monitor and a computer mouse. Computer software (Dube, 1991) controlled all stimulus presentations, procedural sequences, and response recording. Stimuli for all three studies were the arbitrary forms shown in Figure 1. Stimuli will be referred to in the text by the alphanumeric codes in Figure 1, but these designations did not appear in the experimental displays.

Procedure

Matching-to-sample tasks. The participants' task was visual-visual two-choice simultaneous arbitrary MTS. Two MTS task formats were used: *Standard MTS* and *Contextual Control MTS.* Both formats are illustrated in Figure 2. A Standard MTS trial began with a stimulus displayed in the lower sample area of the computer screen (upper panel, a, Figure 2). A response was recorded when the participant moved the mouse cursor to any portion of the sample stimulus and pressed the

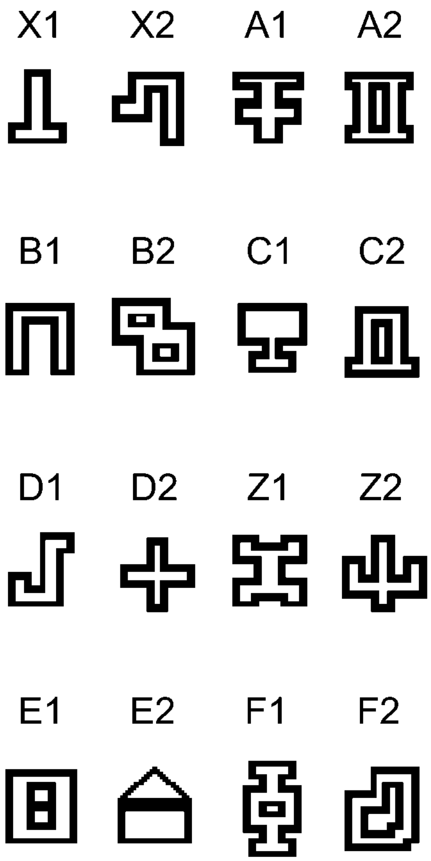

Fig. 1. Form stimuli (and their alphanumeric codes) presented to participants on computer screen across the three studies.

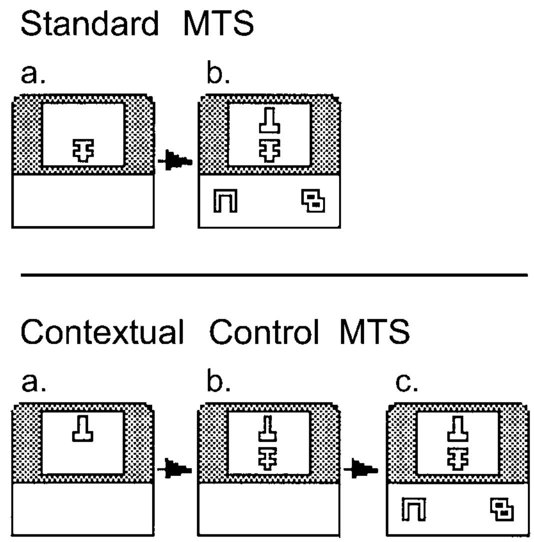

Fig. 2. Standard and contextual control matching-to-sample tasks. The upper panel shows standard matching to sample, in which a sample appears on the computer screen (a); a response to it produces comparison stimuli (b). The lower panel shows contextual control matching to sample, in which a contextual stimulus appears on the computer screen (a); a response to it produces a sample (b); a response to the sample produces the comparison stimuli (c).

mouse button. A response to the sample was followed by the presentation of two comparison stimuli; the sample stimulus remained on the screen (upper panel, b). A response was recorded when the participant moved the cursor to one of the comparison stimuli and pressed the button. Contextual Control MTS trials were identical to Standard MTS trials except that the trial began with the presentation of a stimulus in the upper portion of the sample area, and a response to the contextual stimulus was required for presentation of the sample (lower panel of Figure 2, a, b, and c). Within blocks of MTS trials, the same two stimuli appeared as comparisons across trials with different sample or sample and contextual stimulus combinations. Comparison stimuli alternated unsystematically between the left and right comparison positions.

Feedback. During *feedback* conditions, a response to a comparison stimulus designated correct was followed by the removal of all form stimuli, a flashing computer screen, a 10-note, 700-ms musical jingle, and a 1.5-s intertrial interval (ITI). A response to a comparison stimulus designated incorrect was followed by the removal of all form stimuli, a 1.5-s blackout, and a 1.5-s ITI. A correction procedure was in effect; following errors, the trial was repeated following the ITI. During *no-feedback* conditions, responses to comparison stimuli designated either correct or incorrect were followed only by the removal of all form stimuli and a 1.5-s intertrial interval, and there was no correction procedure.

Sessions. Sessions consisted of several blocks of 32 trials. Session duration was generally 35 to 55 minutes. Participants D.E. and J.S. each completed their participation in Studies 1 and 2 in a single session. At the end of their participation in the study, participants were paid a lump sum that amounted to $5 per session. Participants also received credit for a participant-participation requirement for their psychology course.

Pretraining. At the beginning of the first session, the following message was displayed on the computer screen:

> Your task is to make the correct selections. To make a selection, position the mouse arrow directly on the selection of your choice and press and release the button. When you make a CORRECT selection, you will hear some tones and the screen will flash. If you make an INCORRECT selection, the screen will go black and then the same trial will be presented over.
>
> Good luck, and do your best.
>
> Please follow all printed instructions that appear on the screen.
>
> Press mouse button to continue.

Participants were required to read the message aloud in the presence of the experimenter. Only questions about the operation of the mouse were answered by the experimenter.

To ensure that participants were able to perform the task using the mouse and mouse button, each was presented with 8 to 24 trials of an identity MTS task using the Standard MTS format and the A and B stimuli. The experimenter left the room prior to the beginning of the first AB training block.

Phase 1: Training. Each training block consisted of 32 trials. After each block, the following message appeared on the computer screen: ''Rest your eyes and fingers for a minute. When you are ready, press mouse button to continue.'' Training proceeded in three stages: (a) train AB with Standard MTS and feedback; B1 was designated correct in the presence of A1, and B2 was designated correct in the presence of A2; (b) train X-AB with Contextual Control MTS and feedback; A1B1 and A2B2 were correct in the presence of X1, and A1B2 and A2B1 were correct in the presence of X2; and (c) present X-AB trials with no feedback to verify continued accurate responding in preparation for blocks of test trials with no feedback. Prior to the third stage (c), the following message appeared on the screen:

> Now, you will not hear the tones or see the screen flash when you make a correct selection. Incorrect trials will not be presented over. Please continue to do your best.
>
> When you are ready . . . . . press mouse button to continue.

The criterion for advancing from one stage of training to the next was ≥90% correct for one 32-trial block.

Phase 2: Establish new conditional discrimination (CD). In this phase, a conditional discrimination was established via the unreinforced-conditional-selection procedure. CD stimuli (previously unrelated samples and comparisons) were presented in the Standard MTS format with *no feedback*. Without feedback to specify a contingency, participants could select either comparison in the presence of either sample. Successive 32-trial blocks were presented until participants demonstrated consistent conditional discrimination performance. Consistency was defined as selection of one comparison in the presence of one sample, and selection of the other comparison in the presence of the other sample, greater than 90% of the trials in a block, for one 32-trial block.

Phase 3: Test for generalized contextual control with X-CD. Participants were given blocks of X-CD test trials in Contextual Control MTS format with no feedback. Generalized contextual control would be shown if X1 controlled the CD selections that participants had made during Phase 2, and X2 controlled the opposite CD selections. Successive 32-trial testing blocks were presented until the proportion of participants' responses that were consistent with the predicted contextual control performance was ≥90% for one 32-trial block, or to a limit of three blocks.

Phase 4: Verification of original training. Following the test for generalized contextual control, the originally trained X-AB performance was verified in 16-trial blocks with no feedback, to a criterion of one 32-trial block at ≥90% correct.

Phase 5: Establish new conditional discrimination (EF). In this phase, a new conditional discrimination was established via the unreinforced-conditional-selection procedure. EF stimuli (previously unrelated samples and comparisons) were presented in the Standard MTS format with *no feedback*. Successive 32-trial blocks were presented until participants demonstrated consistent conditional discrimination performance for one 32-trial block.

Phase 6: Test for generalized contextual control with Z-EF. This test examined whether novel

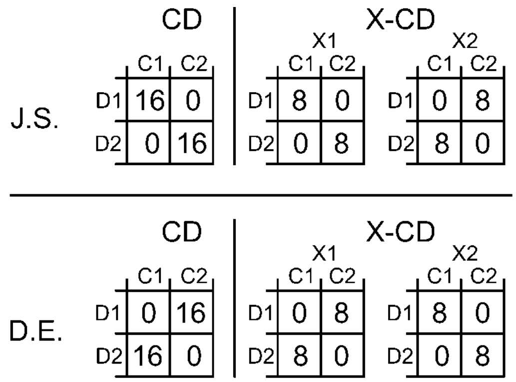

Fig. 3. Study 1 results of CD acquisition via the unreinforced conditional selection procedure (left matrices in the upper and lower portions of the figure) and the X-CD test for transfer of contextual control (right two matrices in the upper and lower portions of the figure) for participants J.S. and D.E. In the left matrices (labeled CD), column labels represent sample stimuli and row labels represent the comparison stimuli. In the right matrices (labeled X-CD), column and row labels also represent samples and comparisons, but each matrix represents CD responding in the presence of different contextual stimuli (X1 and X2). Numbers in the matrices indicate the number of responses to the respective sample-comparison or contextual-sample-comparison relations.

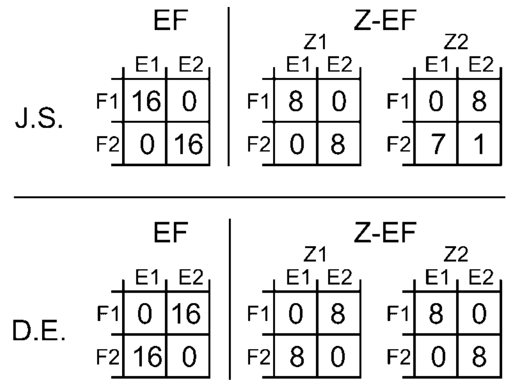

Fig. 4. Study 1 results of EF acquisition via the unreinforced conditional selection procedure (left matrices in the upper and lower portions of the figure) and the Z-EF test for transfer of contextual control (right two matrices in the upper and lower portions of the figure) for participants J.S. and D.E. In the left matrices (labeled EF), column labels represent sample stimuli and row labels represent the comparison stimuli. In the right matrices (labeled Z-EF), column and row labels also represent samples and comparisons, but each matrix represents EF responding in the presence of different contextual stimuli (Z1 and Z2). Numbers in the matrices indicate the number of responses to the respective sample-comparison or contextual-sample-comparison relations.

Z stimuli would exert contextual control over the EF relation that was established in the previous phase. Successive 32-trial testing blocks without feedback were presented until the proportion of participants' responses that were consistent with the predicted contextual control performance was ≥90% for one 32-trial block, or to a limit of three blocks.

Phase 7: Verification of original training. Following the Z-EF test, the originally trained X-AB performance was again verified in 32-trial blocks with no feedback, to a criterion of one block at ≥90% correct.

Results

Both participants met the learning criterion for X-AB baseline training with no feedback in six and three 32-trial blocks, respectively. Figure 3 shows the number of responses to each sample-comparison and contextual-sample-comparison stimulus presentation during CD and X-CD. Each participant showed consistent conditional selection with CD stimuli in Phase 2 within their first blocks of trials, though each participant selected different D comparisons in relation to the C samples (i.e., Participant J.S. selected D1 in the presence of C1 while Participant D.E. selected D2 in the presence of C1). During the Phase 3 test for contextual control, each maintained their original idiosyncratic CD performance in the presence of X1, and made the opposite CD selections in the presence of X2. Finally, each participant showed criterion performance when tested again for the original X-AB performance in Phase 4; Participant J.S. did so on the first test session, and Participant D.E. did so on the second X-AB test (not shown in Figure 3).

The data in Figure 4 show the results of Phases 5 and 6. Both participants showed consistent conditional selection with the EF stimuli in the first block of trials: Participant J.S. selected F1 in the presence of E1, and F2 in the presence of E2; and Participant D.E. selected F2 in presence of E1, and F1 in the presence of E2. Both participants also demonstrated generalized contextual control performance: They maintained their original EF conditional discrimination performance in the presence of one Z stimulus, but made the opposite EF selections in the presence of the other Z stimulus. Both participants were 100% correct in a single 32-trial block with the original X-AB relations (not shown in Figure 4).

Discussion

The participants demonstrated consistent conditional selection following arbitrary matching training. Results of the X-CD test showed that the contextual functions of the X stimuli acquired during training transferred to the new CD conditional discrimination even though the new samples and comparisons were not related by training to the AB samples and comparisons with which the contextual functions for the X stimuli had been established. Thus, this portion of the study replicated the findings from Pérez-González and Serna (2003). However, in a departure from Peréz-González and Serna, the results also showed generalized contextual control performance; control by the contextual stimuli (X) established during training (X-AB) generalized to novel stimuli (Z).

STUDY 2

In Study 1, participants demonstrated generalized Z-EF performance, given a history of both X-AB training and X-CD testing. It is not known, however, whether the X-CD testing was critical to the Z-EF emergence. This history may have been important for generating generalized performance because it established contextual control by the X stimuli with more than one conditional discrimination ''exemplar.'' Therefore, one purpose of Study 2 was to examine whether naive participants would demonstrate generalized contextual control on Z-EF tests merely from a history of X-AB training and EF unreinforced conditional selection, and without the X-CD testing history.

The second purpose of Study 2 was to examine some of the necessary and sufficient conditions for demonstrating generalized contextual control. In the previous studies, prior to tests for generalized contextual control (e.g., Z-EF), consistent responding to new conditional discriminations was first established (e.g., EF). Study 2 asked whether this step was necessary. To answer this question, Z-EF tests were presented to experimentally naive participants immediately following X-AB contextual control training without first establishing the AB conditional discrimination. Would these training conditions lead to generalized contextual control performance?

Method

Participants, Stimuli, and Apparatus

Six experimentally naive young adult participants served. Participant A.C. (m, 18 years old) was recruited from an introductory psychology course at a local university. Participants R.V. (m, 16), W.R. (m, 16), A.G. (female [f], 16), S.C. (m, 16), and L.W. (f, 17) were high school students participating in a summer research program in biochemistry at the Shriver Center. The apparatus was the same as in Study 1.

Procedure

Conditions. Participants were assigned to one of two conditions: *Condition 1, EF Training* or *Condition 2, No EF Training.* In Condition 1, the study proceeded in four phases, similar to the procedure of Study 2. Phase 1 consisted of contextual control training; that is, train AB with feedback, train X-AB with feedback, then present X-AB with no feedback. In Phase 2, participants were given MTS trials with novel samples and comparisons, EF, under no feedback conditions, until they demonstrated consistent conditional selection. In Phase 3, participants were given Z-EF tests for generalized contextual control with no feedback. As in Study 1, testing continued in each until participants demonstrated contextual-control performance on ≥90% of the trials in one 32-trial block. Finally, each participant was again tested under no-feedback conditions to verify the original X-AB performance. Condition 2 differed in that the EF conditional discrimination was not established.

Results

All 6 participants met the criterion for X-AB contextual control performance with no feedback, but at different rates. Participants A.C., R.V., W.R., and A.G. required three training blocks, S.C. required four training blocks, and L.W. required 10 training blocks.

During Z-EF tests, participants varied with regard to the number of exposures to the test blocks prior to reaching criterion consistency. Participants A.C., R.V., and W.R. demonstrated criterion performance within a single 32-trial test block. Participants A.G. and S.C. re-

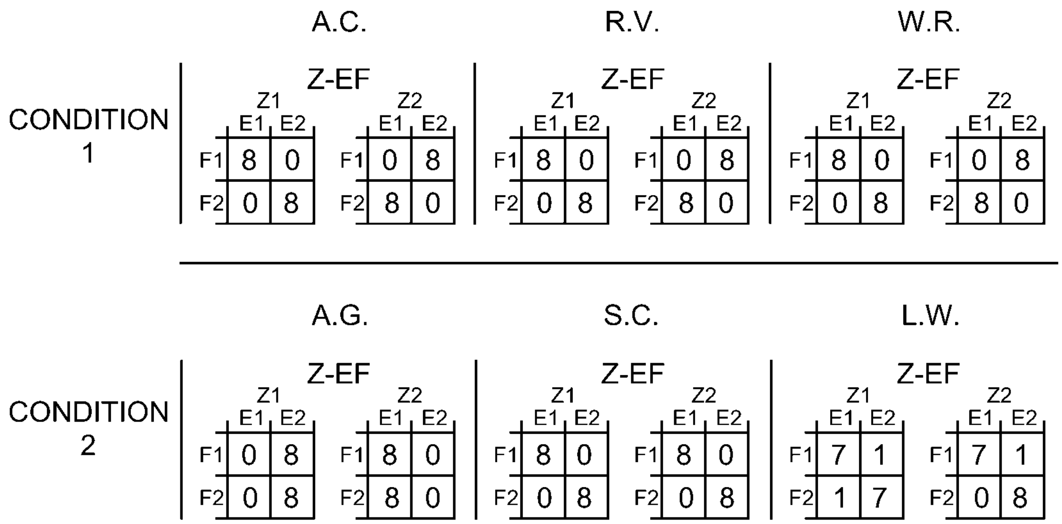

Fig. 5. Results for Participants A.C., R.V., W.R., A.G., S.C., & L.W. in Study 2. Numbers in the matrices indicate the number of responses to the respective sample-comparison or contextual-sample-comparison relations.

quired exposure to two Z-EF test blocks. Participant L.W. required three exposures to reach criterion performance.

Figure 5 shows the performance of each participant on the final block of Z-EF testing. Participants in Condition 1, in which the EF conditional discrimination was first established, demonstrated Z-EF performance consistent with contextual control while those in Condition 2 did not. All participants demonstrated contextual control performance when retested for the original X-EF performance under no-feedback conditions (not shown). Though participants in Condition 2 failed to demonstrate contextual control during the Z-EF test, their performance was nevertheless orderly and stable. Specifically, the lower half of Figure 5 shows that Participant A.G. selected F2 in the presence of Z1, and F1 in the presence of Z2, regardless of which sample, E1 or E2, was present. Participants S.C. and L.W. selected F1 in the presence of E1, and F2 in the presence of E2, regardless of which contextual stimulus, Z1 or Z2, was present.

Discussion

Study 2 showed that generalized contextual control (e.g., Z-EF control) did not require the additional X-CD testing performance. Also, the two conditions in Study 2 begin to define some of the necessary and sufficient conditions for establishing generalized contextual control performance in which all test stimuli are novel. The present study asked whether, given contextual control training, X-AB, participants would demonstrate Z-EF generalized contextual control without prior EF unreinforced conditional selection (Condition 2). During testing, all three Condition 2 participants failed to show Z-EF generalized contextual control. Instead, participants' selection of comparisons appeared to be conditional upon either the contextual stimuli or the samples, but not both. According to Sidman's (1986) analysis, this performance would be characterized as four-term contingency performance, rather than contextual control.

GENERAL DISCUSSION

The primary finding from these studies was that, following contextual control training, participants demonstrated both transfer of, and generalized, contextual control performance. First, in Study 1, training X-AB, then establishing CD, resulted in the emergence of X-CD; participants displayed immediate contextual control by the X stimuli over conditional discriminations that had no previous trained relation to the any of the stimuli in the original training. Second, Studies 1 and 2 showed that, following contextual control training (X-AB), novel stimuli (Z1 and Z2) in the same physical and temporal relation to samples and comparisons as the X stimuli exerted contextual control over new conditional discriminations (EF). Further, Study 2 showed that, under the conditions of the present study, samples and comparisons (EF) must first be related before generalized contextual control performance (Z-EF) will emerge.

In Study 1 of the present investigation, and in Peréz-González and Serna (2003), the initial contextual control training appeared to have established specific functions for the contextual stimuli. As shown in the latter portion of Study 1 and in Study 2, however, contextual control training seems to have engendered a broader kind of generalized contextual control as well. Results of the Z-EF tests suggest that the stimulus control basis for the original X-AB training can be described as, ''In the presence of one stimulus, the original conditional discrimination is in effect. In the presence of the other stimulus, the opposite conditional discrimination is in effect.'' For this rule to operate, an established conditional discrimination appears to be necessary, as shown by the different results of Conditions 1 and 2 in Study 2. Application of this rule likely would be more difficult without having first established a relation between samples and comparisons, as in Condition 1. These results are consistent with those of previous studies in which establishing baselines of contextual control of conditional discriminations was more readily accomplished when the conditional discriminations were taught first (Kennedy & Laitinen, 1988; Lynch & Green, 1991; Serna, 1987).

Study 2 provided some insight regarding the relation between MTS history and subsequent generalized contextual control. Nevertheless, questions remain. For example, would participants show generalized contextual control if their trained baseline history had been extended to include repeated exposure to different stimuli (e.g., AB and X-AB, GH and Y-GH, IJ and W-IJ)? Perhaps the contextual control training history for Study 2 participants was merely insufficient. Also, would participants demonstrate generalized contextual control (e.g., Z-EF) if the training history did not include exposure to conditional discriminations (e.g., AB) prior to the introduction of contextual control trials (e.g., X-AB)? It may be that training AB prior to X-AB facilitates the function of the contextual stimuli as ''original'' and ''opposite'' with regard to conditional discriminations. Otherwise, participants might have learned the four types of X-AB contextual control trials as merely four separate if–then rules, which likely would do little to promote generalized contextual control.

The present findings also extend the ways in which new contextual control performances can emerge. A number of studies have shown that once contextual control is established, contextual stimuli, samples, comparisons, or any combination of the three can be substituted with stimuli that have been made equivalent (e.g., Gatch & Osborne, 1989; Lynch & Green, 1991; Markham & Dougher, 1993; Peréz-González, 1994; Serna, 1991; Wulfert & Hayes, 1988). In each case, matching-to-sample procedures were used to relate new stimuli to the old either directly or via stimulus equivalence (Sidman & Tailby, 1982). For example (using the denotation system of the present study), Markham and Dougher first trained participants to respond to X-AB relations. They then trained participants to select C comparisons in the presence of B samples, BC. In tests for emergent performance, participants demonstrated X-AC. Thus, C stimuli effectively replaced B stimuli, presumably because of the relation established between B and C. What distinguishes the present studies is that participants demonstrated generalized contextual control performances with stimuli that had not been related by direct training, or explicit stimulus equivalence procedures, to those used in the original contextual control training. Similarly, X-AB led to Z-EF performance, in which none of the new stimuli had an explicitly trained relation with the original stimuli.

Though the original and test stimuli in the present studies were not related by training, either directly or through MTS training that gives rise to stimulus equivalence, as in previous studies, stimulus classes of a different nature likely played a role in generalized contextual control performances. Given X-AB training and Z-EF emergent performance, what is the relation between AB and EF? For example, could A and E stimuli be members of a stimulus class? It is possible that training procedures generated classes of contextual stimuli, classes of samples, and classes of comparisons, as suggested by Sidman, Kirk, and Willson-Morris (1985). Thus, A and E may be members of a "sample class," related by the physical location and temporal sequence common to all samples in the present studies. The same could also hold true for contextual and comparison stimuli. Once training and testing have been completed, stimuli within contextual, sample, or comparison classes may also prove functionally substitutable; that is, functionally equivalent (Goldiamond, 1962; Sidman, Wynne, Maguire, & Barnes, 1989). This notion would be an interesting line of future inquiry.

The generalized contextual control demonstrated in the present studies may best be described as instances of unreinforced conditional selection, but at the contextual-control level. Previous studies have shown that human participants who are first taught arbitrary MTS are likely to respond conditionally when presented with unrelated samples and comparisons (R. Saunders et al., 1988; Stromer, 1986, 1989; Williams et al., 1995). Given a history of contextual control of conditional discriminations (X-AB), participants responded in a manner consistent with contextual control when presented with new conditional discriminations that had not been previously related to the contextual stimuli (Z-EF). Thus, the present studies extend the four-term-level findings with unreinforced conditional selection to include even more complex conditional performances.

In a general sense, the derived relations demonstrated in the present studies can be accounted for by relational frame theory (Hayes, 1991, 1994; Hayes & Hayes, 1989). This theory posits that once a human has learned a relation among given stimuli, he or she is going to learn more easily to relate new stimuli with the same relation. The present studies showed that after contextual control training, the participants readily generalized this performance. Relational frame theory would say that the resulting generalized performances were in the same frame as those from the trained relations. Although there is nothing inconsistent about the present results and relational frame theory, the theory is too general and molar for an analysis of the underlying stimulus control processes under investigation in the present studies. Though such accounts may have their place in understanding stimulus control phenomenon (see McIlvane, Serna, Dube, & Stromer, 2000, for a discussion of this issue), questions about the nature of the stimulus control operating in contextual control performances are best answered through a more molecular analysis of the conditions under which such performances are or are not demonstrated. Traditional stimulus control accounts, such as Sidman's (1986, 1994, 2000) stimulus control hierarchy, provide a framework for such analyses.

Finally, it is worth noting the potential contribution of high school and college-aged participants in the present studies. Certainly the rich stimulus control histories established extraexperimentally in the participants played a role in the results. Though the present study population helps extend our knowledge of the characteristics of contextual control performance, we believe that research from a much younger population might also prove instructive. For example, future research involving younger subjects might provide insights into how children, for whom the first instances of contextual control were experimentally established, behave with regard to generalized contextual control performance.

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