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THE TRANSFORMATION OF CONSEQUENTIAL FUNCTIONS IN ACCORDANCE WITH THE RELATIONAL FRAMES OF SAME AND OPPOSITE

ROBERT WHELAN AND DERMOT BARNES-HOLMES

NATIONAL UNIVERSITY OF IRELAND, MAYNOOTH

Although the literature on reinforcement in behavioral psychology is extensive, few studies have examined the derived transformation of reinforcing functions in accordance with equivalence classes, and no published research has yet examined the derived transformation of consequential functions in accordance with nonequivalence relations. In the present study, which consisted of four experiments, the basic preparation was as follows. First, an arbitrary stimulus, B2, was established as a conditioned punisher, using direct stimulus pairing. Following nonarbitrary relational training, designed to establish SAME and OPPOSITE contextual cues, subjects were exposed to arbitrary relational training using these contextual cues to establish A1 as the same as B1 and C1, and as opposite to B2 and C2. Subsequently, C2 (based on its Same relation with B2) functioned as a punisher and C1 (based on its Opposite relation with B2) functioned as a reinforcer in a simultaneous discrimination task. Critically, the C1 stimulus acquired reinforcing functions, based on the derived relation of Opposite, although no such function had actually been established for any member of the network. Furthermore, these effects were observed across ABA reversals in the baseline contingencies.

Key words: consequential functions, relational frame theory, multiple stimulus relations, reversal design, mouse click, human adults

A fundamental tenet of behavior analysis is that responses are more or less probable because of the consequences that they produce. Consequential stimuli that occur contingent on responding and increase response probability are termed reinforcers, and consequential stimuli that occur contingent on responding and decrease response probability are termed punishers. The effectiveness of stimuli that result from contingent relations with other reinforcers or punishers (i.e., conditioned reinforcers and conditioned punishers) is particularly pertinent to the establishment and maintenance of human behavior. According to Williams (1994), ''the current consensus is that conditioned reinforcers acquire value in their own right because of Pavlovian conditioning'' (p. 261). Acknowledging that simple Pavlovian conditioning cannot account for the full range of human behavior, Williams invoked Pavlov's (1927) idea of a ''second signaling system,'' which is the major function of language and which produces mediated conditioning effects that maintain the relation between behavior and the primary reinforcer. Similarly, according to Skinner (1953), temporal gaps between responses and an unconditioned reinforcer are bridged by intervening conditioned reinforcers, and ''among the conditioned reinforcers responsible for the strength of [this] behavior are certain verbal consequences . . . '' (p. 77). It follows, therefore, that modeling the effect of ''verbal'' conditioned reinforcers in the behavioral laboratory may shed light on how behavior in the natural environment can come under the control of consequences that have not been directly paired with primary reinforcers or punishers.

There is an extensive literature on reinforcement and punishment, and Dinsmoor (2001) recently separated behavior-analytic research in this area into two broad approaches: one that he grouped under ''two-factor'' or ''two-process theory,'' and the other that he called ''single-process'' or ''shock-density-reduction theory'' (p. 311). Although these theories of reinforcement and punishment differ in terms of the emphasis that they place on molar versus molecular analyses, they both appeal to differential

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Correspondence and requests for reprints should be sent to Robert Whelan at the Psychology Department, National University of Ireland, Maynooth, County Kildare, Ireland (e-mail: robert.a.whelan@may.ie).

correlations between unconditioned and conditioned reinforcers as a means of explaining how the latter are established and maintained. Research in the derived stimulus relations paradigm suggests, however, that such correlations, at either a molar or molecular level (as traditionally defined), are not necessary in order to establish a conditioned reinforcer or punisher, at least in verbally able humans.

If a verbally capable human subject is trained, in a matching-to-sample context, to match A to B and B to C, he or she will also likely match B to A (mutual entailment), and A to C and C to A (combinatorial entailment) without reinforcement (see Fields, Adams, Verhave, & Newman, 1990; Sidman, 1992). A further aspect of derived relational responding concerns *transformation of function,* in which functions of related stimuli may be altered in accordance with the underlying derived relation. In this way, stimuli may acquire control over behavior in the absence of direct training (Dougher & Markham, 1994; Hayes, 1991). The transformation of functions in accordance with equivalence relations has been demonstrated with discriminative, self-discriminative, respondent eliciting, extinction, sexual arousal, avoidance evoking, and consequential functions in adults, children, and developmentally disabled individuals (e.g., Barnes & Keenan, 1993; Dougher, Auguston, Markham, Greenway, & Wulfert, 1994; Wulfert & Hayes, 1988).

Hayes, Kohlenberg, and Hayes (1991) examined the transformation of consequential functions (both reinforcement and punishment) in accordance with three-member equivalence classes, demonstrating that consequential functions given to one member of an equivalence class emerged for the other members of that class. The basic procedure was as follows. The stimulus B1 was established as a conditioned reinforcer and B3 was established as a conditioned punisher. Next, subjects were presented with a series of conditional discriminations (A-B then A-C) and subsequent testing for symmetry (e.g., B-A) and equivalence responding (e.g., C-A). Having passed these tests, subjects were exposed to the transformation of consequential functions test, in which C1 and C3 were used as feedback in a sorting task. Eight of 9 subjects exposed to this procedure demonstrated the predicted transformation of consequential control for the C stimuli, based on their equivalence relations to the B stimuli (i.e., C1 functioned as a reinforcer and C3 as a punisher). Hayes et al. conducted subsequent experiments that replicated and extended this basic effect.

Since Hayes et al.'s (1991) research, several studies have provided empirical evidence that it is possible for human subjects to respond in accordance with relations other than equivalence. For example, subjects can be trained to respond in accordance with a variety of derived stimulus relations, including; Same, Opposite, and Different (Dymond & Barnes, 1996; Roche & Barnes, 1996, 1997; Roche, Barnes-Holmes, Smeets, Barnes-Holmes, & McGeady, 2000; Steele & Hayes, 1991; Whelan, 2002), More-than and Less-than (Dymond & Barnes, 1995; O'Hora, Barnes-Holmes, Roche, & Smeets, 2002; see also Y. Barnes-Holmes et al., 2001), and Before and After (D. Barnes-Holmes, Hayes, Dymond, & O'Hora, 2001). These nonequivalence relations are frequently referred to generically as *multiple stimulus relations* (see Hayes & Barnes, 1997). Parenthetically, when discussing specific relations, the initial letter is capitalized (e.g., a Same relation); when discussing a contextual cue, the entire word is capitalized (e.g., a SAME contextual cue).

Multiple stimulus relations, or relational frames, are defined by different behavioral patterns, and studies on relational frame theory (RFT) require procedural controls in order to support specific conclusions concerning the nature of the relational frames involved. For example, equivalence always yields the same derived relations across pairs of stimuli in a set (i.e., if A is equivalent to B and B is equivalent to C, then A and C are also equivalent). Opposition and difference do not, however, always yield the same relations among members within a set. In the former case, if A is the opposite of B and B is the opposite of C, then A and C are the same, not opposite. In the latter case, if A is different from B and B is different from C, then the relation between A and C remains unspecified (i.e., A and C could either be the same, different, or opposite; see also Roche & Barnes, 1996). This is an important issue in the context of the present research.

To date, there has been no published ex-

perimental analysis of the transformation of consequential functions in accordance with multiple stimulus relations. Given the importance attached to the role of consequences in behavior analysis, the systematic investigation of the derived transformation of consequential functions would seem to be called for. Indeed, this research may help us to understand the perhaps complex behavioral processes involved in establishing conditioned reinforcers or punishers in verbally able humans. If a child were told, for example, that a newly available candy bar tastes awful, and the child was also told that awful was the opposite of nice, the new candy bar may fail to function as a reinforcer because it now participates in a frame of opposite with directly experienced ''nice-tasting'' candy bars.

The aim of the present study was to determine if consequential functions would be transformed in accordance with Same and Opposite relations, using procedures broadly similar to those developed by Steele and Hayes (1991) and Dymond and Barnes (1996). Subjects were first exposed to a stimulus-pairing component designed to establish a stimulus as a punisher that was subsequently incorporated into a network of Same and Opposite relations. Next, subjects' responses to nonarbitrary stimulus relations of Sameness and Opposition were brought under contextual control. Specifically, subjects were trained to relate physically same stimuli (e.g., a short line with a short line) in the presence of a SAME cue (in the actual experiment the cues were arbitrary stimuli, not relational words), and physically opposite stimuli (e.g., a long line with a short line) in the presence of an OPPOSITE contextual cue. Subjects were then trained on a series of conditional discriminations with arbitrary stimuli, with each discrimination being made in the presence of one of the two contextual cues. The aim of this phase was to establish responding in accordance with relations of Sameness and Opposition between the experimental stimuli (i.e., to establish A1 as the same as B1 and C1, and as opposite to B2 and C2). Subjects were then tested to determine if the punishing functions would transform in accordance with the relational network, such that a stimulus in a relational frame of opposition with a conditioned punisher would function as a conditioned reinforcer. The present research also employed ABA reversal designs because no published study has yet reported the use of this methodology in the analysis of multiple stimulus relations.

GENERAL METHOD

Subjects

Sixteen subjects (age range 17 to 22 years) began the experiments. Subjects were recruited either through personal contacts or notice-board advertisements. None of the subjects in Experiments 1 to 3 were paid for their participation; subjects in Experiment 4 were paid €40 (approximately $40 US at the time of the experiment), contingent on completing the experiment. Of the 11 who completed the experiments, Subjects 1 and 4 were high school students, Subjects 2 and 3 were psychology undergraduates, Subjects 8, 10, and 11 were undergraduate students in disciplines other than psychology, and Subjects 5, 6, 7, and 9 were postgraduate students in disciplines other than psychology. None of the subjects reported having any prior knowledge of RFT, or the stimulus equivalence literature more generally.

Apparatus and Setting

Subjects were seated at a table in an experimental room containing an Apple Macintosh™ iBook computer with a 12.1 in. (30.73 cm) display. Stimuli were presented and responses were recorded using a custom program written using the application Psyscope (Cohen, MacWhinney, Flatt, & Provost, 1993; see also Roche, Stewart, & Barnes-Holmes, 1999). All responses were made by moving and clicking a Macintosh™ optical mouse.

General Procedure

The procedure consisted of four initial phases followed by one or more reversals, in which some of the stimulus relations established during the initial phases were reversed. The purpose of these reversals was to demonstrate clear within-subject experimental control over the derived stimulus relations and transformation of functions observed within the study. Subjects were trained and tested individually during sessions that lasted between 45 and 90 min each. If a subject did not complete the experiment in one session

then he or she was asked to return on a subsequent day (usually the following day). The maximum number of sessions required to complete the experiment was two. To ensure that the previously established performances were still intact, at the beginning of the next session the subject was reexposed to those phases of the experiment that he or she had previously completed. When the experiment was finished, each subject was thanked and fully debriefed.

In Experiments 1 to 3, subjects who failed to reach criterion within four exposures to a preliminary training phase (Phase 3, described below) were dropped from the experiment and their results are not discussed here. In Experiment 4, subjects were exposed to Phase 3 until they reached criterion.

EXPERIMENT 1

Procedure

As an aid to the reader, Figure 1 displays diagrammatic representations and brief descriptions of the typical experimental tasks that were presented during the four phases.

Phase 1: Establishing consequential functions. The aim of this phase was to establish, and test for, the consequential functions of two arbitrary shapes (A1 and X1). Phase 1 was composed of four blocks; each block consisting of six trials of stimulus pairing followed by eight trials of simultaneous discrimination probe trials. The stimulus-pairing procedure involved pairing A1 with the loss of points and X1 with the gain of points (note that X1 was not subsequently included in the relational network). Within each six-trial block, A1 was presented twice and X1 was presented four times in a quasi-random order. X1 was presented twice as often as A1 so that the number of points gained by the end of the phase would be greater than at the beginning of the phase. Pilot studies indicated that subjects tended to ignore the pairing procedure if at least some points were not accrued by the end of the phase. The number of points won or lost on any particular trial was one, two, or three, and was chosen at random by the computer program. Subjects were given feedback on their overall scores every four trials, on average. If the subject pressed any key during a stimulus-pairing trial, the computer screen color turned from dark green to blue for 10 s, and the phrase ''ILLEGAL RESPONSE'' appeared in white letters in the middle third of the screen; key presses by the subject during this timeout did not have any effect. When the 10-s timeout was completed, the subject was exposed to the same trial again. The overall scores, if they appeared, were in the top left corner of the screen and were preceded by the words ''YOUR SCORE:''. The following instructions were presented to subjects at the beginning of Phase 1.

> Your task during this phase of the experiment is to earn as many points as possible. You will only receive feedback on your overall score during certain trials of this phase. The computer will determine when the scores will be shown. During the other trials you will have to make your best guess about what is the right thing to do to earn maximum points.

At the beginning of each stimulus-pairing trial, the screen was blank except for the top right-hand corner, which contained the phrase ''YOU CANNOT PRESS NOW.'' Three seconds after the start of a trial, an arbitrary shape (the putative CS+ or CS−) appeared in the center of the screen for 1.5 s, after which the center of the screen went blank for 0.5 s. Immediately thereafter, the phrase ''YOU HAVE WON X POINTS!'' or ''YOU LOSE X POINTS!'' appeared in the center of the screen, with X a randomly generated integer between one and three.

Immediately following the six trials of stimulus pairing, subjects were exposed to eight simultaneous discrimination probe trials that used A1 and X1 as differential consequences. Responses during this task had no effect on the subjects' scores (subjects were not told this), and scores were never presented to the subject during simultaneous discrimination trials. On the top right of the screen was the phase ''CLICK ON A WORD TO CHOOSE IT.'' On the bottom left and the bottom right of the screen there were 2 three-letter nonsense words: these positions were counterbalanced randomly across trials. Clicking on one of the nonsense words was consequated with the A1 stimulus, which appeared in the middle of the screen for 2 s. Similarly, clicking on the other nonsense word produced X1 as a consequence. The aim of these simultaneous

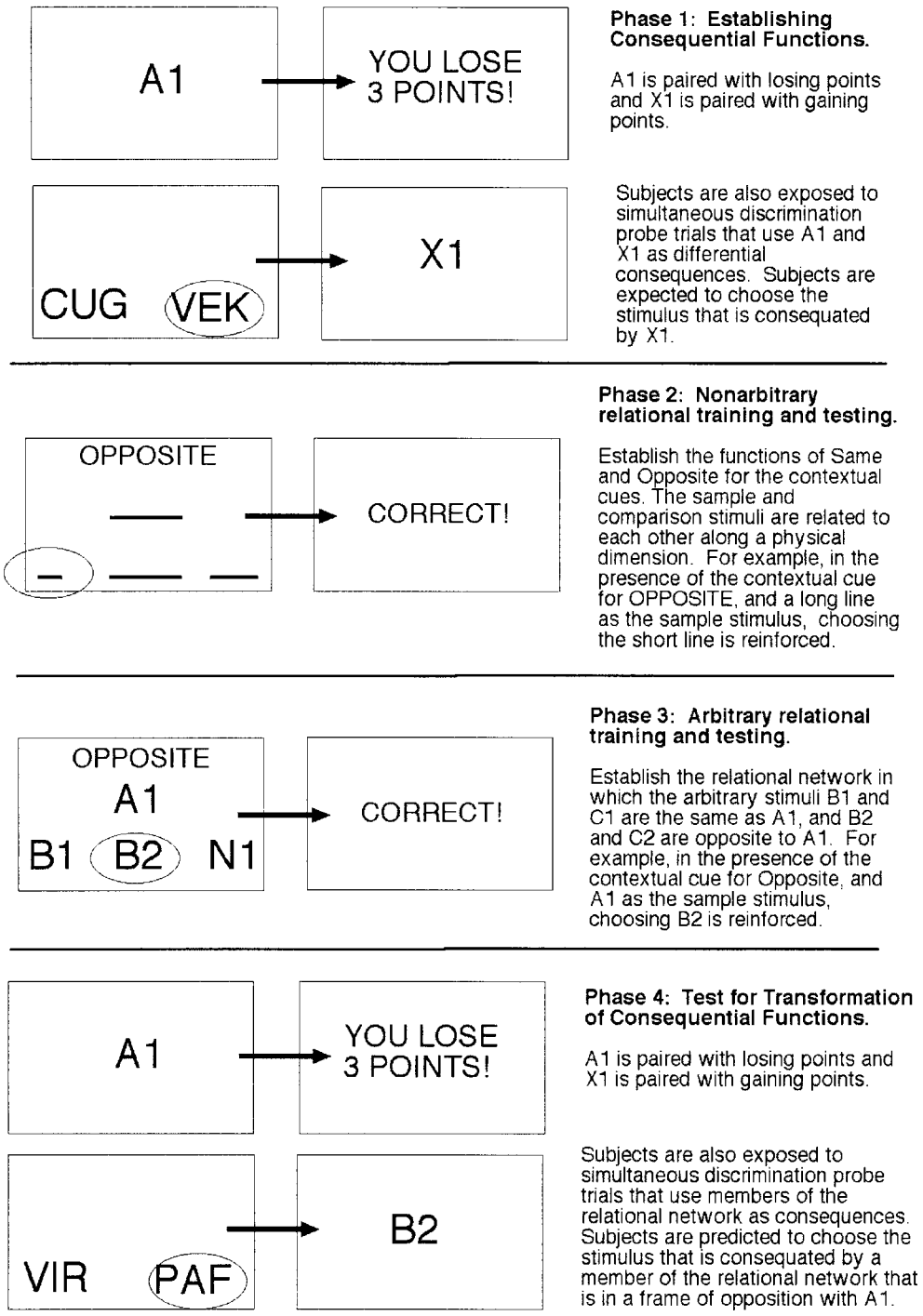

Fig. 1. Diagrammatic representations and brief descriptions of the typical experimental tasks that were presented during the four phases. The figures on the left are representative of the tasks that appeared on the computer screen. The arrow indicates that the screen on the right followed the screen on the left. The experimenter-designated correct choice is indicated by a circle. Experimental stimuli are labeled using alphanumerics and the contextual cue is denoted by the English word "OPPOSITE" for the sake of clarity—subjects were not exposed to these labels.

discrimination probe trials was to determine if A1 and X1 had become effective as punishers and reinforcers, respectively, based on their prior pairing with point loss and point gain. After eight simultaneous discrimination trials, the second block commenced and subjects were reexposed to six trials of stimulus pairing before returning again to the simultaneous discrimination task, in which the same two discriminative stimuli were employed. After four blocks of stimulus pairing and simultaneous discrimination testing, the phrase "THANKS—PLEASE CONTACT THE EXPERIMENTER NOW" appeared in the middle of the screen in yellow letters. When the subject reported to the experimenter, he or she was asked to remain outside the experimental room while the data were checked. In order to reach criterion for this phase, subjects were required to choose the stimulus that produced X1 across at least the final 10 trials of the simultaneous discrimination task before proceeding to Phase 2.

Phase 2: Nonarbitrary relational training and testing. The aim of this phase was to establish the functions of SAME and OPPOSITE for the contextual cues that were to be used in the arbitrary relational training and testing phases (Phase 3). The contextual cues were arbitrary shapes, but the sample and comparison stimuli used during Phase 2 were related to each other along a physical dimension. For example, one set of stimuli in this phase consisted of a long line, a medium-length line, and a short line. Thus if the subject was presented with the contextual cue for OPPOSITE, and the sample stimulus was a short line, then choosing the long line was reinforced; if the subject was presented with the contextual cue for SAME, and the sample stimulus was a short line, then choosing the short line was reinforced. The sample stimuli were either one of the two endpoints of the stimulus sets (e.g., the short or the long line). The other sets of stimuli in Phase 2 consisted of light, medium, and dark squares; six sets of three arbitrary geometric shapes that, within sets, were either small, medium or large in size; and two sets of stimuli derived from clip-art pictures enclosed by a rectangular border (one, three, and six ducks; small, medium, and large pencils). Subjects were trained across a maximum of six sets and tested (without differential feedback) across the four remaining sets until they reliably demonstrated appropriate contextual control by the SAME and OPPOSITE cues (see Dymond & Barnes, 1996, for a detailed description of this procedure).

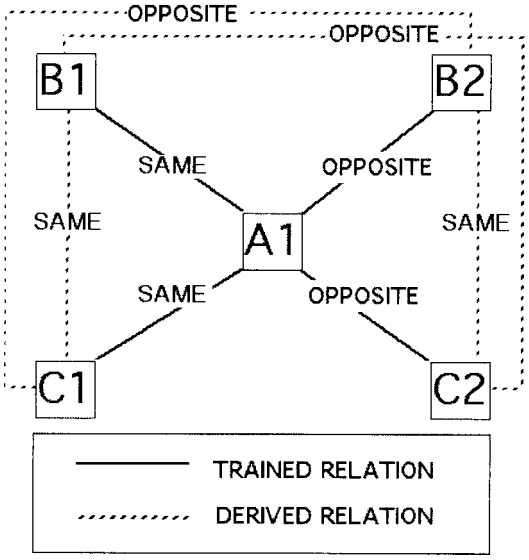

Fig. 2. The relational network that was established in the baseline condition for all subjects.

Phase 3: Arbitrary relational training and testing. Immediately following Phase 2, subjects were exposed to arbitrary relational training. The aim of this phase was to establish a relational network in which the arbitrary stimuli B1 and C1 were the same as A1, and B2 and C2 were opposite to A1 (see Figure 2). The contextual cues were the same as those used in Phase 2. All sample and comparison stimuli used in the relational training phase were novel arbitrary geometric shapes, with the exception of A1, which had been presented in Phase 1. Different stimuli were used as samples or as comparison stimuli for each subject. For ease of presentation, these stimuli are labeled using alphanumerics (A1, B1, B2, C1, C2, N1, N2, N3, N4, Z1, Y1, Y2, Y3, and Y4), but subjects were not exposed to these labels.

Match-to-sample (MTS) probes for arbitrary relational training and testing are described using the following convention: The contextual cue is given first in capitals, followed by the sample stimulus, followed by the three comparison stimuli in brackets. The experimenter-designated correct comparison is

in italics. For example, the notation SAME/A1-[*B1*-B2-N1] indicates that in the presence of the contextual cue SAME and the sample stimulus A1, selecting B1 was reinforced. All subjects were presented with the following training trial types: SAME/A1-[*B1*-B2-N1], SAME/A1[*C1*-C2-N2], OPPOSITE/A1-[B1-*B2*-N1], OPPOSITE/A1-[C1-*C2*-N2], SAME/Z1-[*Y1*-B1-N3], SAME/Z1[*Y2*-C1-N4], OPPOSITE/Z1-[*Y3*-B2-N3], and OPPOSITE/Z1-[*Y4*-C2-N4]. Training occurred in blocks of eight trials, with each of eight trial types presented once per block. The subjects were required to choose the correct comparison across 10 consecutive trials before being exposed to arbitrary relational testing.

The aim of arbitrary relational testing was to determine if responding in accordance with the derived relations of Sameness and Opposition would emerge during nonreinforced MTS probes. The test trial types were as follows: SAME/B1-[*C1*-C2-N2], SAME/B2[C1-*C2*-N2], OPPOSITE/B1-[C1-*C2*-N2], and OPPOSITE/B2-[*C1*-C2-N2] (Z1, Y1, Y2, Y3, Y4, N1, N3, and N4 were not presented to the subjects during arbitrary relational testing). Responding in accordance with the predicted relational network required that subjects would (a) choose C1 given B1 in the presence of SAME (C1 and B1 are both the same as A1 and therefore the same as each other); (b) choose C2 given B2 in the presence of SAME (C2 and B2 are both opposite to A1 and therefore the same as each other); (c) choose C2 given B1 in the presence of OPPOSITE (C2 is opposite to A1, and B1 is the same as A1, and therefore C2 is opposite of B1); and (d) choose C1 given B2 in the presence of OPPOSITE (C1 is the same as A1, and B2 is opposite to A1, and therefore C1 is opposite to B2). Testing occurred in a block of 16 trials, with each of the four tasks presented four times in quasi-random order. If subjects did not demonstrate the predicted performance on all of the trials for each trial type, they were reexposed to the relational training and testing sequence up to a maximum of four times. Figure 3 presents a diagrammatic representation of the procedure employed for Subjects 1 to 3.

Phase 4: Test for transformation of consequential functions. The aim of this phase was to determine whether B1, B2, C1, and C2 would function as differential consequences in a simultaneous discrimination task. Phase 4 was broadly similar to Phase 1 in that it contained both simultaneous discrimination and stimulus-pairing trials. There was no feedback regarding ''scores'' during this phase. The following instructions were presented to subjects at the beginning of Phase 4.

> Your task during this phase of the experiment is to earn as many points as possible. You will have to make your best guess about what is the right thing to do to earn maximum points.

As in Phase 1, A1 was paired with point loss and X1 with point gain. Unlike Phase 1, however, these two trial types were not presented in separate blocks. Instead, both trial types were presented in blocks of five, in which the first trial involved stimulus pairing, and the next four trials were simultaneous discrimination probes. Thus, in this phase, subjects were presented with a total of 32 simultaneous discrimination probe trials, interpolated with eight stimulus-pairing trials.

For the simultaneous discrimination probe trials, B1, B2, C1, and C2 (rather than A1 and X1) were used as consequences. Two novel nonsense words were used as discriminative stimuli in the simultaneous discrimination task. A transformation of functions in accordance with the relational network predicts that subjects should demonstrate a preference for the stimulus that produces B2 and C2 as consequences, rather than B1 and C1, because the former stimuli participate in a frame of Opposition with the conditioned CS− (i.e., A1). If a subject failed to demonstrate the predicted transformation of consequential functions, then he or she was reexposed to Phases 1 through 4.

Reversal 1. The aim of Reversal 1 was to examine if a change in the baseline contingencies would correspond to a change in the performances in the transformation of consequential functions test. During this phase, subjects were reexposed to Phases 2 through 4, but during the arbitrary relational training phase the contextually controlled MTS tasks were altered in order to reverse the relations of Same and Opposite among certain stimuli within the network. Specifically, the contextual cues in four of the relational training trials were reversed; SAME/A1-B1 became OPPOSITE/A1-B1, SAME/A1-C1

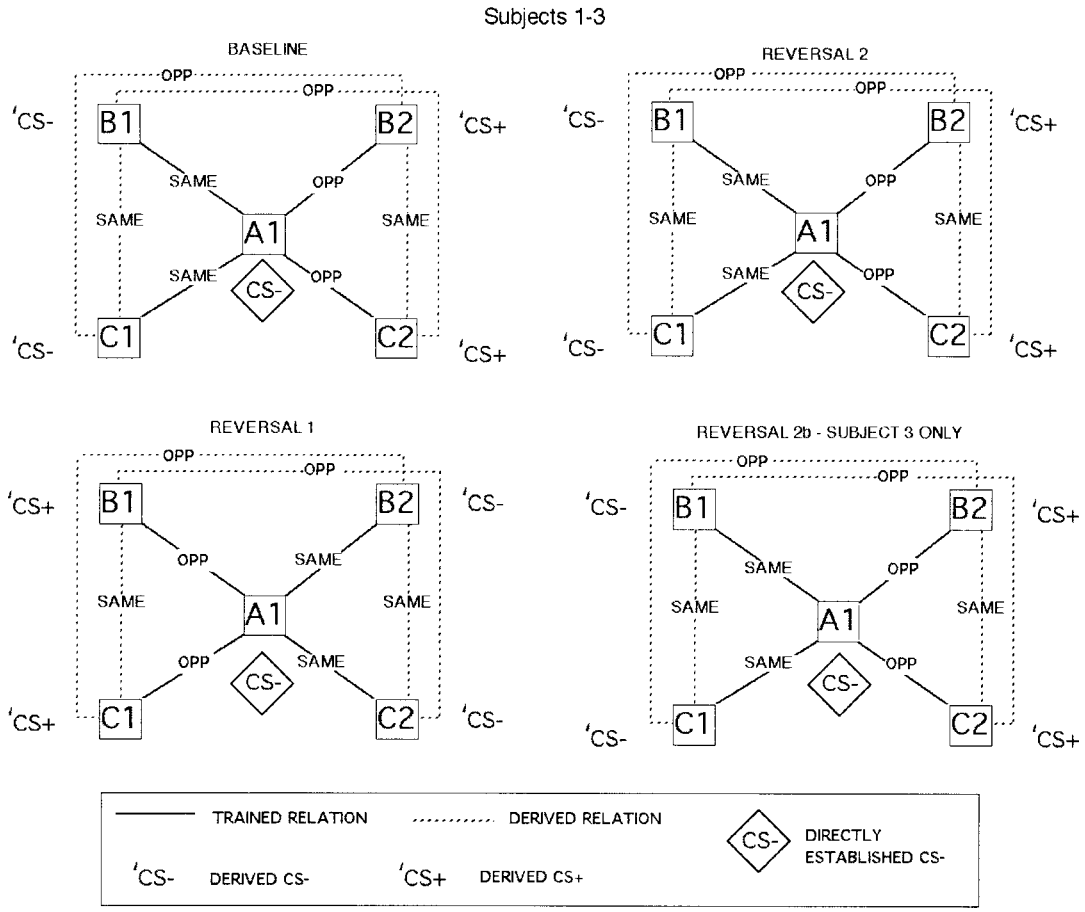

Fig. 3. Overview of the procedure for Subjects 1 to 3 (Experiment 1), displaying the trained and tested relational networks in the Baseline, Reversal 1, Reversal 2, and, in the case of Subject 3, sham reversal conditions.

became OPPOSITE/A1-C1, OPPOSITE/A1-B2 became SAME/A1-B2, and OPPOSITE/A1-C2 became SAME/A1-C2. Subjects were not informed that this reversal training was to be introduced. The details of the reversal procedure differed across subjects; variations will be described within the context of the Results. A subject who did not produce the predicted performance during reexposure to Phase 2, 3, or 4 was reexposed to that phase again. Two novel nonsense words were used as discriminative stimuli in the simultaneous discrimination task.

Reversal 2. Reversal 2 was similar to Reversal 1, except that subjects were reexposed to the original arbitrary relational training during Phase 3. Two novel nonsense words were used as discriminative stimuli in the simultaneous discrimination task. One possible outcome of this reversal procedure is that the consequential functions of the B and C stimuli reverse, not as a function of the change in the arbitrary relational training contingencies, but rather as a result of reexposure per se to earlier phases in the experiment. That is, because contingent recycling of training and testing was employed when subjects failed to produce predicted performances, it could be argued that returning a subject to Phase 2 at the beginning of a reversal was discriminative for altering the previously produced response pattern. To control for this possibility, an ABAA "sham" reversal design was employed for Subject 3. If reexposure alone functioned as a discriminative stimulus for reversing the previous response pattern, then a second exposure to the A condition should produce a reversal in the consequen-

Table 1

The column on the right presents data for Subjects 1 to 3 in Phase 4 of Experiment 1. The relation obtained between A1, the direction established CS−, and each stimulus in the relational network is also displayed. Subjects were expected to chose the stimulus that was consequated by the presentation of a member of the relational network that was in a frame of opposition with A1.

Experiment 1								
			Mutually entailed		Combinatorially entailed		Phase 4: % of trials selected	
Subject	Condition	Direct CS−	Same	Opposite	Same	Opposite	B1/C1	B2/C2
1	Baseline	A1	B1 C1	B2 C2	—	—	0	100
	Reversal 1	A1	B2 C2	B1 C1	—	—	94	6
	Reversal 2	A1	B1 C1	B2 C2	—	—	0	100
2	Baseline	A1	B1 C1	B2 C2	—	—	0	100
	Reversal 1	A1	B2 C2	B1 C1	—	—	100	0
	Reversal 2	A1	B1 C1	B2 C2	—	—	3	97
3	Baseline	A1	B1 C1	B2 C2	—	—	0	100
	Reversal 1	A1	B2 C2	B1 C1	—	—	97	3
	Reversal 2	A1	B1 C1	B2 C2	—	—	3	97
	Sham reversal	A1	B1 C1	B2 C2	—	—	0	100

tial functions, although there is no change in the relational training contingencies.

Results and Discussion

Five subjects began Experiment 1. Two subjects failed to reach criterion within four exposures to Phase 3. These subjects were excluded from further participation in the study, and their data are not presented.

All 3 subjects passed Phase 1 (establishing consequential functions) and Phase 2 (nonarbitrary relational training and testing) on their first exposures. For example, Subject 1 produced 30 out of 32 correct responses in Phase 1, required 25 training trials, and then produced 10 out of 10 correct test responses during Phase 2. During Phase 3 (arbitrary relational training and testing), Subject 1 required four cycles and Subject 2 required two cycles of arbitrary relational training and testing (see Appendix for details). Subject 3 was exposed to three cycles of arbitrary relational training and testing, and on the third cycle only responded correctly across 7 of 16 test trials, and the session was terminated at this point. The subject returned the next day and passed Phases 1 through 3 on his first exposures to each.

During Phase 4, the transformation of consequential functions test, all 3 subjects demonstrated the predicted transformation of functions. Specifically, the responding of all 3 subjects came under the consequential control of the B2 and C2 stimuli, which were in frames of Opposite with the directly established CS−; each subject produced 100% relation-consistent responding (see Table 1).

In Reversal 1, all 3 subjects were exposed to Phases 2, 3, and 4 again, but the contextual cues in four of the relational training trials (in Phase 3) were reversed; SAME/A1-B1 became OPPOSITE/A1-B1, SAME/A1-C1 became OPPOSITE/A1-C1, OPPOSITE/A1-B2 became SAME/A1-B2, and OPPOSITE/A1-C2 became SAME/A1-C2. All subjects passed Phase 2 on their first exposures. Subjects 1 and 2 required two exposures to Phase 3, and Subject 3 required three exposures to Phase 3.

In the test for transformation of consequential functions, Phase 4, in Reversal 1, the responding of all 3 subjects came under the consequential control of the B1 and C1 stimuli, which were now in frames of Opposite with the directly established CS−. Specifically, Subject 1 produced 94% relation-consistent responding, Subject 2 produced 100% relation-consistent responding, and Subject 3 produced 97% relation-consistent responding.

For Reversal 2, the subjects were again exposed to Phases 2, 3, and 4; but the original contingencies for the relational training were reinstated. All 3 subjects passed Phases 2 and 3 on their first exposures. In the test for transformation of consequential functions, Phase 4, in Reversal 2, the responding of all 3 subjects came under the consequential control

of the B2 and C2 stimuli, which were again in frames of Opposite with the directly established CS−. Specifically, Subject 1 produced 100% relation-consistent responding, and Subjects 2 and 3 produced 97% relation-consistent responding.

Subject 3 was exposed to the sham reversal. This subject passed Phases 2 and 3, and produced relation-consistent responding on 100% of trials in Phase 4, the test for transformation of consequential functions.

All subjects in Experiment 1 who met the mastery criterion on the relational test phase successfully completed all tests for transformation of consequential functions (i.e., including both Reversals 1 and 2, and in the case of Subject 3, a sham reversal) in accordance with the mutually entailed relations of Same and Opposite.

EXPERIMENT 2

Experiment 1 apparently demonstrated a transformation of consequential functions in accordance with the mutually entailed relations of Same and Opposite. However, from the perspective of RFT it is necessary to demonstrate more complex patterns of responding, because without combinatorial entailment it is not possible to distinguish clearly among relational frames. In the case of the relations of Same and Opposite, for example, the mutually entailed relations are both symmetrical (i.e., if A1 is the same as B1, then B1 is the same as A1; and if A1 is opposite to B1, then B1 is opposite to A1). Distinct patterns only emerge at the level of combinatorial entailment (e.g., if B2 is opposite to A1, and A1 is opposite to C2, then B2 and C2 are the same, not opposite). Experiment 2 sought to investigate the transformation of consequential functions in accordance with combinatorially entailed Same and Opposite relations.

The relational network that was trained and tested during baseline in Experiment 2 was the same as in Experiment 1 (see Figure 2). In Experiment 2, however, B1, rather than A1, was established as a conditioned punisher. Subjects were subsequently tested to determine if this punishing function would be transformed in accordance with the network; if so, C2 should function as a conditioned reinforcer, and C1 as a conditioned punisher.

Procedure

As an aid to the reader, Figure 4 displays a diagrammatic representation of the procedures employed for Subjects 4 and 5. The procedure in Experiment 2 was similar to that employed in Experiment 1, except for the following details. In Phase 1, B1, rather than A1, was established as a conditioned punisher by pairing it with the loss of points. Phases 2 and 3 were identical to Experiment 1. In Phase 4, the transformation of consequential functions test, only C1 and C2 (i.e., not B1 and B2) were used as consequences. During Reversal 1, for Subject 4 the contextual cues in two of the relational training trials were reversed; SAME/A1-B1 became OPPOSITE/A1-B1, and OPPOSITE/A1-B2 became SAME/A1-B2. Altering the contextual cues in this way reversed the functions of SAME and OPPOSITE between A1 and B1, and A1 and B2; B1 was now the same as C2, and B2 was the same as C1.

An additional control measure was introduced for Subject 5. During Reversal 1, the contextual cues in four of the relational training trials were reversed; SAME/A1-B1 became OPPOSITE/A1-B1, SAME/A1-C1 became OPPOSITE/A1-C1, OPPOSITE/A1-B2 became SAME/A1-B2, and OPPOSITE/A1-C2 became SAME/A1-C2. Reversing the contextual cues across all four tasks renders the derived combinatorially entailed relations that should emerge in Reversal 1 identical to those that emerged prior to the reversal. In other words, Subject 5 should produce the same performance, both before and after Reversal 1, even though the contextual cues have been altered across the training tasks. If this pattern emerged, it would demonstrate that the reversal performances are a function of the *specific* relations that are trained and tested across reversals, and not a generalized response to *any* change in the contextual cues.

Reversal 2 was identical to Experiment 1 for Subjects 4 and 5 (i.e., subjects were reexposed to the original relational training during Phase 3).

Results and Discussion

Three subjects began Experiment 2. One subject failed to produced relation-consistent responding within four exposures to the relational training and testing procedures

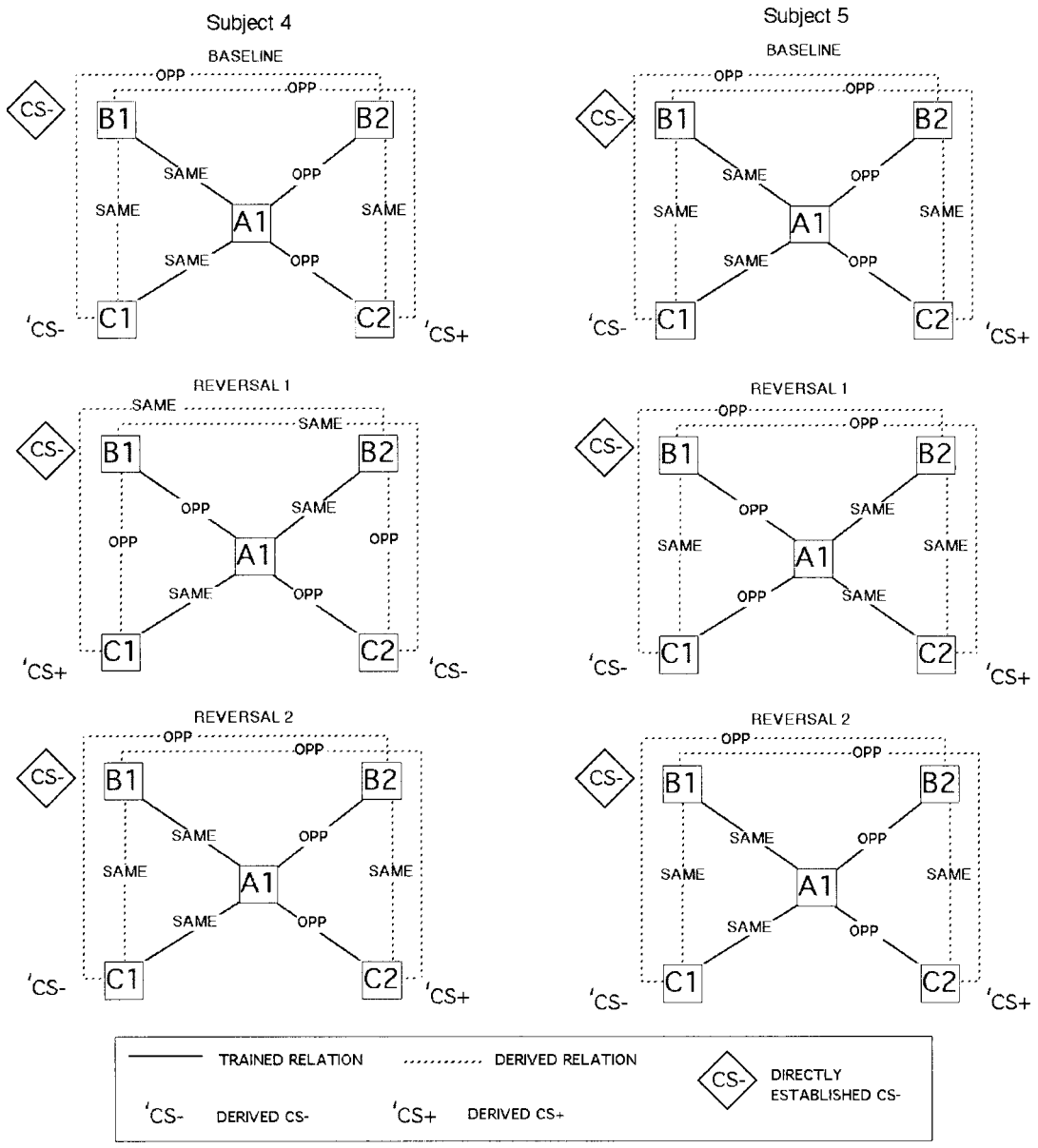

Fig. 4. Overview of the procedure for Subjects 4 and 5 (Experiment 2), displaying the trained and tested relational networks in the Baseline, Reversal 1, and Reversal 2 conditions.

(Phase 3). This subject was excluded from further participation in the study, and his data are not presented. Table 2 presents the results for the transformation of consequential functions test for Subjects 4 and 5, and also displays the relation obtained between B1, the directly established CS−, and each stimulus in the relational network. Performances for Subjects 4 and 5 in Phases 1 through 3 are included in the Appendix.

Both Subject 4 and Subject 5 passed Phases 1 and 2 (establishing consequential functions and nonarbitrary relational training and testing, respectively) on their first exposures. Subject 4 passed Phase 3 at his first attempt. Subject 5 failed to pass Phase 3 after two ex-

Table 2

The column on the right presents data for Subjects 4 and 5 in Phase 4 of Experiment 2. The relation obtained between B1, the directly established CS−, and each stimulus in the relational network is also displayed. Subjects were expected to choose the stimulus that was consequated by the presentation of a member of the relational network that was in a frame of opposition with B1.

Experiment 2								
			Mutually entailed		Combinatorially entailed		Phase 4: % of trials selected	
Subject	Condition	Direct CS−	Same	Opposite	Same	Opposite	C1	C2
4	Baseline	B1	A1	—	C1	B2 C2	0	100
	Reversal 1	B1	—	A1	C2[a]	B2 C1	84	16
	Reversal 2	B1	A1	—	C1	B2 C2	12	88
5	Baseline	B1	A1	—	C1	B2 C2	3	97
	Reversal 1	B1	—	A1	C1[a]	B2 C2	9	91
	Reversal 2	B1	A1	—	C1	B2 C2	6	94

[a] The combinatorially entailed Same relation is derived from two mutually entailed Opposite relations.

posures and the session was terminated at this point. This subject returned the next day and completed all three phases successfully.

During Phase 4, the test for transformation of consequential functions, the responding of both subjects appeared to come under the consequential control of C2, which was in a frame of opposite with B1, a directly established CS−. Specifically, Subject 4 produced relation-consistent responding on 100% of the trials, and Subject 5 produced relation-consistent responding on 97% of the trials.

In Reversal 1, both subjects passed Phase 2 on their first exposures. Subject 4 required two exposures to Phase 3, and Subject 5 required one exposure to Phase 3. In Phase 4, the test for transformation of consequential functions, Subject 4 produced relation-consistent responding on 84% of trials, and Subject 5 produced relation-consistent responding on 91% of trials. In effect, Subject 5 produced the same performance that was observed prior to the reversal. This result indicates that the transformation of functions was in accordance with the new relational network in which the mutually entailed relations were changed but the combinatorial relations were not. In effect, simply changing the network did not produce a reversal in the subject's response patterning on the transformation of consequential functions test.

In Reversal 2, both Subject 4 and Subject 5 passed Phases 2 and 3 on their first exposures. During Phase 4, Subject 4 produced relation-consistent responding on 88% of trials, and Subject 5 produced relation-consistent responding on 94% of trials.

In Experiment 2, the 2 subjects who met the mastery criterion on the relational test phase successfully completed all tests for transformation of consequential functions (i.e., Baseline, Reversal 1, and Reversal 2) in accordance with the combinatorially entailed relations of Same and Opposite. It appears, therefore, that specific consequential functions can be transformed in accordance with two derived relations, and these transformation effects are relatively flexible in that they systematically can be reversed when the relational network is suitably modified.

EXPERIMENT 3

One criticism that might be made of Experiment 2 is that the transformation of CS− functions occurred initially *only* via Same relations. That is, because the CS− function of C1 was acquired via frames of coordination, it is possible that the Opposite frames played no role in the transformation of functions (i.e., subjects simply responded away from the derived CS−). In order to address this issue, Subjects 6 and 7 were exposed to a procedure in which B2, rather than B1, was paired with the loss of points. Hence, these subjects were expected to choose the stimulus that produced C1, rather than C2, in the initial test for transformation of consequential functions, because C1 was in a frame of Opposition with B2. Although it is still possible

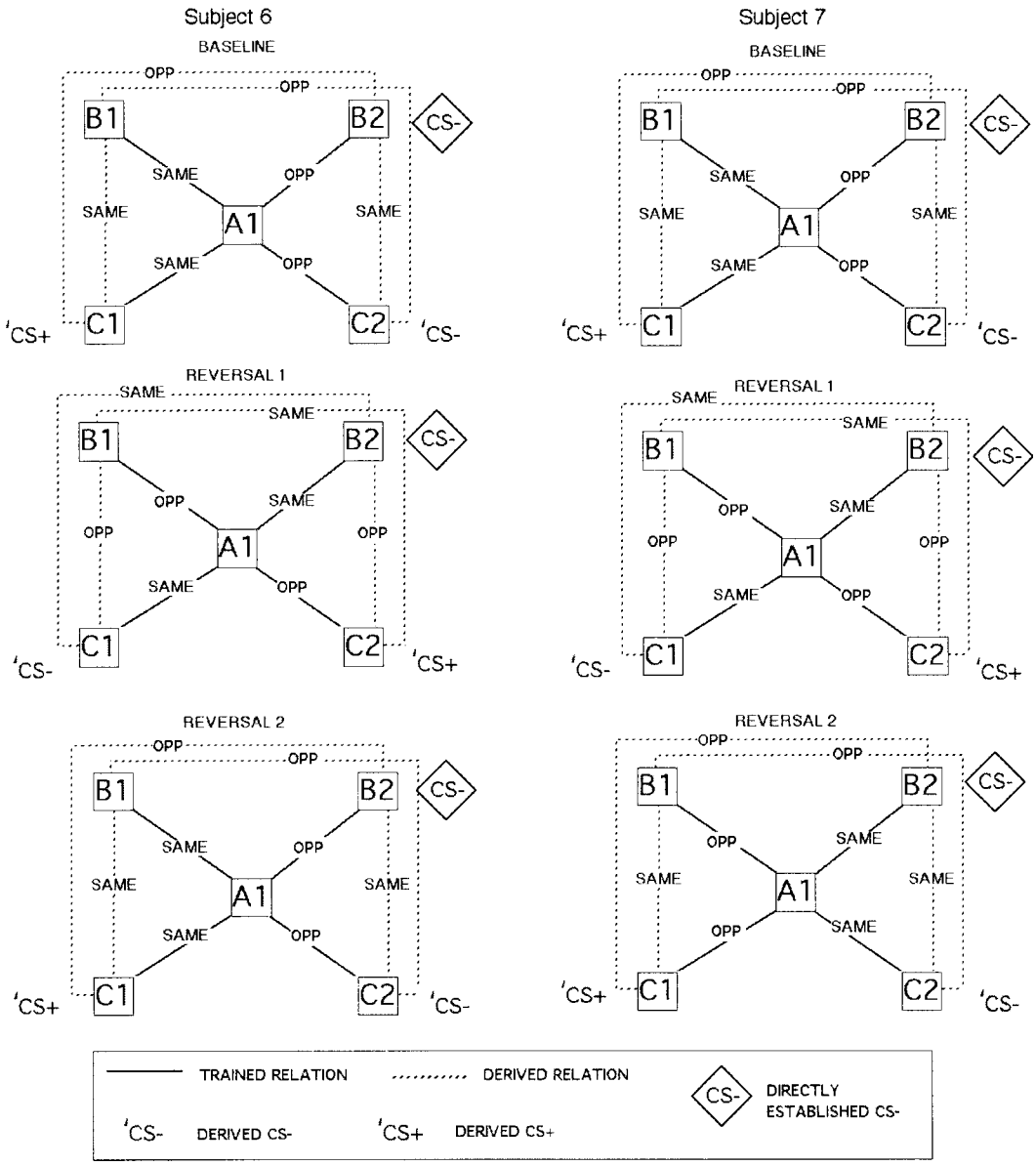

Fig. 5. Overview of the procedure for Subjects 6 and 7 (Experiment 3), displaying the trained and tested relational networks in the Baseline, Reversal 1, and Reversal 2 conditions.

that subjects responded away from the CS−, this derived form of S− control could *only occur in accordance with two Opposite relations* (because C2 and B2 were both opposite to A1, and thus the same). In addition, the mastery criterion for the arbitrary relational training phase was increased from 10 consecutive correct responses to 16 consecutive correct responses.

Procedure

As an aid to the reader, Figure 5 presents a diagrammatic representation of the procedures employed for Subjects 6 and 7. The procedure in Experiment 3 was similar to that employed in Experiment 2, except that in Phase 1, B2, rather than B1, was established as a conditioned punisher by pairing it with

Table 3

The column on the right presents data for Subjects 6 and 7 in Phase 4 of Experiment 3. The relation obtained between B2, the directly established CS−, and each stimulus in the relational network is also displayed. Subjects were expected to choose the stimulus that was consequated by the presentation of a member of the relational network that was in a frame of opposition with B2.

Experiment 3								
			Mutually entailed		Combinatorially entailed		Phase 4: % of trials selected	
Subject	Condition	Direct CS−	Same	Opposite	Same	Opposite	C1	C2
6	Baseline	B2	—	A1	C2[a]	B1 C1	81	19
	Reversal 1	B2	A1	—	C1	B1 C2	16	84
	Reversal 2	B2	—	A1	C2[a]	B1 C1	84	16
7	Baseline	B2	—	A1	C2[a]	B1 C1	94	6
	Reversal 1	B2	A1	—	C1	B1 C2	6	94
	Reversal 2	B2	A1	—	C2	B1 C1	97	3

[a] The combinatorially entailed Same relation is derived from two mutually entailed Opposite relations.

the loss of points. Phases 2 and 3 were identical to Experiments 1 and 2. In Phase 4, the transformation of consequential functions test, C1 and C2 were used as consequences. The procedure for Reversal 1 was identical to that of Experiment 2 for both subjects (i.e., the contextual cues in two of the relational training trials were reversed; SAME/A1-B1 became OPPOSITE/A1-B1, and OPPOSITE/A1-B2 became SAME/A1-B2). Reversal 2 for Subject 6 consisted of reexposure to the relational training tasks presented in Phase 3. In the case of Subject 7, however, Reversal 2 did not consist of reexposure to the original baseline contingencies. Instead, the contextual cues were reversed in the following way: SAME/A1-C1 became OPPOSITE/A1-C1, and OPPOSITE/A1-C2 became SAME/A1-C2. Hence, in Reversal 2, the derived combinatorially entailed relations that were predicted to emerge in the transformation of consequential functions test were identical to those that emerged in the first transformation of consequential functions test.

Results and Discussion

Four subjects began Experiment 3. Two subjects failed to produce relation-consistent responding within four exposures to the relational training and testing procedures (Phase 3). These subjects were excluded from further participation in the study, and their data are not presented. In Experiment 3, successful completion of the transformation of function test was defined as consistently choosing the stimulus that produced the member of the relational network that was in a frame of Opposition with the putative CS−. Table 3 presents the results for the transformation of consequential functions test for Subjects 6 and 7, and also displays the relation obtained between B2, the directly established CS−, and each stimulus in the relational network. Performances for Subjects 6 and 7 during exposure to Phases 1 through 3 are included in the Appendix.

Both Subjects 6 and 7 passed Phases 1 and 2 on their first exposures to each. Subject 6 was exposed to Phase 3 twice, but failed the arbitrary relational test. Subject 6 was then reexposed to Phase 2 again and subsequently passed Phase 3 after two further exposures. In Phase 4, the test for transformation of consequential functions, Subject 6 produced relation-consistent responding 81% of the time, and Subject 7 produced relation-consistent responding 94% of the time.

In Reversal 1, both subjects passed Phases 2 and 3 on their first exposures to each. In Phase 4, Subject 6 produced relation-consistent responding on 84% of trials, and Subject 7 produced relation-consistent responding on 94% of trials.

In Reversal 2, both subjects passed Phases 2 and 3 on their first exposures to each. In Phase 4, Subject 6 produced relation-consistent responding on 84% of trials, and Subject 7 produced relation-consistent responding on 97% of trials.

In Experiment 3, both subjects who met

the mastery criterion on the relational test phase successfully completed all tests for transformation of consequential functions in accordance with the combinatorially entailed relations of Same and Opposite. Furthermore, because B2 (rather than B1) was paired with the loss of points, the data from Experiment 3 also indicate that a transformation of consequential functions occurred in accordance with an Opposite frame. Again, the data demonstrate that these transformation effects are flexible, in that they systematically can be reversed when the relational network is suitably modified.

EXPERIMENT 4

Although Experiment 3 seemed to demonstrate a transformation of consequential functions in accordance with relational frames of Opposition, it is still possible that responding in the test for transformation of consequential functions was based on a type of S− control for a derived punisher. In this case, the stimulus that comes to function as a reinforcer does so, not via a transformation of consequential functions in accordance with an opposite relation, but rather via an avoidance response to the derived punisher. This is always a possibility when only two comparison stimuli are available. However, if three stimuli are available—a punisher, a reinforcer, and a novel or neutral stimulus—and subjects consistently emit responses that produce the derived reinforcer, there are stronger grounds on which to conclude that the derived reinforcer acquired its controlling properties not through avoidance per se, but through the relational network. In Experiment 4, therefore, three comparison stimuli were used in the test for transformation of consequential functions.

Procedure

Phases 1, 2, and 3 were identical to those employed for Subject 7 in Experiment 3 (see Figure 5) for all subjects in Experiment 4. In Phase 4, however, *three* stimuli were presented as discriminative stimuli in the simultaneous discrimination task, and three different consequential stimuli (C1, C2, and a third stimulus) were presented contingent upon choosing each of the three stimuli. In the case of Subjects 8 and 9, the third consequential stimulus (V1) was completely novel; in the case of Subjects 10 and 11, the third consequential stimulus had been presented in Phase 3, but did not enter into the relational network (N3 for Subject 10 and Y1 for Subject 11).

Results and Discussion

Four subjects began Experiment 4. All subjects reached criterion in the relational test, requiring between one and seven exposures to Phase 3. Table 4 displays the performances in Phase 4 for Subjects 8 to 11 and also displays the relation obtained between B2, the directly established CS−, and each stimulus in the relational network. Performances for Subjects 8 to 11 during exposure to Phases 1 through 3 are included in the Appendix. In Phase 4, the V1 stimulus was used as a consequential stimulus for Subjects 8 and 9, and either N3 or Y1 was used as a consequential stimulus for Subjects 10 and 11.

Subject 9 differed from the other subjects in failing Phase 4, the test for transformation of consequential functions, after successfully completing Phases 1, 2, and 3 (see Appendix for details). Note that the generic description of the results does not include reference to Subject 9's first cycle through Phases 1 through 4.

All subjects passed Phase 1 on their first exposure (note: this was Subject 9's second session). All 4 subjects passed Phase 2 at the first attempt. In Phase 3, Subjects 8 and 9 passed after one exposure. Subject 10 did not pass Phase 3 after two exposures. This subject was reexposed to Phase 2, which he then passed. Subject 10 required three further exposures to Phase 3 before reaching criterion on the arbitrary relational test. Subject 11 passed Phase 3 after three exposures. In Phase 4, Subject 8 produced relation-consistent responding on 75% of trials, Subjects 9 and 10 on 94% of trials, and Subject 11 on 88% of trials.

In Reversal 1, Subject 8 did not pass Phase 3 after three exposures. This subject was reexposed to Phase 2, which he then passed, and subsequently passed Phase 3 after one exposure. Subjects 9 to 11 passed Phases 2 and 3 on their first exposures to each. In Phase 4, Subject 8 produced relation-consistent responding on 81% of trials, Subject 9 produced on 91% of trials, Subject 10 on 100%

Table 4

The column on the right presents data for Subjects 8 to 11 in Phase 4 of Experiment 4. The relation obtained between B2, the directly established CS−, and each stimulus in the relational network is also displayed. Subjects were expected to choose the stimulus that was consequated by the presentation of a member of the relational network that was in a frame of opposition with B2.

Experiment 4									
		Direct	Mutually entailed		Combinatorially entailed		Phase 4: % of trials selected		
Subject	Condition	CS−	Same	Opposite	Same	Opposite	C1	C2	V1
8	Baseline	B2	—	A1	C2[a]	B1 C1	75	9	16
	Reversal 1	B2	A1	—	C1	B1 C2	13	81	6
	Reversal 2	B2	A1	—	C2	B1 C1	81	6	13
9[b]	Baseline	B2	—	A1	C2[a]	B1 C1	94	0	6
	Reversal 1	B2	A1	—	C1	B1 C2	6	91	3
	Reversal 2	B2	A1	—	C2	B1 C1	91	6	3
							C1	C2	N3
10	Baseline	B2	—	A1	C2[a]	B1 C1	94	3	3
	Reversal 1	B2	A1	—	C1	B1 C2	0	100	0
	Reversal 2	B2	A1	—	C2	B1 C1	97	3	0
							C1	C2	Y1
11	Baseline	B2	—	A1	C2[a]	B1 C1	88	6	6
	Reversal 1	B2	A1	—	C1	B1 C2	6	91	3
	Reversal 2	B2	A1	—	C2	B1 C1	94	3	3

[a] The combinatorially entailed Same relation is derived from two mutually entailed Opposite relations.
[b] Data from second session only.

of trials, and Subject 11 on 91% of trials. In Reversal 2, all 4 subjects passed Phase 2 on the first attempt. Subject 8 required three exposures to Phase 3, and Subjects 9 to 11 all passed Phase 3 on their first exposure. In Phase 4, Subject 8 produced relation-consistent responding on 81% of trials, Subject 9 on 91% of trials, Subject 10 on 97% of trials, and Subject 11 on 94% of trials.

In Experiment 4, all subjects successfully completed all tests for transformation of consequential functions. The use of three discriminative and three consequential stimuli in the simultaneous discrimination probe phase (Phase 4) controls for derived S− control. At this point, therefore, an interpretation of the current data in terms of the derived transformation of consequential functions in accordance with Opposite relations is made more plausible.

GENERAL DISCUSSION

The results of the four experiments presented here indicate that a consequential function given to one member of a relational network can be transformed in accordance with the relations within that network. Experiment 1 demonstrated that a punishing function attached to one stimulus appears to transform the functions of a second stimulus that is mutually entailed through a relation of Opposite, such that the second stimulus acquires a reinforcing function. In Experiments 2 through 4, similar effects were obtained through combinatorially entailed relations (rather than mutual entailment alone). The present study thus extends that of Hayes et al. (1991) by examining the transformation of consequential functions among nonequivalent stimuli and by demonstrating within-subject reversals.

In a previous study, Roche and Barnes (1997) reported the transformation of eliciting functions through Same and Opposite relations. In their study, however, an emotionally arousing function was explicitly trained to one member of the network, and a separate nonarousing function was trained to another member of the network. These two functions subsequently emerged for other related stimuli. In contrast, the present study involved training a single punishing function to one member of the network, and based on the derived relations of Same and Opposite, other members acquired reinforcing functions, although *no* such consequential function had actually been explicitly trained within the

context of the experiment. These data replicate and extend previous research by demonstrating that a specific behavioral function can emerge within a relational network without that function being explicitly trained to any member of the network. Multiple stimulus relations, therefore, appear to enhance or extend the generativity of derived relational responding, at least in human adults.

The present findings must be viewed as preliminary. This research employed verbally sophisticated adults, each of whom had unknown preexperimental histories that, presumably, included substantial experience with the relations of Same and Opposite. The experimental procedures could have harnessed these histories. If so, it is possible that the same procedures would yield different outcomes with less verbally capable subjects, or with individuals lacking a history involving the concepts of Same and Opposite. Certainly, RFT would predict that such relational performances would co-vary as a function of verbal history (O'Hora, Palaez, Barnes-Holmes, & Amesty, in press). In a related vein, in Experiments 1 through 3, 5 subjects out of 12 did not complete the study after failing to acquire essential repertoires. Thus an important goal of future studies will be to specify the conditions under which the derivation of multiple stimulus relations occur.

Nevertheless, in showing that such derivations *can* occur, the present research highlights a limitation of the two main theoretical approaches to conditioned reinforcement and punishment. According to Dinsmoor (2001), the two current behavior-analytic approaches, one-process and two-process accounts,

> . . . differ with respect to the consequences that are assumed to reinforce the behavior that precludes, postpones, or reduces the severity of forthcoming electric shock. A contemporary variant of the traditional two-factor or two-process theory relies on the reinforcing effect of terminating stimuli that have been paired with shock . . . and producing stimuli that have been paired with the absence of shock. . . . An alternative formulation, sometimes known as the single-process or shock-density-reduction theory, hypothesizes a direct reinforcing effect resulting from the negative correlation over extended periods of time between rate of responding and the frequency or the severity of the shocks. . . . (p. 311)

The present experiments indicate that additional processes are at work beyond those specified by one- and two-factor theories. Consider Experiment 1, for example, in which A1 was paired with the loss of points and, subsequently, subjects were trained to match B2 with A1 in the presence of the OPPOSITE contextual cue. Given that A1, B2, and OPPOSITE were all paired/correlated during the MTS training, both one- and two-factor theories predict that B2 should become a conditioned punisher if a punishing function was trained to A1. In the present study, however, B2 reliably acquired a reinforcing, rather than a punishing, function. It appears, therefore, that neither stimulus pairings nor negative correlations over extended periods of time can account for the present data. Rather, the relational functions of the contextual cues involved appeared to alter the simple associative or correlational effects that are the focus of one- and two-factor theories of reinforcement and punishment. A more complete account of reinforcement and punishment in behavior analysis therefore requires that direct contingency analyses, in terms of stimulus parings and/or correlations, be supplemented with theoretical and empirical analyses of the role played by multiple stimulus relations in the establishment and maintenance of consequential stimuli.

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APPENDIX

Detailed results for Subjects 1 to 11.

Experiment	Subject	Condition	Phase 1	Phase 2		Phase 3		Phase 4
				Training	Testing	Training	Testing	
1	1	Baseline	30/32 P	14/25	10/10 P	45/74	7/16 F	
						14/18	11/16 F	
						27/35	7/16 F	
						18/20	16/16 P	32/32
		Reversal 1		10/10	10/10 P	18/24	13/16 F	
						17/18	16/16 P	30/32
		Reversal 2		10/10	10/10 P	11/12	16/16 P	32/32
1	2	Baseline	30/32 P	21/30	10/10 P	20/33	10/16 F	
						17/21	16/16 P	32/32
		Reversal 1		10/10	10/10 P	12/15	2/16 F	
						10/10	16/16 P	32/32
		Reversal 2		10/10	10/10 P	10/11	16/16 P	31/32
1	3	Baseline	28/32 P	17/27	10/10 P	37/44	4/16 F	
						45/53	9/16 F	

APPENDIX

(*Continued*)

Experiment	Subject	Condition	Phase 1	Phase 2		Phase 3		Phase 4
				Training	Testing	Training	Testing	
				10/10	10/10 P	10/10	7/16 F[a]	
		Baseline[b]	32/32 P	15/16	10/10 P	15/16	16/16 P	32/32
		Reversal 1		10/10	10/10 P	31/39	6/16 F	
						10/11	0/16 F	
						21/23	16/16 P	31/32
		Reversal 2		10/10	10/10 P	10/11	16/16 P	31/32
		Sham reversal		10/10	10/10 P	16/17	16/16 P	32/32
2	4	Baseline	30/32 P	13/16	10/10 P	30/44	16/16 P	32/32
		Reversal 1		10/10	10/10 P	24/28	1/16 F	
				10/10	10/10 P	10/10	16/16 P	27/32
		Reversal 2		10/10	10/10 P	19/21	16/16 P	28/32
2	5	Baseline	30/32 P	23/28	10/10 P	39/58	7/16 F	
						39/51	11/16 F[a]	
		Baseline[b]	32/32 P	10/10	10/10 P	10/10	12/16 F	
						10/10	16/16 P	31/32
		Reversal 1		10/10	10/10 P	22/29	16/16 P	29/32
		Reversal 2		10/10	10/10 P	12/14	16/16 P	30/32
3	6	Baseline	28/32 P	11/15	10/10 P	57/83	5/16 F	
						16/16	4/16 F	
				10/11	10/10 P	25/26	11/16 F	
						16/16	16/16 P	26/32
		Reversal 1		10/10	10/10 P	27/29	16/16 P	27/32
		Reversal 2		10/10	10/10 P	27/28	16/16 P	27/32
3	7	Baseline	30/32 P	10/14	10/10 P	45/87	16/16 P	30/32
		Reversal 1		10/10	10/10 P	23/25	16/16 P	30/32
		Reversal 2		10/10	10/10 P	16/19	16/16 P	31/32
4	8	Baseline	30/32 P	22/30	10/10 P	48/61	16/16 P	24/32
		Reversal 1		10/10	10/10 P	17/20	0/16 F	
						16/16	0/16 F	
						25/36	8/16 F	
				10/10	10/10 P	16/19	16/16 P	26/32
		Reversal 2		10/10	10/10 P	15/18	0/16 F	
						33/39	0/16 F	
						16/17	16/16 P	26/32
4	9	Baseline	18/32 F					
			24/32 F					
			29/32 P	22/28	10/10 P	63/84	10/16 F	
						17/18	9/16 F	
				10/10	10/10 P	16/16	10/16 F	
						25/27	6/16 F	
						16/16	6/16 F	
						21/24	13/16 F	
						16/16	16/16 P	18/32[a]
		Baseline[b]	30/32 P	10/10	10/10 P	20/21	16/16 P	30/32
		Reversal 1		10/10	10/10 P	19/27	16/16 P	29/32
		Reversal 2		10/10	10/10 P	21/28	16/16 P	29/32
4	10	Baseline	29/32 P	15/18	10/10 P	90/150	9/16 F	
						18/21	0/16 F	
				10/10	10/10 P	29/31	1/16 F	
						30/34	1/16 F	
						16/16	16/16 P	30/32
		Reversal 1		10/10	10/10 P	18/20	16/16 P	32/32
		Reversal 2		10/10	10/10 P	17/19	16/16 P	31/32
4	11	Baseline	30/32 P	13/19	10/10 P	22/34	7/16 F	
						16/16	13/16 F	
						16/18	16/16 P	28/32
		Reversal 1		10/10	10/10 P	20/24	16/16 P	29/32
		Reversal 2		10/10	10/10 P	26/32	16/16 P	30/32

[a] Session terminated at this point.
[b] Start of a new session.
Note. P means the subject passed the testing; F means the subject failed the testing.