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A TRANSFORMATION OF RESPONDENTLY CONDITIONED STIMULUS FUNCTION IN ACCORDANCE WITH ARBITRARILY APPLICABLE RELATIONS

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Adult male subjects saw a sexual film clip paired with a nonsense syllable (C1). Similarly, an emotionally neutral film clip was paired with a second nonsense syllable (C3). Responses to the nonsense syllables were recorded as skin resistance responses. Subjects were also trained in a series of related conditional discriminations, using the C1 and C3 stimuli, from which the following equivalence relations were predicted; A1-B1-C1, A2-B2-C2, and A3-B3-C3. Some subjects were given matching-to-sample (equivalence) tests after the conditional discrimination training (Experiment 1), whereas others were not (Experiment 2). Subjects were tested for a transformation of eliciting functions by presenting the A1 and A3 stimuli, which were related through equivalence to C1 and C3, respectively. Five of the 6 subjects who showed significantly greater conditioned responses to C1 than to C3, also showed significantly greater skin resistance responses to A1 than to A3. Two additional subjects demonstrated a transformation of an eliciting stimulus function in accordance with five-member equivalence relations (Experiment 3), and another 5 subjects demonstrated similar effects in accordance with the relations of sameness and opposition (Experiment 4).

Key words: equivalence, opposition, transformation of function, respondent conditioning, sexual arousal, electrodermal responses, humans

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When verbally able humans are taught a series of interrelated conditional discriminations, the stimuli involved often become related to each other in untrained ways. For example, when a subject is taught to select Stimulus B in the presence of Stimulus A and to select Stimulus C in the presence of B, it likely that the subject will also select A in the presence of B and B in the presence of C (symmetry), C in the presence of A (transitivity), and A in the presence of C (combined symmetry and transitivity, or equivalence) without further training. When this occurs, the stimuli are said to participate in an equivalence relation (e.g., Barnes, 1994; Barnes, Browne, Smeets, & Roche, 1995; Barnes & Holmes, 1991; Barnes, McCullagh, & Keenan, 1990; Barnes, Smeets, & Leader, 1996; Fields, Adams, Verhave, & Newman, 1990; Hayes, 1991, 1994; Roche, Barnes, & Smeets, in press; Sidman, 1990, 1992). If the subject is then further trained to emit a particular response in the presence of C, it is likely that the subject will also emit that response in the presence of A. When this occurs, a transformation of functions in accordance with an equivalence relation is documented (see Barnes, 1994; Barnes, Browne, Smeets, & Roche, 1995; Barnes & Holmes, 1991; Barnes & Keenan, 1993; de Rose, McIlvane, Dube, Galpin, & Stoddard, 1988; Dougher, Augustson, Markham, Greenway, & Wulfert, 1994; Dymond & Barnes, 1994; Gatch & Osborne, 1989; Hayes, 1991; Hayes, Devany, Kohlenberg, Brownstein, & Shelby, 1987; Hayes, Kohlenberg, & Hayes, 1991; Wulfert & Hayes, 1988). (The word *transformation,* rather than *transfer,* will be used throughout the present paper, because the transformation of stimulus function is a defining feature of arbitrarily applicable relational responding, and equivalence responding may itself be viewed as a transformation of functions; see Barnes & Roche, 1996; Dymond & Barnes, 1996; Hayes, 1994.)

Although many experiments have examined the derived transformation of function, only one of these studies has done so by combining operant and respondent procedures.

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Dougher et al. (1994) trained subjects on a series of interrelated conditional discrimination tasks that led to the emergence of two four-member equivalence relations (A1-B1-C1-D1 and A2-B2-C2-D2). A mild electric shock applied to each subject's forearm then served as an unconditional stimulus (US) that followed presentations of B1 (i.e., respondent conditioning). Stimulus B2 was also presented, but in the absence of the US. Conditioned emotional responses to B1 and B2 were measured as skin conductance responses. Subjects were then presented with some of the remaining members of each equivalence class to test for a transformation of eliciting function. Five of the 8 subjects showed evidence of respondent conditioning and a transformation of respondent function. Dougher et al. suggested that these findings have important implications for our understanding of maladaptive and unexplained emotional behavior.

The transformation of eliciting function might also contribute to our understanding of unexplained or novel patterns of sexual behavior insofar as respondent and operant processes, as traditionally defined, cannot readily account for instances of sexual behavior that emerge in the absence of an explicit conditioning history (Barnes & Roche, in press; Gelder, 1979; McConaghy, 1987). For example, we might account for the emergence of some instances of transvestism in terms of a derived transformation of function (Barnes & Roche, in press). Consider a boy who is told by his classmates that "wild," "kinky," or "bizarre" behavior is often considered to be sexually arousing, and also that it is "wild," "kinky," or "bizarre" to dress in the clothes of the opposite sex. Under these conditions, the words *sexual arousal* may become related to the words *cross-dressing* because both are related via equivalence to the phrase "wild, bizarre, kinky behavior." Of greater interest here, however, is the fact that the words *sexual arousal* and *cross-dressing* also participate in socially established equivalence relations with actual sexual arousal and actual cross-dressing, respectively. These relations make it possible that, in some contexts, the functions of actual sexual arousal will transfer to actual cross-dressing in accordance with the previously outlined equivalence relation (i.e., actual sexual arousal → *sexual arousal* → "wild, bizarre, kinky behavior" → *cross-dressing* → actual cross-dressing). This equivalence interpretation, therefore, may help us to analyze a wide range of human sexual behavior in strictly functional-analytic terms (see Barnes & Roche, in press).

The transformation-of-function interpretation might also help us to analyze the emergence of a highly unusual fetish, such as a fire fetish (see Cox, 1979), by pointing to the similarity of terms used to describe sexual arousal and fire (Barnes & Roche, in press). For instance, both sexual arousal and fire are spoken of as "explosive" and "hot." In popular romantic literature lust is often referred to as "burning desire" and love as a "flame." Furthermore, the *Collins English Dictionary and Thesaurus* lists the terms *ardor, excitement, luster,* and *passion* under the reference term *fire.* Thus, given that terms pertaining to fire and sexual behavior often participate in equivalence relations with each other, we might expect to observe occasionally a transfer of function from sex to fire, even though prevailing physical contingencies make such a transformation unlikely (i.e., exposure to "sexually attractive" fire is painful). Clearly, the foregoing examples of a transformation of sexual arousal function are highly speculative. Nevertheless, an important first step in assessing the functional utility of such speculation would be to conduct an analogue study to determine whether the eliciting function of sexual stimuli can in fact be transformed in accordance with arbitrarily applicable relations. The present series of experiments aimed to demonstrate this type of a transformation of function.

In Experiment 1, adult male subjects were exposed to respondent conditioning trials in which presentations of the nonsense syllables C1 and C3 were followed by film clips showing sexual and nonsexual material, respectively. Subjects were also exposed to conditional discrimination training that would permit the emergence of the following equivalence relations: A1-B1-C1, A2-B2-C2, and A3-B3-C3. Tests for respondent conditioning (i.e., greater skin resistance responses, SRRs, to C1 over C3) and a transformation of eliciting function in accordance with equivalence relations (i.e., greater SRRs to A1 over A3) were also administered. Experiment 2 was conducted to determine whether formal matching-to-sample equivalence testing was a necessary precondition for the transformation of an eliciting function. Subjects from Experiment 2, therefore, did not receive a matching-to-sample equivalence test until they had completed the test for derived transformation. Experiment 3 attempted to extend the scope of the experimental procedures by examining the transformation of an eliciting function in accordance with five-member, instead of three-member, equivalence relations. Finally, Experiment 4 used relational frame procedures, similar to those used by Steele and Hayes (1991, Experiment 1), to transform an eliciting function in accordance with the two arbitrarily applicable relations of sameness and opposition.

EXPERIMENTS 1 AND 2

Method

Subjects

All subjects were recruited through notice board advertisements and personal contacts. Seven male subjects, aged between 18 and 23 years, completed Experiments 1 (4 subjects) and 2 (3 subjects), and were paid three Irish punts (approximately $4.50) per hour for their participation. An additional 5 subjects began but did not complete the experiments (see below). All subjects were undergraduate students, except Subject 7, who was a psychology postgraduate. None of the subjects had studied stimulus equivalence or relational frame theory as a part of their undergraduate training.

Apparatus

Subjects were seated at a table in a small experimental room (2 by 2 m) containing a microcomputer (Apple® Model LC) that displayed black characters on a white background. The computer presented all characters in 12-point New York font. Stimulus presentations and the recording of responses were controlled by the computer, which was programmed in BBC BASIC.

Nine nonsense syllables were employed in Experiments 1 and 2 (JOM, CUG, BEH, YIM, ROG, DAX, PAF, VEK, and ZID). These were randomly assigned as sample and comparison stimuli for each subject and are labeled, in the interests of clarity, using the alphanumerics A1, A2, A3, B1, B2, B3, C1, C2, and C3 (subjects were not exposed to these labels). Differential eliciting functions were established for two nonsense syllables (C1 and C3) using 45- to 60-s film clips taken from a popular sex instruction video or a geographic documentary. Sexual clips depicted heterosexual "necking," heavy petting, coitus, cunnilingus, and fellatio, whereas nonsexual clips depicted scenic landscapes of mountainous or desert regions (a detailed description of the video clips is available from the authors). Sexual film clips were not continuous with each other but were selected such that they depicted one or more of the aforementioned sexual activities.

All film clips were played on a Panasonic® portable video player (Model NV 80) located in a monitoring room and were relayed to subjects on a Panasonic® 14-in. television monitor located in an adjacent room and placed directly beside a microcomputer. Respondent conditioning of general autonomic arousal was measured as SRRs on a Grass® polygraph (Model 7P1), which supplied a 10-μA constant current through two (1 cm^2) rim-sealed silver metal electrodes. The polygraph was located beside the video player in the monitoring room. Electrodes were prepared with an electrolyte that was produced from a Unibase (Parke Davis) and a 0.5% NaCl solution (Lykken & Venables, 1971). Electrodes were secured to the electrode placement sites (see below) with regular self-adhesive waterproof bandage (Ax, 1964).

Response Quantification

Phasic changes in SRRs were used as the measure of respondent conditioning (see Appendix A, Point 1). In mathematical terms, skin resistance is simply the reciprocal of skin conductance (but see Roche & Barnes, 1995a, 1995b) and is measured in ohms per centimeter squared (see Appendix A, Point 2). Electrodermal activity (EDA) provides a direct and undiluted representation of sympathetic activity (Dawson, Schell, & Filion, 1990). Furthermore, because electrodermal responses are easily discriminable and quantifiable immediately following stimulus presentations, EDA represents a convenient measure of autonomic activity when experimental paradigms involve the repeated presentation of discrete stimuli. In effect, electrodermal measures are more sensitive than other measures of arousal (e.g., penile plethysmograpy, heart rate) to paired stimulus paradigms with short intertrial intervals (Dawson et al., 1990). Indeed, it has been argued that of all the nongenital measures of sexual arousal, EDA is perhaps the most reliable (see Zuckerman, 1983). In the current study, verbal reports were also recorded as a further measure of stimulus function and their transformation.

Following extensive pilot testing (see Roche & Barnes, 1995a), an SRR was defined as the maximum absolute decrease in ohmic skin resistance, as compared with the skin resistance level taken at the time of stimulus onset (see Appendix A, Point 3), recorded within 5 s of stimulus onset. Increases in skin resistance (indicating relaxation) were not quantified but were read as having a value of zero. Although including zero values in statistical analyses may confound response frequency with response amplitude (Prokasy & Kumpher, 1973), the omission of zero values in psychophysiological studies often leaves researchers with little or no data to analyze (Dawson et al., 1990). This was the case in the current study, and thus zero values were included in all statistical analyses (see Roche & Barnes, 1995b).

General Experimental Sequence

All subjects were exposed individually to the experimental procedures, and times were arranged so that subjects did not meet each other in the vicinity of the laboratory. During pilot testing it was noted that extended experimental sessions (exceeding 2 hr) led to fatigue and diminished SRRs. Thus, in order to minimize fatigue, the experiment was divided into two sessions conducted on consecutive days. Each session lasted approximately 1.5 hr.

During the first session, subjects were exposed to preliminary respondent conditioning trials, but SRRs were not monitored during this session. Thus, if subjects found the sexual material to be embarrassing, offensive, or distressing, they could abandon the experiment within the first few minutes of their participation without having to call for assistance to remove the polygraph electrodes (none of the subjects in Experiments 1 and 2 chose to leave). If the subjects did not object, they were then exposed to the preliminary matching-to-sample procedures. The second session involved further matching-to-sample training (and testing in Experiment 1) followed by respondent conditioning trials, and finally the test for a derived transformation of an eliciting function.

Session 1

Preliminary respondent conditioning. Upon entering the experimental room for the first session, each subject was required to read and sign a consent form (Appendix B) acknowledging his awareness of the sexually explicit nature of some of the film clips that he was about to see. The subject was also informed that he was free to terminate participation at any time, and was asked not to discuss the study with anyone. The subject was then seated comfortably approximately 1 m from the television monitor and was left in privacy.

A nonsense syllable, C1 or C3 (7 cm by 3 cm), was presented in the center of the monitor. Each stimulus remained on for 3 s and was followed by a 5-s interval during which the monitor went dark. At the end of the 5-s interval, a sexual or nonsexual US was presented, following C1 or C3, respectively (i.e., a trace conditioning procedure). A simultaneous conditioning procedure was also employed on each conditioning trial, in which the CS was flashed (once per second) periodically (every 15 s for 5 s) in the top right corner of the television monitor during the presentation of the US. In effect, each respondent conditioning trial consisted of a combination of trace and simultaneous conditioning (see Chance, 1988, p. 52). Pilot work in our laboratory indicated that this was a relatively reliable procedure for producing respondently conditioned SRRs (Roche & Barnes, 1995a).

The USs differed on every conditioning trial but were taken either from the sex instruction video or from the nature documentary, respectively. The film clips varied from 45 to 60 s in duration. Intertrial intervals also varied from 45 to 60 s. Subjects were exposed to 12 trials (six exposures to both CSs), the order of which was randomized across subjects, with the restriction that neither CS could appear more than three times in succession.

In this procedure, the probability of a US presentation following a CS presentation was

.8 (i.e., the US was omitted for one in five presentations of each CS). Omission trials were interspersed quasirandomly among conditioning trials (i.e., no more than four presentations of either CS were reinforced in succession). Thus, four or five presentations of each CS were followed by a US across each block of 12 trials. On those trials with no US, the CS was followed by the normal intertrial interval of 45 to 60 s, and the CS did not flash during the intertrial interval. Pilot testing indicated that this procedure enhanced resistance to extinction, thus facilitating repeated testing for the transformation of function during the second experimental session when USs were not presented. The preliminary respondent conditioning phase of the experiment lasted approximately 30 min.

Preliminary matching-to-sample procedures. Immediately following the termination of the respondent conditioning film, the experimenter reentered the experimental room to begin the preliminary matching-to-sample training phase of the session. The subject was oriented toward the microcomputer on which all conditional discrimination trials were presented. The following instructions were then delivered on the computer screen.

> In a moment some images will appear on the computer. Your task is to look at the image in the middle of the screen and choose one of the images which appears at the bottom of the screen by pressing the ''Z,'' ''V,'' or ''M'' key. For example, if you want to choose the image on the left, you should press the ''Z'' key. If you wish to choose the image in the middle, press the ''V'' key, and to choose the image on the right, press the ''M'' key.

The experimenter read these instructions aloud while pointing at the keys in question. When the first sample and comparison stimuli appeared on the computer screen, the subject was told to ''press any of the three keys (Z, V, or M) and see what happens.'' If the choice was defined as correct, the screen cleared and ''correct'' appeared on the screen for 1.5 s, accompanied by a beep from the computer. If the choice was defined as incorrect, the screen cleared and ''wrong'' appeared on the screen for 1.5 s. The subject was then told to ''please continue in the same manner.'' The experimenter then left the room.

On each trial, the sample stimulus appeared in the middle of the computer screen, and after a 1-s delay three comparison stimuli appeared in a line at the bottom of the screen (the sample and comparison stimuli remained on the screen together, and no observing response to the sample was required). The screen position of the comparison stimuli (left, middle, or right) was counterbalanced across trials. Feedback (''correct'' or ''wrong'') followed responses on all training trials, and was followed in turn by an intertrial interval (the screen remained blank for 2.5 s).

There were six training tasks: Choose B1, B2, or B3 given A1, A2, or A3, respectively, and choose C1, C2, or C3, given B1, B2, or B3, respectively. Subjects were exposed to each of the six tasks in a quasirandom order (i.e., each of the six tasks was presented once in every block of six trials). Training trials were presented in blocks of six until subjects produced a minimum of 18 consecutive correct responses. When this criterion was met, subjects from Experiment 2 were thanked for their participation in Session 1 and were asked to return for the second experimental session on the following day.

Subjects participating in Experiment 1 were exposed to equivalence test trials following matching-to-sample training. Subjects in Experiment 2 were not exposed to this phase until they had completed the test for a transformation of function in Session 2. During test trials no feedback was provided; the intertrial interval began immediately following a response. The instructions administered to subjects before the test phase were identical to those administered before the training phase. The testing phase probed for the three equivalence relations C1-A1, C2-A2, and C3-A3 (i.e., each of the three C stimuli were presented as samples with A1, A2, and A3 as comparison stimuli). Testing occurred across 30 trials, with each of the three tasks presented 10 times in a quasirandom order. Subjects in Experiment 1 were exposed to the training and testing sequence up to a maximum of four times in each experimental session (a maximum of eight exposures in total). Subjects were dropped from the study if they failed to choose the class-consistent comparison on at least nine of the 10 trials for each task, after four exposures to the testing and training sequence in Session 1. Three subjects were dropped from Experiment 1 on these grounds, and their data are not reported. As soon as a criterion test performance was produced, the subject was thanked for his participation and was asked to return for the second experimental session on the following day.

Session 2

Upon returning for the second experimental session, subjects in Experiment 1 were again exposed to the conditional discrimination training and equivalence testing that they had completed during the first experimental session. When these subjects had produced a criterion performance on the equivalence test during this session (i.e., chose the class-consistent comparison on at least nine of the 10 trials for each task within four exposures to the training and test sequence), they were exposed to a second but longer series of respondent conditioning trials, similar to those used during Session 1 (i.e., film clips for both sessions were taken from the same sources). All subjects in Experiment 1 demonstrated equivalence responding within two exposures to the test phase during this second session, and thus no additional subjects were dropped from Experiment 1. Subjects from Experiment 2 were again exposed to the conditional discrimination training alone (as in Session 1). When criterion performances were shown (i.e., 18 consecutive correct responses), subjects were exposed immediately to the longer series of respondent conditioning trials. The following instructions were delivered to all subjects in Experiments 1 and 2, immediately prior to the respondent conditioning phase:

> During this phase of the Experiment we are interested in examining electrical changes in your skin as you watch the film before you. The wires that I will attach to your index and middle finger will cause you no discomfort whatsoever. These wires do not allow us to "read your mind." All you are required to do now is relax and watch the television monitor. If you have any questions please ask them now.

Skin resistance electrodes were then prepared with electrolyte (see above) and were applied to the volar surfaces of the distal phalanges of the index and middle finger of the left hand (Dawson et al., 1990; see Appendix A, Point 4). The experimenter then left to monitor SRRs from an adjacent room.

Tests for respondent conditioning and transformation of function. Approximately 1 min after leaving the experimental room, the experimenter began relaying respondent conditioning trials to the subject's television monitor. Subjects were exposed to a minimum of 24 trials (12 exposures to each CS) in which C1 and C3 were followed on 80% of trials by sexual and nonsexual USs, respectively (no more than four successive presentations of either CS were followed by a US). Unbeknownst to the subject, recording of conditioned SRRs began on the seventh exposure to each CS (i.e., from the point of CS onset for the subsequent 5 s). Responses to the CS could not be contaminated by responses to the US because response measurement ceased 3 s before the onset of the US. The experimenter recorded a minimum of six responses to each CS, including omission trials. The experimenter terminated the training if visual inspection of the graphical representations of SRRs (continuously fed from the polygraph) suggested a response differential between C1 and C3 across the 12 respondent conditioning trials. The continuous graphical readout from the polygraph made it difficult to adhere to a strict criterion for judging an acceptable response differential, but in general training ceased when there appeared to be at least twice as many decreases in SRRs to C1 as to C3, or the majority of decreases in SRRs to C1 were of greater magnitude than those to C3. When there did not appear to be a clear response differential, additional training trials were presented, with ongoing visual comparison of the effects of the two CSs. Training trials continued until (a) the experimenter judged that a clear response differential had emerged by applying the above criteria across all training trials, or (b) a maximum of 24 additional training trials had been presented (i.e., a maximum of 12 additional exposures to each stimulus, with US presentations on 80% of the trials; see Appendix A, Point 5). When extra training trials were delivered, all additional and all previous SRR measures were included in subsequent statistical analyses. Two subjects failed to produce any discernible changes in skin resistance across 36 training trials, and thus these two "stabiles" (see Augustson, Markham, &

Dougher, 1994) were dropped from the study, were fully debriefed, and were paid for their time (their results are not presented).

The test for a transformation of eliciting function in accordance with equivalence relations (i.e., C1 → B1 → A1 and C3 → B3 → A3) was administered to those subjects who demonstrated visual evidence of respondent conditioning. This test began immediately and without warning following the final respondent conditioning trial. That is, after the standard 45- to 60-s intertrial interval, one of the two stimuli, A1 or A3, was presented for 3 s. The two stimuli were then presented in a quasirandom order (i.e., no more than three successive exposures to either stimulus) for 3 s per presentation until a subject had been exposed to each stimulus at least six times. An intertrial interval of 45 to 60 s separated all test trials. Conditioned SRRs to these stimuli were measured using the same procedures employed during respondent conditioning, from the point of stimulus onset for the subsequent 5 s. The sexual and nonsexual USs were not relayed to the television monitor during this testing phase.

As stated earlier, it came to the attention of the experimenters that subjects often became fatigued and unresponsive to experimental stimuli when experimental sessions exceeded 2 hr. However, when the test for derived transformation was completed comfortably within this time limit, additional test trials were administered to the subject. Thus, the number of trials presented during the test for a transformation of function varied across subjects. All additional measures of a transformation of function were included in subsequent statistical analyses.

When A1 and A3 had each been presented six times, or when the 2-hr time limit had expired, the test for a transformation of function was complete. At this stage, subjects from Experiment 2 were exposed to the equivalence test as described above. Finally, subjects from Experiments 1 and 2 were asked to respond to a series of semantic differential scales by rating, on a scale of 1 to 5, the degree to which each of the four experimental stimuli (C1, C3, A1, and A3) predicted the onset of a sexual film clip, where 5 indicated certainty that sexual material would follow, and 1 indicated certainty that sexual material would not follow. This was done as a further measure of the transformation of stimulus function.

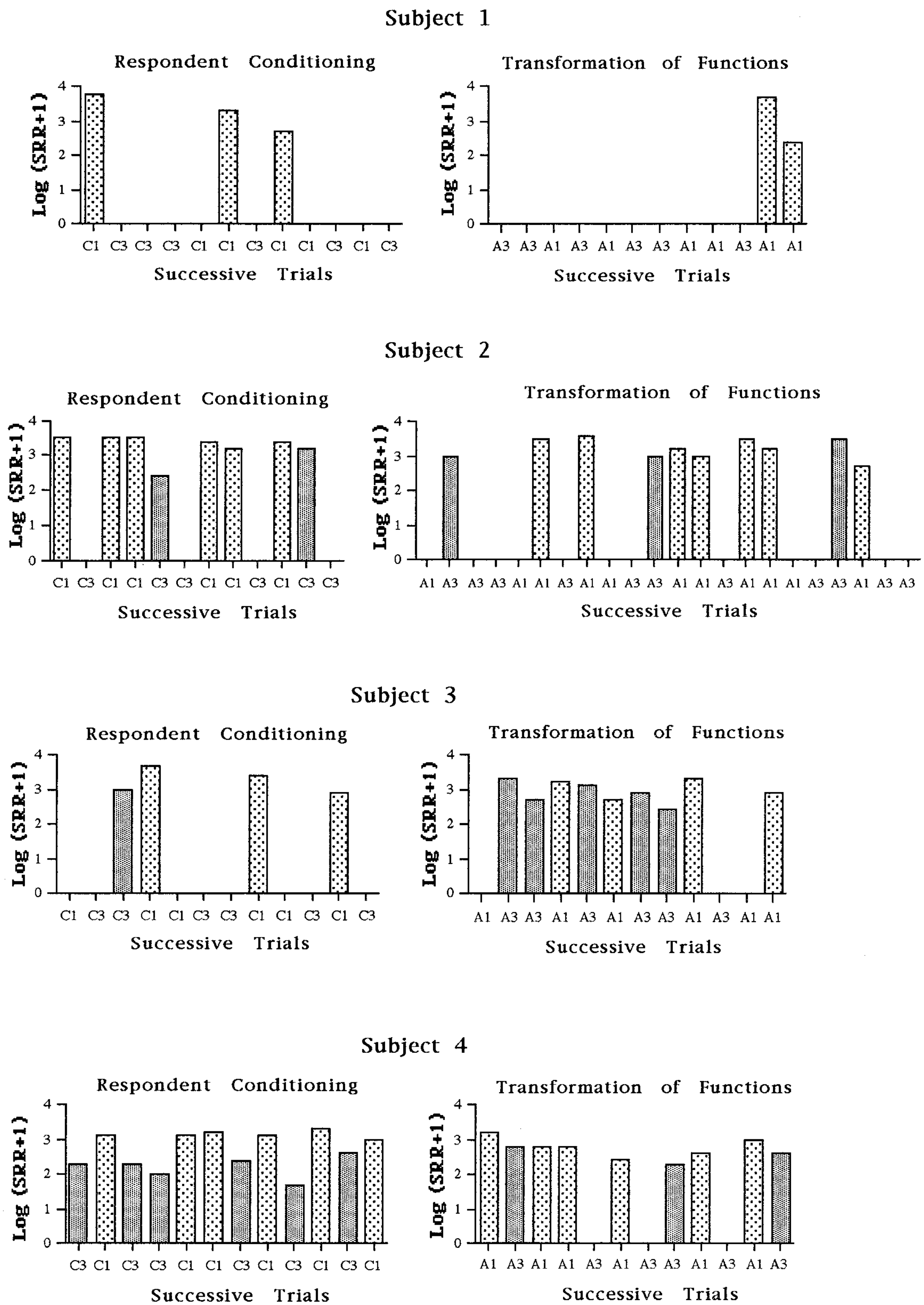
Results and Discussion

Responses to each presentation of the four experimental stimuli (C1, C3, A1, A3) can be seen in Figure 1 (Experiment 1) and Figure 2 (Experiment 2). For the purposes of graphical representation and statistical analysis, SRRs were transformed according to the function log (SRR + 1) (Venables & Christie, 1980). This transformation reduces the skew and kurtosis commonly observed across multiple SRRs and permits the inclusion of zero values, because the log of zero is undefined. Dependent t tests were used to analyze the response differentials (converted into log values). Two separate t tests were used for each subject to compare all SRRs to C1 and C3 and all SRRs to A1 and A3. This general statistical model was also used in all subsequent experiments. The t test was chosen because it is most appropriate when successive experimental trials are assumed to be independent of each other (Box & Tiao, 1965).

Experiment 1

Table 1 shows the number of training trials subjects required during each experimental session, and the number of times they responded in accordance with equivalence relations during each test phase. All 4 subjects produced response patterns that were consistent with equivalence relations within two exposures to the test phase during each experimental session. Subjects 1, 2, and 4 each demonstrated statistically greater responses to C1 than to C3 ($p < .05$) (see Figure 1). Subjects 2 and 4 each demonstrated a transformation of this respondently conditioned response differential, with significantly greater responses to A1 than to A3 ($p < .05$). Subject 1 demonstrated a response differential to A1 and A3 that was not significant ($p > .05$) but was in the predicted direction. Subject 3 showed a nonsignificant ($p > .05$) response differential to C1 and C3 in the predicted direction but showed neither statistical nor visual evidence of greater SRRs to A1 over A3.

Each subject's postexperimental responses to the semantic differential scales are shown in Table 2. In general, these verbal reports were consistent with the electrodermal measures. Verbal report functions clearly trans-


Subject 1
Respondent Conditioning
Log (SRR+1)
0 1 2 3 4
C1 C3 C3 C3 C1 C1 C3 C1 C1 C3 C1 C3
Successive Trials
Transformation of Functions
Log (SRR+1)
0 1 2 3 4
A3 A3 A1 A3 A1 A3 A3 A1 A1 A3 A1 A1
Successive Trials
Subject 2
Respondent Conditioning
Log (SRR+1)
0 1 2 3 4
C1 C3 C1 C1 C3 C3 C1 C1 C3 C1 C3 C3
Successive Trials
Transformation of Functions
Log (SRR+1)
0 1 2 3 4
A1 A3 A3 A3 A1 A1 A3 A1 A1 A3 A3 A1 A1 A3 A1 A1 A1 A3 A3 A1 A3 A3
Successive Trials
Subject 3
Respondent Conditioning
Log (SRR+1)
0 1 2 3 4
C1 C3 C3 C1 C1 C3 C3 C1 C1 C3 C1 C3
Successive Trials
Transformation of Functions
Log (SRR+1)
0 1 2 3 4
A1 A3 A3 A1 A3 A1 A3 A3 A1 A3 A1 A1
Successive Trials
Subject 4
Respondent Conditioning
Log (SRR+1)
0 1 2 3 4
C3 C1 C3 C3 C1 C1 C3 C1 C3 C1 C3 C1
Successive Trials
Transformation of Functions
Log (SRR+1)
0 1 2 3 4
A1 A3 A1 A1 A3 A1 A3 A3 A1 A3 A1 A3
Successive Trials

ferred from C1 and C3 to A1 and A3, respectively, for 2 of the 3 subjects who demonstrated visual evidence of respondent conditioning and a transformation of function (i.e., Subjects 1 and 4). Somewhat weaker evidence of a transformation was obtained from Subject 2. Subject 3, who failed to show either a significant level of respondent conditioning or any evidence of a transformation of function, also failed to make discriminations between C1 and C3 or between A1 and A3 in terms of their association with sexual film clips.

Experiment 2

Table 3 presents the number of training trials subjects required during each experimental session, and the number of times they responded in accordance with equivalence relations during the test phase at the end of Session 2. Conditioned SRRs to each of the four experimental stimuli (C1, C3, A1, A3) can be seen in Figure 2. Following matching-to-sample training, Subjects 5, 6, and 7 each demonstrated significant ($p < .05$) respondent conditioning, with greater responses to C1 than to C3 during Session 2. Furthermore, this significant response differential transferred in accordance with equivalence relations to the A stimuli, such that each subject produced significantly greater responses to A1 than to A3 ($p < .05$).

All subjects responded in accordance with the predicted equivalence relations on their first exposure to the equivalence test following the test for a transformation of function (Table 3). Each subject's responses to the semantic differential scales are shown in Table 2. Verbal reports transferred from C1 and C3 to A1 and A3, respectively, for all 3 subjects.

The data from Experiments 1 and 2 were combined to permit group analyses. The mean SRR to each of the four experimental stimuli (C1, C3, A1, A3) was calculated for each of the 7 subjects by averaging their multiple responses to C1, C3, A1, and A3. Two separate t tests were then used to compare the mean response differentials between C1 and C3 and between A1 and A3. The analysis indicated significant ($p < .05$) respondent conditioning and transformation of function across the 7 subjects. A graphical representation of subjects' response means is shown in Figure 3.

In summary, Experiment 1 demonstrated the transformation of a conditioned eliciting function in accordance with equivalence relations, and Experiment 2 found that such transformations can precede the administration of a formal matching-to-sample equivalence test. Furthermore, subjects' verbal reports were usually consistent with the transformation effects that were visible in the graphical representations of their SRRs.

EXPERIMENT 3

Experiments 1 and 2 demonstrated a transformation of function in accordance with two three-member equivalence relations both before and after matching-to-sample equivalence testing. Although these data are consistent with the possibility that human sexual behavior may emerge in the absence of direct reinforcement or stimulus pairings, the derived transformation of eliciting function may be a relatively restricted phenomenon. Because the previous two experiments showed a transformation of function across only one node (e.g., an eliciting function was established for C1 and it transferred via a single node, B1, to A1), it remains to be seen whether a function would be transformed when two or more nodes are involved. Such a demonstration would support the possibility that stimuli may acquire their sexual function in relatively indirect and complex ways. This demonstration would also extend the work of Dougher et al. (1994), insofar as their research involved only one-node transformation effects. In their study, subjects were trained on a series of conditional discriminations (A1-B1, A1-C1, A1-D1, A2-B2, A2-C2, A2-D2) leading to the emergence of two four-member equivalence relations, and after eliciting fear functions were directly established

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Fig. 1. Experiment 1: electrodermal responses to each presentation of the four experimental stimuli. For this and all subsequent figures, the quasirandom order of stimulus presentation is preserved along the x axis. Light bars represent responses to C1 or A1, and dark bars represent responses to C3 or A3.

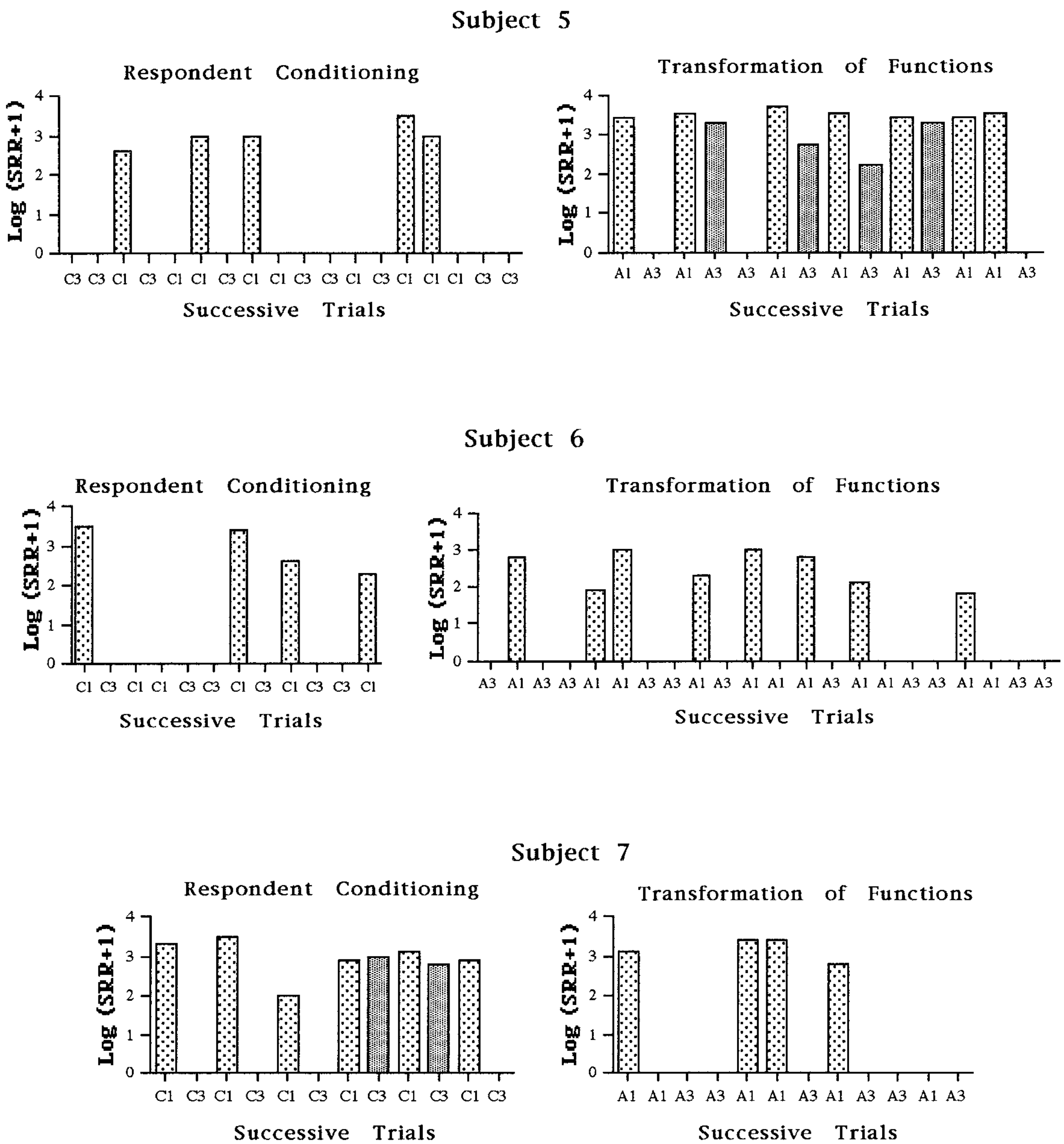


Fig. 2. Experiment 2: electrodermal responses to each presentation of the four experimental stimuli. Light bars represent responses to C1 or A1, and dark bars represent responses to C3 or A3.

for B1, they emerged for C1 and D1 via the A1 node.

Experiment 3 attempted to demonstrate a derived transformation of respondent function in accordance with two five-member three-node equivalence relations (e.g., E1 → D1 → C1 → B1 → A1). To achieve this, subjects were trained on a series of related conditional discriminations (i.e., A1-B1, B1-C1, C1-D1, D1-E1; A2-B2, B2-C2, C2-D2, D2-E2; A3-B3, B3-C3, C3-D3, D3-E3) that led to the emergence of equivalence relations during testing (e.g., E1-A1, E2-A2, E3-A3). A differential eliciting function was also established for E1 and E3 using sexual and nonsexual film clips. Subjects who demonstrated a response differential between E1 and E3 during respondent conditioning were tested for a

Table 1

Number of training trials and number of trials on which equivalence performances were shown across both sessions of Experiment 1.

Session	Task type	Subject 1		Subject 2		Subject 3	Subject 4	
1	Training trials	156	18	90	66	90	54	
	C1-A1	6	10	10	10	10	10	
	C2-A2	1	9	3	10	10	10	
	C3-A3	10	10	9	9	10	10	
2	Training trials	18		66		36	24	24
	C1-A1	10		10		10	1	10
	C2-A2	10		10		10	2	10
	C3-A3	10		9		10	3	10

Note. Successive exposures to equivalence training and testing are represented from left to right in the data columns, where more than one exposure to these phases was required. Subjects were exposed to each test task 10 times on any one exposure to the test phase.

Table 2

Verbal reports of the degree to which each experimental stimulus predicted the onset of a sexual film clip.

Experiment	Subject	C1	C3	A1	A3	E1	E3	A1	A3	B1	B2	C1	C2
1	1	5	1	4	2								
	2	5	1	2	1								
	3	3	3	2	2								
	4	5	1	4	1								
2	5	5	1	4	1								
	6	5	1	3	1								
	7	5	1	5	1								
3	8					4	1	4	1				
	9					5	1	4	1				
4	10									5	1	4	1
	11									5	1	4	1
	12									5	2	4	2
	13[a]									1	5	2	4
	14[a]									1	5	1	3
	15[a]									1	5	1	5

Note. 1 indicates certainty that sexual material would not follow; 5 indicates certainty that sexual material would follow.

[a] The functions of B1 and B2 were reversed for these subjects.

transformation of that stimulus function in accordance with the three-node equivalence relations. This was done by measuring SRRs to A1 and A3 in the absence of sexual and nonsexual USs.

METHOD

Subjects

Two male subjects, aged 21 and 36 years, were recruited for Experiment 3. The 1st subject was an undergraduate commerce student, and the 2nd was an American attorney on a career break in Ireland. Both subjects were paid three Irish punts (approximately $4.50) per hour for participation in the experiment. One additional subject, a female, was dropped from the study when her SRRs failed to change across 36 respondent training trials. Results obtained from this subject are not presented.

Apparatus

The materials were identical to those used in Experiments 1 and 2, except that an additional six nonsense syllables (MEL, NEP, MAU, LER, JUR, and FID) were employed. All nonsense syllables were assigned randomly as sample and comparison stimuli for each subject.

Session 1

All procedures were the same as those followed during Session 1 in Experiments 1 and 2, except for the following details. The preliminary respondent conditioning procedure was designed to establish differential eliciting stimulus functions in E1 and E3 (rather than C1 and C3). That is, E1 was paired with the sexual film clips, and E3 was paired with the nonsexual film clips. There were 12 matching-to-sample training tasks (rather than six): Choose B1, B2, and B3 given A1, A2, and A3,

Table 3

Number of training trials across both sessions of Experiment 2 and equivalence test performances during Session 2.

Session	Task type	Subject 5	Subject 6	Subject 7
1	Training trials	198	498	30
2	Training trials	198	66	30
	C1-A1	10	10	10
	C2-A2	9	9	10
	C3-A3	10	10	10

Note. Subjects were exposed to each test task 10 times during exposure to the test phase.

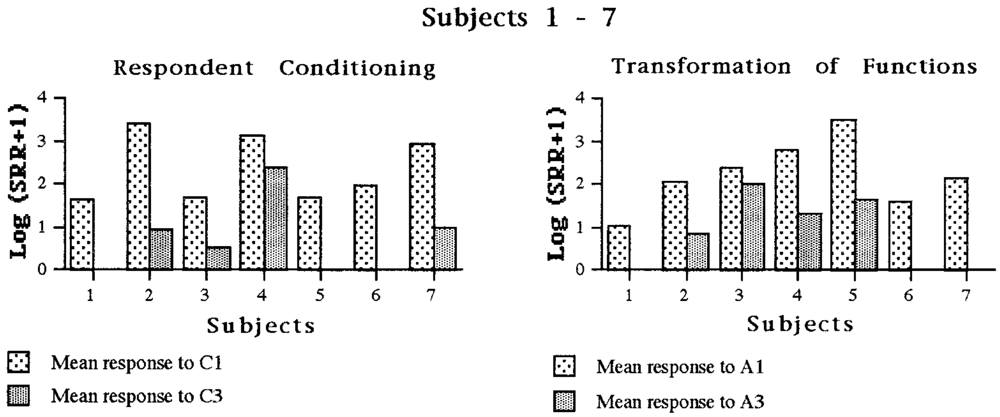


Fig. 3. Experiments 1 and 2: mean electrodermal response across all presentations of each of the four experimental stimuli for each subject.

respectively; choose C1, C2, and C3, given B1, B2, and B3, respectively; choose D1, D2, and D3, given C1, C2, and C3, respectively; and choose E1, E2, and E3, given D1, D2, and D3, respectively. The A stimuli were first presented with B1, B2, and B3 in a quasirandom order. Each task was presented twice every six trials until the subject responded correctly across a single block of six trials. The B-C tasks were then added and presented in a quasirandom order (i.e., two exposures to each A-B and B-C task, every 12 trials) until the subject responded correctly across a single block of 12 trials. The C-D tasks were then added and presented in a quasirandom order (i.e., two exposures to each A-B, B-C, and C-D task, every 18 trials) until the subject produced 18 consecutive correct responses across a single block of 18 trials. Finally, the D-E tasks were added and presented in a quasirandom order (i.e., two exposures to each A-B, B-C, C-D, and D-E task, every 24 trials) until the subject produced 24 consecutively correct responses. This training sequence differed from that employed in Experiments 1 and 2, in which all relations were established simultaneously.

The testing phase used nine tasks (rather than three) to probe for the following emergent stimulus relations: E1-A1, E2-A2, E3-A3, E1-B1, E2-B2, E3-B3, E1-C1, E2-C2, E3-C3. For each of these nine tasks, one of the E stimuli was presented as a sample stimulus, with the A, B, or C stimuli as comparisons (e.g., E1 [A1-A2-A3]). Testing occurred across 45 trials, with tasks presented in a quasirandom order.

Because of the large number of test tasks (nine) administered, subjects were exposed to each task on five trials rather than 10. A predetermined mastery criterion of 80% was employed in Experiment 3, such that subjects were exposed to the testing phase until they chose the class-consistent comparison at least four times across five exposures to each task. Because of the increased complexity of the equivalence test compared to the three-member equivalence relations that were examined in the previous experiments, subjects were not required to produce equivalence responding during Session 1 (nor did they), but were simply exposed to matching-to-sample training and testing for the duration of the experimental session (2 hr). It was agreed that subjects who failed to produce equivalence responding within five exposures to the test phase, across both sessions of Experiment 3, would be dropped from the study.

Session 2

All of the procedures were the same as those followed during Session 2 in Experiment 1, except for the following details. Subjects were reexposed to the matching-to-sample training and testing, outlined in the previous section, until they responded in accordance with equivalence relations (e.g., E1-C1, E1-B1, E1-A1), or until they had been exposed to the training and testing cycle a total of five times. During respondent condi-

Table 4

Performances on successive exposures to the equivalence test for both sessions of Experiment 3.

Task type	Subject 8				9			
Training trials	96	66	78	102	834	180	60	66
E1-C1	1	1	0	5	2	2	5	5
E2-C2	5	2	0	5	1	1	0	5
E3-C3	0	3	2	4	2	1	0	5
E1-B1	5	5	1	5	3	2	0	5
E2-B2	0	1	1	5	4	1	0	5
E3-B3	1	2	1	5	2	0	5	5
E1-A1	0	1	1	5	2	2	0	5
E2-A2	1	3	0	5	4	4	5	5
E3-A3	1	2	1	5	1	1	0	4

Note. Each test task was presented five times during each test phase. The four columns of data appearing for each subject represent, from left to right, the number of trials on which responses were consistent with equivalence relations during successive exposures to the equivalence training and testing across both experimental sessions.

tioning, responses to E1 and E3 were recorded using the same procedures employed during Experiments 1 and 2 (i.e., from the point of stimulus onset for the subsequent 5 s). The test for a transformation of function examined whether the response differential to E1 and E3 transferred to A1 and A3 in accordance with the three-node equivalence relations.

Results and Discussion

Table 4 presents the number of training trials subjects required during each training phase, and the number of times they responded in accordance with the equivalence relations during each test phase. Both subjects required the entire first session to complete their first exposure to the matching-to-sample training and testing. Both subjects then required three further exposures to the training and testing cycle before producing equivalence responding.

Responses to each presentation of the four experimental stimuli (E1, E3, A1, A3) can be seen in Figure 4. Two separate *t* tests indicated that both subjects demonstrated significantly greater conditioned responses to E1 than to E3 ($p < .05$). An additional two *t* tests also showed a significant response differential between A1 and A3 ($p < .05$) for both subjects, indicating the successful transformation of an eliciting function in accordance with the three-node equivalence relations (i.e., significantly greater responses to A1 than to A3). Subjects' verbal reports were consistent with physiological measures of respondent conditioning and the transformation of function (see Table 2).

In summary, Experiment 3 demonstrated that the derived transformation of respondently conditioned stimulus functions can be extended across three-node equivalence relations. Thus, it seems plausible that many of the stimuli that an individual responds to as sexual may acquire such functions in highly complex and indirect ways.

EXPERIMENT 4

The results of Experiments 1 through 3 extend the derived transformation-of-function effect. Experiment 4 attempted to extend this transformation effect even further by adopting procedures that allowed a test for a transformation of eliciting function in accordance with more than one type of arbitrarily applicable relation.

One recent account that places considerable emphasis on the analysis of multiple arbitrarily applicable relations is relational frame theory (Barnes, 1994; Barnes & Holmes, 1991; Barnes & Roche, 1996; Dymond & Barnes, 1995, 1996; Hayes, 1991; Roche & Barnes, 1996; Steele & Hayes, 1991). In the first empirical investigation of this account (Steele & Hayes, 1991, Experiment 1), subjects were trained to relate "same" stimuli (e.g., a long line with a long line) in the presence of one contextual cue, and "opposite" stimuli (e.g., a long line with a short line) in the presence of a second contextual cue. Subsequently, subjects were taught an extensive network of conditional discriminations, with each discrimination being made in the presence of one of the two contextual cues (i.e., same or opposite). For example, consider the following two training trials, O/A1-(B1-*B2*) and O/A1-(C1-*C2*), where O represents the opposite contextual cue, A1 represents the sample stimulus, and the B and C stimuli represent the comparison stimuli (italic stimuli represent the reinforced choices for each task). Having been exposed to the above training tasks, a relevant test trial was as follows: O/B2-(C1-C2). The equivalence para-

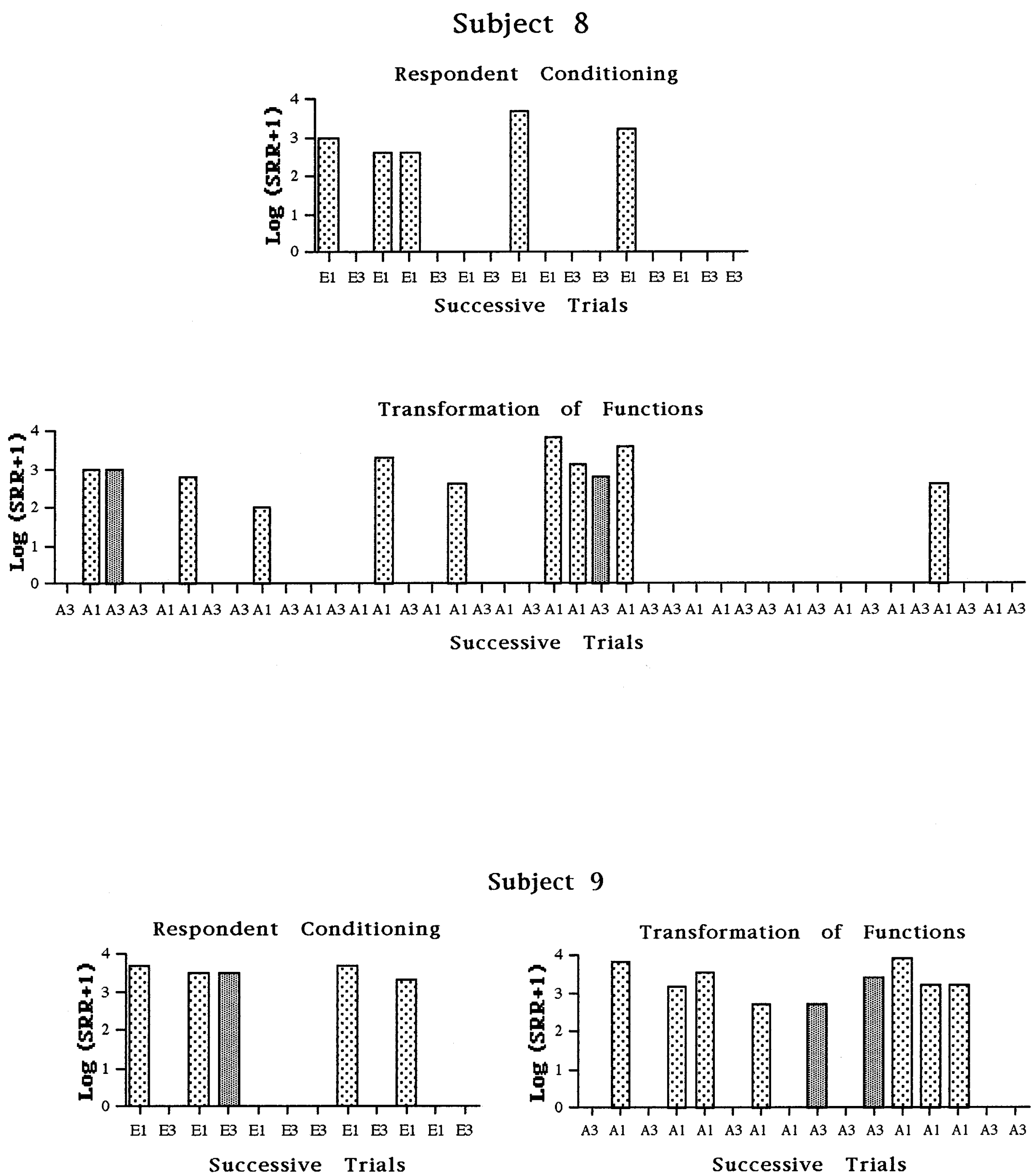


Fig. 4. Experiment 3: electrodermal responses to each of the four experimental stimuli. Light bars represent responses to E1 or A1, and dark bars represent responses to E3 or A3.

digm predicts that subjects should choose C2 on this task because choices of B2 and C2 were reinforced in the presence of A1 during training. Even if subjects responded directly to the O stimulus as a sample, C2 would still be the predicted choice because choosing C2 had been reinforced in the presence of the O stimulus. In fact, subjects chose C1, indicating that they were responding in accordance with the derived relation of opposition (i.e., because both B2 and C2 were the opposite of A1, C2 and B2 were the same as each other and therefore could not be opposites).

Relational frame theory may have important implications for the analysis of a broad range of complex human sexual behavior, insofar as the concepts of gender and sex-appropriate behavior are often discussed in terms of same and opposite (e.g., opposite sex, same sex, opposite orientation) (see Barnes & Roche, in press). For illustrative purposes, consider the following speculative example. Women are often referred to as the opposite of men. It is not unreasonable to expect, therefore, that in the context of sex-appropriate behavior, men may respond to women as opposites. One effect of this might be that men who emulate traditional masculine characteristics, such as emotional control, may respond to women as emotionally weak (i.e., if women are opposite to men, they should be opposite to emotionally strong). Of even greater relevance to the current paper, however, is that sexual stimulus functions may now transform in accordance with such a relational network. For instance, a man may now respond to emotionally weak women (e.g., women who cry easily) as being sexually attractive because such women are seen to be genuinely opposite to men, or genuinely feminine, despite the fact that sexual attraction to emotionally weak women has not been explicitly reinforced. Experiment 4 of the current study examined the possibility that a respondently conditioned eliciting function may transform in accordance with the arbitrarily applicable relations of sameness and opposition.

Method

Subjects

Three male and 3 female subjects, aged between 18 and 21 years, completed Experiment 4. Two additional subjects were dropped from the study following their failure to satisfy the mastery criterion employed during the relational testing phase of the experiment (see below), and another chose to terminate her participation due to the graphic nature of the sexual film clips. Subjects 10, 11, and 13 were female psychology undergraduates, Subject 12 was a male undergraduate art student, and Subjects 14 and 15 were male computer science students. None of these subjects was familiar with stimulus equivalence or relational frame theory. Each subject was paid three Irish punts (approximately $4.50) per hour for participation in the experiment.

Apparatus

The materials were identical to those used in Experiments 1 and 2, with the following exceptions. Two stimuli, each consisting of a string of six characters (!!!!!! and %%%%%%) were used as contextual cues (i.e., same and opposite). For each subject these stimuli were randomly assigned to the roles of same and opposite. Finally, 14 of the 15 nonsense syllables used in Experiment 3 were also employed in Experiment 4. These were randomly assigned as samples, comparisons, and conditioned stimuli for each subject in the experiment.

Relational training and testing tasks were presented on a British Broadcasting Corporation microcomputer (Master Series 128, Acorn Computer Ltd.) with a floppy disk drive (pace) and a RGB computer screen (Type 28 ADF32) that displayed green characters on a black background. Stimulus presentations and the recording of responses were controlled by the computer, which was programmed in BBC BASIC.

Session 1

The preliminary respondent conditioning procedure was identical to that used during Experiments 1 and 2 except that for Subjects 10, 11, and 12, sexual and nonsexual film clips were paired with B1 and B2, respectively, whereas for Subjects 13, 14, and 15, sexual and nonsexual film clips were paired with B2 and B1, respectively.

The matching-to-sample training and testing used in Experiments 1 and 2 was replaced by relational pretraining, relational training, and relational testing. On all tasks (pretraining, relational training, and testing), the contextual stimulus (see below) appeared in the center top third of the computer screen. The sample stimulus appeared in the middle of the screen 1 s later, and after an additional 1-s delay, three comparison stimuli appeared in a row at the bottom of the screen. Contextual cue, sample, and comparison stimuli remained on the screen together, and no observing response to the sample was required.

The screen position of the comparison stimuli (left, middle, or right) was counterbalanced across trials. Feedback ("correct" or "wrong") followed responses on all training trials, and was followed in turn by an intertrial interval (the screen remained blank for 2.5 s). During relational testing tasks, all feedback was omitted; responses were simply followed by the intertrial interval. Subjects were not informed that feedback would be terminated during this phase.

Same/opposite pretraining. The relational pretraining was designed to establish functions of same and opposite for the contextual cues (!!!!!!, %%%%%%) that would be used subsequently in the relational training and testing. The sample and comparison stimuli used during pretraining were related to each other along a physical dimension. For example, one set of comparison stimuli for this stage consisted of a long line, a medium line, and a short line. Thus, given a short-line sample stimulus in the presence of the opposite contextual cue, choosing the long-line comparison stimulus was reinforced. However, given the same contextual cue and a short line, choice of the short-line comparison was reinforced. In this way contextual control was established. Four tasks constituted one problem set (i.e., same/long line-long line, same/short line-short line, opposite/long line-short line, opposite/short line-long line). In total, there were eight problem sets (based on the Steele & Hayes, 1991, problem sets; see also Dymond & Barnes, 1995, 1996), each consisting of four tasks.

The tasks for each problem set were presented in a quasirandom order in blocks of four trials, with each task presented once per block until the subject produced four consecutive correct responses. Subjects were then trained on a second problem set, and after four consecutive correct responses they were trained on a third problem set. Following four consecutive correct responses on this third problem set, tasks from all three problem sets were presented in a quasirandom order (i.e., one task from each problem set presented every three trials) until subjects produced six consecutive correct responses. Feedback was then terminated without warning, and subjects were tested on three novel problem sets (Sets 4, 5, and 6). These were presented in a quasirandom order (throughout pretraining, the quasirandom order always involved presenting one task from each of the n problem sets every n trials). If subjects met the mastery criterion (i.e., produced six consecutive correct responses across the first six trials), the pretraining was terminated. If subjects failed to meet this criterion (six consecutive correct responses), they were retrained on Problem Sets 1 to 4. Tasks were presented in a quasirandom order until subjects produced eight consecutive correct responses. Feedback was then terminated and subjects were tested on Problem Sets 5 and 6 and a completely novel Set 7. These were presented in a quasirandom order, and if subjects met the mastery criterion, the pretraining was terminated. If subjects failed to meet the criterion they were retrained on Problem Sets 1 to 5. Tasks were presented in a quasirandom order until subjects produced 10 consecutive correct responses. Feedback was then terminated and subjects were tested on Problem Sets 6 and 7 and a completely novel Set 8. These were presented in a quasirandom order, and if subjects met the mastery criterion the pretraining was terminated. None of the subjects failed at this level of testing.

Relational training. Immediately following relational pretraining, Subjects 10, 11, 13, and 14 were exposed to the following training tasks: same/A1-(*B1*-B2-N1), same/A1-(*C1*-C2-N2), opposite/A1-(B1-*B2*-N1), opposite/A1-(C1-*C2*-N2) (italic comparison stimuli indicate reinforced choices). The N1 and N2 stimuli were included as incorrect comparison stimuli but were not employed during respondent conditioning or the test for a transformation of function.

Training occurred in blocks of 40 trials, with each of the four tasks presented 10 times in a quasirandom order. Subjects were required to choose the correct comparison at least nine times across 10 exposures to each of the tasks within a block in order to complete training. The relational network is shown in Figure 5.

The relational training for Subjects 12 and 15 employed the same four tasks used for the other subjects. However, an additional four tasks were also employed for these subjects: same/X1-(*Y1*-B1-N3), same/X1-(*Y2*-C1-N4), opposite/X1-(*Y3*-B2-N3), opposite/X1-(*Y4*-C2-N4). The N3 and N4 stimuli were

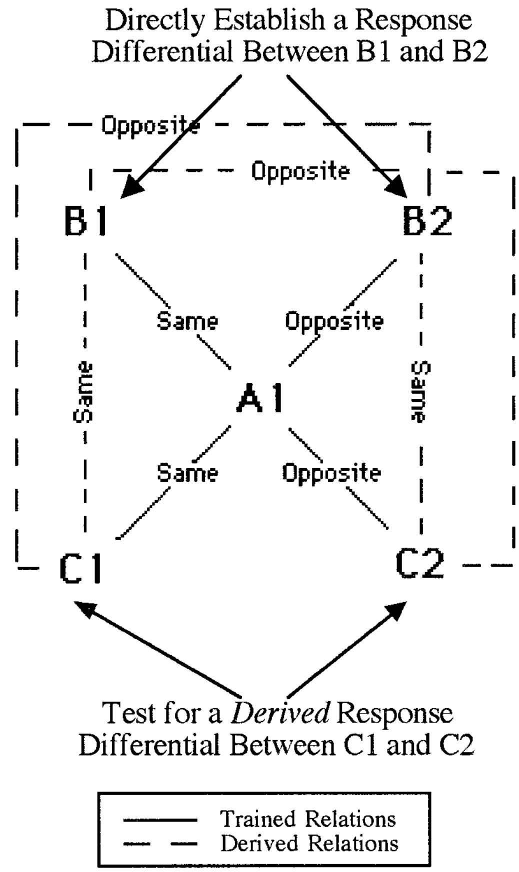


Fig. 5. Diagrammatic representation of the relational network that was trained and tested in Experiment 4.

included as incorrect comparison stimuli but were not employed during respondent conditioning or during the test for a transformation of function. These four additional training tasks were included to ensure that choosing B1 and C1 in the presence of same, and choosing B2 and C2 in the presence of opposite, would be reinforced on some trials but not on others. This pattern of reinforcement was used to control for the possibility that the same and opposite cues could function as mediating nodes for simple equivalence relations between B1 and C1 and between B2 and C2, respectively (see Dymond & Barnes, 1995, 1996, for detailed discussions of this issue).

Training for Subjects 12 and 15 occurred in blocks of 80 trials, with each of the eight tasks presented 10 times in a quasirandom order. The subjects were required to choose the correct comparison at least nine times across 10 exposures to each task to complete the relational training.

Relational testing. The relational testing phase determined whether responding in accordance with the derived relations of sameness and opposition would emerge. The test tasks were as follows: same/B1-(C1-C2-N2); same/B2-(C1-C2-N2); opposite/B1-(C1-C2-N2); opposite/B2-(C1-C2-N2). Note that the X, Y, Z, N3, and N4 stimuli were not presented to any of the subjects during relational testing. It was predicted that subjects would (a) relate B1 with C1 in the presence of same (i.e., B1 and C1 are both the same as A1 and therefore the same as each other), (b) relate B2 with C2 in the presence of same (i.e., B2 and C2 are both opposite to A1 and therefore the same as each other), (c) relate B1 with C2 in the presence of opposite (i.e., B1 is the same as A1 and C2 is opposite to A1, and therefore B1 is opposite to C2), and (d) relate B2 with C1 in the presence of opposite (i.e., B2 is opposite to A1 and C1 is the same as A1, therefore B2 is opposite to C1). Testing occurred across blocks of 40 trials, with each of the four tasks presented 10 times in a quasirandom order. If a subject failed to produce the predicted performance on nine of 10 trials for each task, he or she was reexposed to the relational training and testing sequence up to a maximum of four times in each session (i.e., a maximum of eight exposures in total).

Session 2

Upon returning for the second experimental session, subjects were reexposed to the relational training and testing, but not to the relational pretraining, that they had completed during Session 1. The respondent conditioning and transformation test procedure was identical to that followed during Experiments 1 and 2, except that for Subjects 10, 11, and 12, sexual and nonsexual film clips were paired with B1 and B2, respectively, whereas for Subjects 13, 14, and 15, the functions of B1 and B2 were reversed. This procedure allowed us to examine whether an explicitly established response differential could be transformed in accordance with the relations of sameness and opposition (i.e., in the context of the relational training, B1 is related to C1 in accordance with two same relations and B2 is related to C2 through two opposite relations).

Subjects were not presented with contextual cues during the test for a transformation of function. It was assumed that, in the absence of any contextual cues, an eliciting function established for one stimulus would also emerge for a second stimulus that was related via sameness to the first stimulus. This assumption is consistent with relational frame theory, which views sameness or equivalence as the most common and fundamental type of relational responding (see Barnes, 1994; Barnes & Roche, 1996; Hayes & Hayes, 1989).

RESULTS

Table 5 shows the number of training trials and the number of times each subject responded in accordance with the predicted stimulus relations for each exposure to the test phase, during both experimental sessions. Performances on the relational pretraining phase of Session 1 are not included. Subjects' SRRs to each of the four experimental stimuli B1, B2, C1, and C2 can be seen in Figures 6 (Subjects 10, 11, and 12) and 7 (Subjects 13, 14, and 15). (The reader is again reminded that the functions of B1 and B2 were reversed for Subjects 13, 14, and 15.)

Table 5

The number of training trials and relation-consistent responses on each testing task in Experiment 4.

Session	Task type	Subject 10	11		12		13	14	15	
1	Training trials	80	120	80	240	160	120	80	420	80
	Same/B1-C1	10	6	10	6	9	9	10	7	10
	Opp/B1-C2	9	6	10	8	10	9	10	9	10
	Same/B2-C2	10	5	10	7	10	9	10	8	10
	Opp/B2-C1	9	8	9	7	10	10	10	5	9
2	Training trials	40	80	40	80		40	40	80	
	Same/B1-C1	10	8	10	10		10	10	9	
	Opp/B1-C2	10	7	10	10		10	10	10	
	Same/B2-C2	10	7	10	10		9	10	9	
	Opp/B2-C1	10	9	10	10		10	10	9	

Note. Successive exposures to relational training and testing are represented from left to right in the data columns, where more than one exposure to these phases was required. Subjects were exposed to each test task 10 times on any one exposure to the test phase. Subjects 10, 11, 13, and 14 were exposed to training in blocks of 40 trials, whereas Subjects 12 and 15 were trained in blocks of 80 trials before being exposed to the test phase.

Subject 10 demonstrated a visible but statistically insignificant response differential to B1 over B2 ($p > .05$). She subsequently failed to produce any discernible responses to either C1 or C2 during the test for a transformation of function. It was discovered that this subject had fallen asleep during the test for derived transformation. Subjects 11 and 12 each demonstrated significantly greater responses to B1 than to B2 ($p < .05$) and a subsequent transfer of this response differential to C1 and C2, respectively (i.e., significantly greater responses to C1 over C2; $p < .05$). Subject 13 demonstrated significantly greater responses to B2 than to B1 ($p < .05$), but failed to demonstrate a significant derived response differential to C2 and C1 ($p > .05$). Visual inspection of Figure 7, however, shows that the response differential was in the predicted direction. Subjects 14 and 15 each demonstrated significantly greater responses to B2 than to B1 ($p < .05$) and the

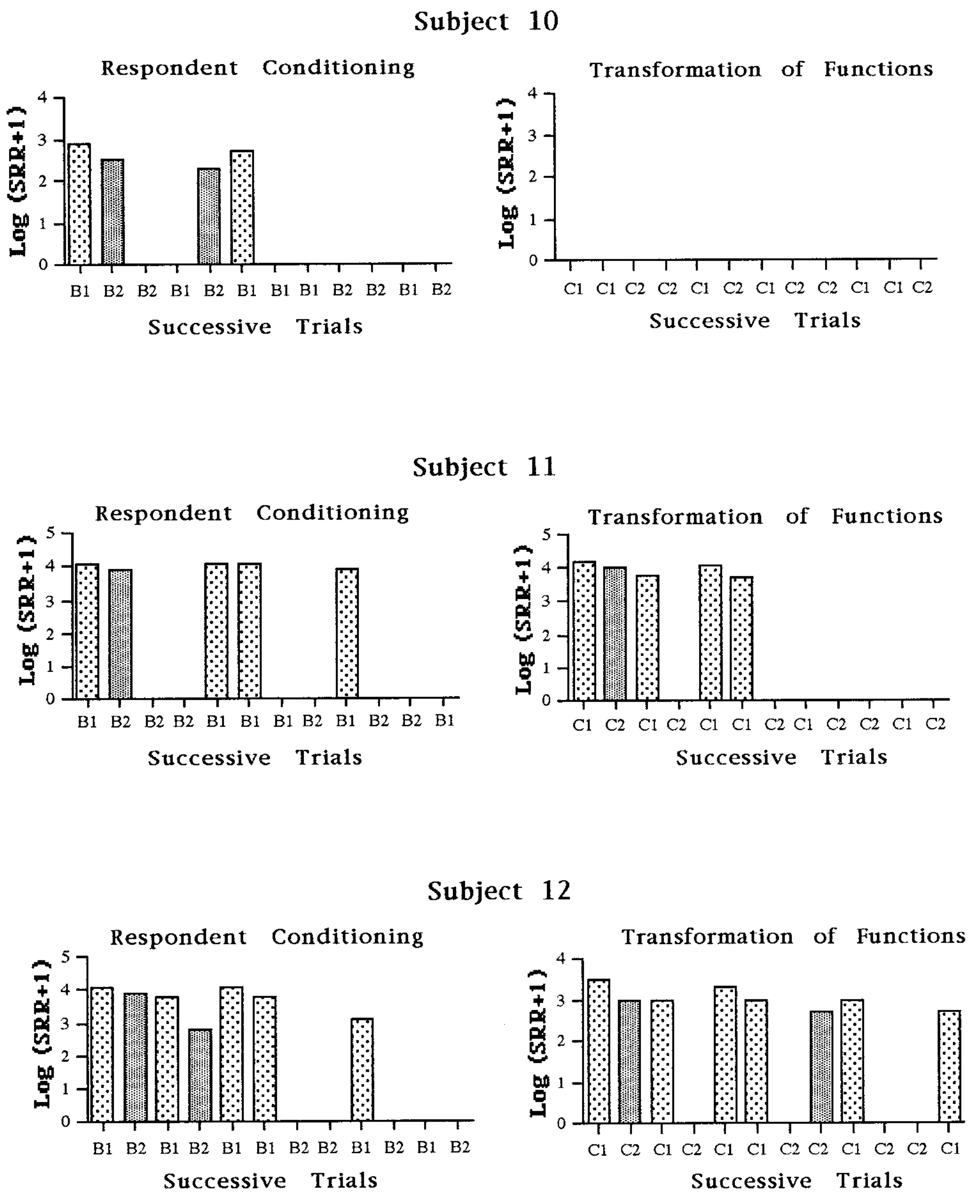


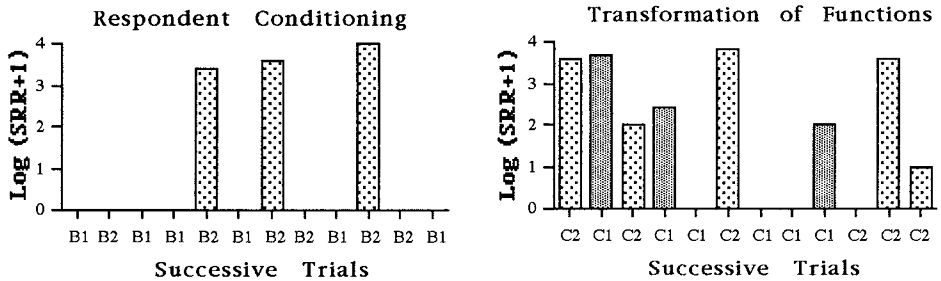
Fig. 6. Experiment 4: electrodermal responses produced by Subjects 10, 11, and 12 to each of the four experimental stimuli. Light bars represent responses to B1 or C1, and dark bars represent responses to B2 or C2.

subsequent transformation of this response differential according to the relational network (i.e., significantly greater SRRs to C2 over C1; $p < .05$). Verbal reports (Table 2) were consistent with the physiological measures of response transformation in all but one case. Subject 10 did not produce any discernible responses during the transformation test but reported a greater expectation of sexual material following the presentation of C1 over C2. In summary, these data demonstrate that a respondently conditioned eliciting function can be transformed in accordance with the relations of sameness and opposition.

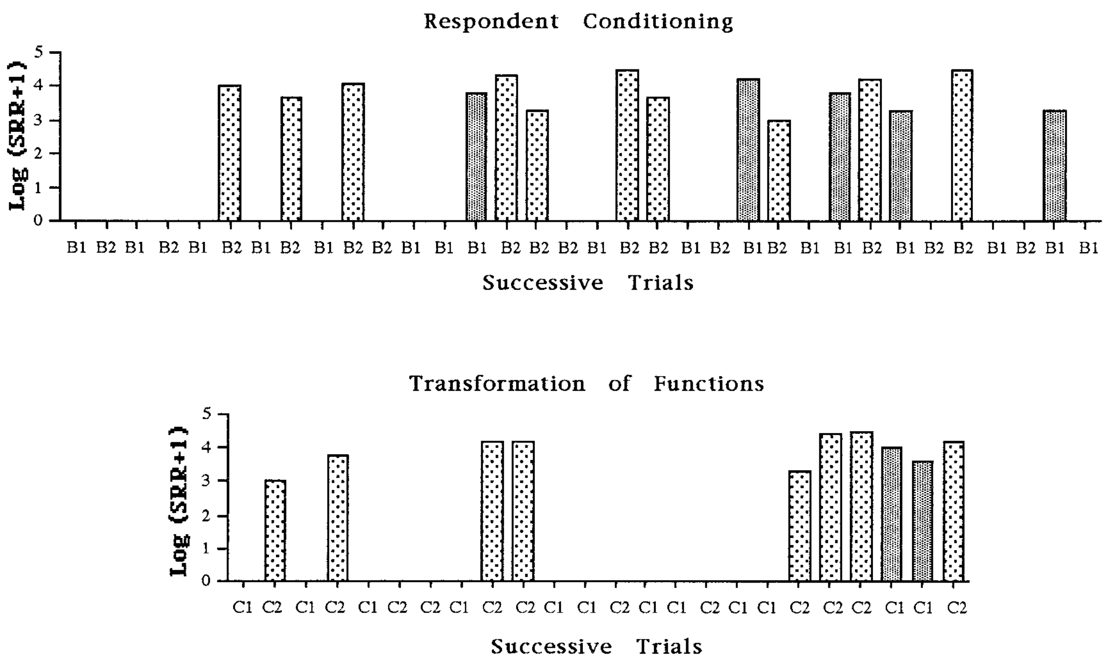
GENERAL DISCUSSION

All four experiments demonstrated that a respondently conditioned eliciting function

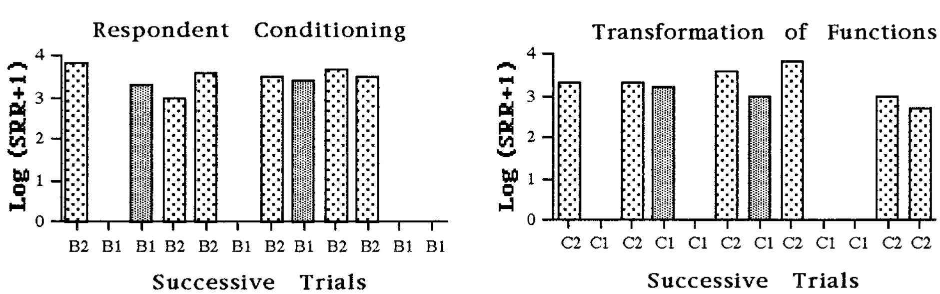
Subject 13



Subject 14



Subject 15



may be transformed in accordance with derived, arbitrarily applicable relations. Eleven of the 15 subjects demonstrated both respondent conditioning and a derived transformation of function at a significant level. Of the remaining 4 subjects, 1 demonstrated nonsignificant conditioning effects and failed to produce any discernible responses during the test for a transformation of function when she fell asleep. Another subject demonstrated nonsignificant respondent conditioning and transformation effects in the predicted direction. The remaining 2 subjects demonstrated significant respondent conditioning and a nonsignificant derived response differential in the predicted direction. These data clearly support the only other published findings in this area (Dougher et al., 1994). The current study also examined a number of important issues that extend and supplement Dougher et al.'s research. The following eight points briefly review the essential differences between the two studies.

(a) The current research examined the derived transformation of eliciting function using sexual film clips as unconditioned stimuli, instead of shock. To the extent that the elicited responses in this study were sexual in nature, it broadens the range of human behavior that can be generated through the derived transformation of respondent function. The validity of this possibility will be examined subsequently.

(b) The measurement of SRRs extends the effects found by Dougher et al. (1994), in which skin conductance responses were used to demonstrate conditioning and the derived transformation of function. It should be noted, however, that the exact nature of the relationship between skin resistance and skin conductance remains unclear, because the physiological mechanisms that underlie the electrodermal response are not fully understood, and many of these mechanisms may as yet be unidentified (Dawson et al., 1990; Fowles, 1986; see also Augustson, 1995; Roche & Barnes, 1995a, 1995b, for an informative exchange on this issue). Nevertheless, the current data serve to illustrate that transformation effects are not specific to one electrodermal measure.

(c) Experiment 2 of the current study demonstrated that formal matching-to-sample equivalence testing is not a necessary precondition for the transformation of a respondent function, and thus the transformation effects (at least in Experiment 2) cannot be readily explained on the basis of a direct association established during simultaneous presentation of the A and C stimuli during an equivalence test (see Barnes & Keenan, 1993; Hayes et al., 1991).

(d) Experiment 3 demonstrated a transformation of a respondently conditioned function in accordance with three-node equivalence relations. In the Dougher et al. (1994) study, a respondent eliciting function was transformed in accordance with one node only. Thus, the current demonstration suggests that sexual stimulus functions may emerge in even more indirect ways than might be envisaged given the data reported by Dougher et al.

(e) Experiment 4 extended research on the transformation of respondent function by demonstrating the derived transformation of function in accordance with stimulus relations other than equivalence. Specifically, relational frame procedures were used to transform respondent functions in accordance with the relations of sameness and opposition.

(f) The present research employed minimal instructions at all times. For example, before matching-to-sample training and testing, subjects in the current study were simply told, "Your task is to look at the image in the middle of the screen and choose one of the images which appears at the bottom of the screen." In contrast, Dougher et al. (1994) instructed subjects to "choose the correct symbol" and informed subjects that "the experiment will increase in difficulty, and choosing the correct symbols in the latter part of the experiment will depend on the knowledge you gain during the early parts of the experiment" (p. 334). Furthermore, Dougher et al. also informed their subjects

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Fig. 7. Experiment 4: electrodermal responses produced by Subjects 13, 14, and 15 to each of the four experimental stimuli. Light bars represent responses to B2 or C2, and dark bars represent responses to B1 or C1.

before the matching-to-sample training that, "Things that you learn during this part of the study may be important later on" (p. 334). The current study is important, therefore, in that it clearly shows that an eliciting function can transform in accordance with arbitrarily applicable relations in the absence of complex and detailed spoken or written instructions.

(g) During the tests for respondent conditioning and derived transformation, subjects were exposed to each stimulus at least six times. This contrasts with the Dougher et al. (1994) study, in which subjects were presented with each stimulus only once during these test phases. Repeated measures in the current study facilitated a statistical analysis of subjects' responsivity to each of the experimental stimuli. Psychophysiologists consider this strategy to increase measurement accuracy (Blascovich & Kelsey, 1990) because, it is argued, electrodermal measures do not correlate perfectly with the emotional intensity of stimuli (Grossman, 1967). Indeed, in the current study, responses to the experimental stimuli were discernible on as few as 50% of trials for several subjects.

(h) One final procedural distinction between the current study and that of Dougher et al. (1994) relates to the order in which conditioning trials and conditional discrimination training phases were administered to subjects. Because Dougher et al. first exposed subjects to conditional discrimination training, initial stimulus pairings (e.g., A1-B1, A1-C1, A1-D1) involved neutral stimuli with respect to their eliciting properties. Subsequent pairing of B1 with shock and the later transfer of eliciting functions to C1 and D1 seems to be broadly analogous to the phenomenon of sensory preconditioning. In contrast, subjects in Experiment 1, 2, and 3 of the current study were first exposed to a respondent conditioning procedure in which a stimulus, C1 (Experiments 1 and 2) or E1 (Experiment 3), was paired with sexual stimuli. Subjects were exposed subsequently to arranged stimulus pairings in the form of conditional discrimination training (e.g., A1-B1, B1-C1 in Experiments 1 and 2 or A1-B1, B1-C1, C1-D1, D1-E1 in Experiment 3). Consequently, the emergence of eliciting function in A1 for these experiments seems to be broadly analogous to the phenomenon of higher order conditioning rather than sensory preconditioning (see Rizley & Rescorla, 1972; see also Bierley, McSweeney, & Vannieuwkerk, 1985).

Response Variability

One problem that was encountered in the present research was that it proved to be difficult to demonstrate clear conditioning effects using electrodermal measures. Many subjects failed to produce a discernible response to every presentation of the CS that had been related to sexual film clips, and relatively large SRRs were occasionally observed upon the presentation of the CS that had been paired with nonsexual film clips. The existence of variable data is, to some extent, an inherent property of the electrodermal measure. Thus, future studies of human sexual conditioning and derived transformation of function might employ alternative measures (e.g., genital responses) that are likely to be more reliable.

Although the variable nature of our data did not cloud the observation of significant conditioning and transformation effects, it may be worthwhile to consider some of the possible sources of the observed variability. First, the CS-US contingency employed during respondent conditioning may have increased variability during transformation tests by reducing the reliability of CSs as indicators of US onset. Another source of response variability may lie in the repeated presentation of test stimuli during conditional discrimination training and equivalence testing. Specifically, the repeated presentation of these stimuli in the absence of film clips may have resulted in extinction or latent inhibition effects during respondent conditioning and during the test for a transformation of function. This issue clearly deserves further empirical analysis. Finally, a third possible source of response variability may lie in the training and testing sequence employed in the current study. As mentioned earlier, in the Dougher et al. (1994) study, subjects were not exposed to respondent conditioning trials until conditional discrimination training was complete. In the current study, however, subjects were exposed to preliminary respondent conditioning trials at the beginning of Session 1. Thus, responses to the CSs may have begun to extinguish by the end of the second session.

Another problem encountered in the current study involved the use of sexual unconditioned stimuli. We found that extensive pilot testing was necessary in order to select sexual film clips that could be used to produce reliable conditioning effects across most subjects. Several subjects, however, still remained unresponsive to the sexual material, at least as determined with electrodermal measures. The main problem here is that the intensity of a sexual stimulus presumably depends, at least in part, on the unique personal history of each subject (Zuckerman, 1983). Thus, sexual stimuli may not be the best stimuli to use in the analysis of respondent conditioning and derived transformation per se. Nevertheless, if behavior analysis is to make a useful contribution to the investigation of human sexuality, then it behooves us to develop the most effective procedures possible to conduct the appropriate analyses.

Construct Validity

A related issue concerns the validity of EDA as an index of sexual arousal. It could be argued, for example, that in the context of the current study, electrodermal responses reflected social embarrassment on the part of subjects. There are two points to be made, however, before taking this view. First, as mentioned earlier, EDA probably represents the most reliable nongenital measure of sexual arousal (see Zuckerman, 1983). Second, subjects' verbal reports, obtained using the semantic differential scales, were correlated with the EDA measures, and thus it might be argued that the sexual CSs did indeed actualize some sexual stimulus functions (i.e., expectations or thoughts of sexual material). This suggests that the current conditioning procedure was particularly effective, insofar as sex researchers have often found correlations between subjective and physiological measures difficult to establish (e.g., Farkas, Sine, & Evens, 1979; Kantorowitz, 1978; Korff & Geer, 1983; McConaghy, 1969; Osborne & Pollack, 1977; Speiss, Geer, & O'Donohue, 1984; Wincze, Hoon, & Hoon, 1977). Without doubt, however, it may be useful for future studies to examine whether other responses often measured by sex researchers (e.g., penile volume, vaginal temperature, heart rate, finger pulse amplitude, pupilliary dilation) would also transform in accordance with arbitrarily applicable relations using the current procedures.

Semantic Generalization and Symbolic Control

The current research also bears some interesting parallels with previous research on semantic generalization. For example, previous studies have found that when a particular word (e.g., *cow*) was established as a CS by pairing it with shock, the effects generalized to other semantically related words (e.g., *plow, corn, tractor,* etc.) but not to unrelated words (e.g., Lacey & Smith, 1954; Lacey, Smith, & Green, 1955). In effect, the group of semantically related words participated in a stimulus relation. The main difference between such studies of semantic generalization and the transformation of function lies in the origin of the stimulus relations; in the former, the relations are preexisting, but in the latter they are created within the context of the experiment. Thus, the present research strategy may represent an improvement on the early semantic generalization research by allowing us to identify the behavioral processes that give rise to what has been called semantic generalization. In any case, relating the present work to past research on semantic generalization places it into a larger intellectual context and helps to support the claim made by a number of theorists that the derived transformation of function, including sexual arousal functions, is synonymous with the symbolic or verbal control of behavior (e.g., Barnes, 1994, 1996; Barnes & Hampson, 1993a, 1993b, in press; Barnes, Lawlor, Smeets, & Roche, 1995; Barnes et al., 1990; Barnes & Roche, 1996, in press; Cullinan, Barnes, Hampson, & Lyddy, 1994; Grey & Barnes, 1996; Hayes, 1991, 1994; Leader, Barnes, & Smeets, 1996; Roche & Barnes, 1995c).

Equivalence and Derived Transformation: A Single Process?

Throughout this paper we have often distinguished between emergent responding on the matching-to-sample tests and the derived transformation of function. It is important to understand that this distinction was purely procedural, in that we generally referred only to the untrained emergence of matching-to-sample responding when discussing equivalence, sameness, and opposition relations, and referred to the transformation of function (in accordance with those relations) when discussing the untrained emergence of a differential eliciting function. However, although we made a procedural distinction, we adopt the view that a single behavioral process can account for the subjects' performances on the matching-to-sample and transformation-of-function tests. According to the relational frame account, the relational responding on the matching-to-sample tests and the untrained emergence of eliciting function are both considered to be instances of a transformation of function in accordance with equivalence relations (and sameness and opposition relations in Experiment 4) (see Dymond & Barnes, 1994, pp. 263–264 for a detailed discussion of this issue; see also Barnes, 1994; Barnes & Roche, 1996; Hayes, 1994; Roche & Barnes, 1996). We can, therefore, view the distinction between an equivalence relation (or any other relation) and the transformation of eliciting function in accordance with it as referring to the two defining but inseparable properties of the same behavioral process: (a) a transformation of sample-comparison and eliciting functions in accordance with (b) the combinatorially entailed relation of equivalence (and in Experiment 4 the relations of sameness and opposition). As an aside, Sidman (1994) has recently revised his mathematical formulation of equivalence classes to account for equivalence responding and the derived transfer of function in terms of a single behavioral process (but see Barnes & Roche, 1996, for a detailed discussion of some of the problems inherent in this new formulation).

Conclusion

The current study may have important and wide-ranging implications for the analysis of human sexual behavior, insofar as the findings allow us to address the criticism that behavior-analytic principles cannot account for the emergence of many instances of complex human sexual behavior, such as fire fetishism (Bourget & Bradford, 1987; Cox, 1979) and transvestism (McConaghy, 1987). The current empirical work may represent an important step in building a solid empirical base for the construction of a behavior-analytic account of human sexuality (see Barnes & Roche, in press). Of course, critics of behavior analysis may respond by arguing that these experimental demonstrations suffer from a lack of ecological validity; sexual behavior in the real world may simply not arise in the manner suggested. However, it is not unreasonable to assume that derived sexual behavior may emerge over time in a verbal social environment in which words and phrases are consistently related both directly and indirectly to sexual stimuli in a variety of contexts (e.g., jokes, innuendoes, locker-room bravado). Considerable research will be needed to test this suggestion, but such a research program would represent a functional-analytic approach to an area of human behavior that is traditionally seen to be outside the purview of behavior analysis (Barnes & Roche, in press). Finally, it is hoped that the transformation-of-function interpretation presented here will contribute a theoretical framework within which clinicians can treat the entire range of sexual disorders that patients present in therapy (see Barnes & Roche, in press).

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APPENDIX A

Point 1. The measurement of tonic (more permanent) changes in skin resistance was not practical in the context of the current study given that the procedure involved the repeated presentation of discrete stimuli with an intertrial interval of only 45 to 60 s (see Dawson et al., 1990). Furthermore, as phasic SRRs have been found to correlate extremely highly with more permanent (tonic) changes in skin resistance (Lykken & Venables, 1971), the measurement of tonic changes in skin resistance levels appeared to be superfluous in the context of this study.

Point 2. Skin resistance is typically measured using 1-cm^2 electrodes and quantified in ohms per centimeter squared. The 1-cm^2

electrode surface area allows a simple and direct calculation of resistance per centimeter squared. In fact, it is customary to assume that skin resistance measures are always calculated per centimeter squared even when this is not specified. However, when electrode surface area deviates from the normal 1 cm^2, researchers should modify their measures and report them in ohms per centimeter squared or a function thereof.

Point 3. The relevant psychophysiological literature suggests that SRRs should be measured from the skin resistance level at the point of response onset. This measure, however, did not prove to be satisfactory in the context of the present study for the following reasons. First, different researchers suggest different minimum response amplitudes as defining characteristics of a phasic electrodermal response (e.g., Dawson et al., 1990; Levis & Smith, 1987). Thus, measuring electrodermal responses from the point of response onset leaves room for variability across researchers. Second, because the level of electrodermal activity is constantly fluctuating, the point of response onset can be difficult to identify by visual inspection and thus, as a measure, is prone to subjective bias. The point of response onset is even more difficult to ascertain when responses to previous stimuli have not fully recovered before the presentation of subsequent stimuli. This was a particular problem in the current study, which employed an experimental paradigm involving the repeated presentation of discrete stimuli with relatively short intertrial intervals. Third, the response onset criterion often allows for the measure of responses from their onset to their peak, irrespective of response rise time, response latency, or both. However, the literature suggests that phasic electrodermal responses typically begin within 3 s and peak within 5 s of stimulus presentation (Dawson et al., 1990; Levis & Smith, 1987). In effect, electrodermal activity that occurs more than 5 s after stimulus presentation is difficult to relate reliably to experimental manipulations. On the other hand, a short measurement period directly following the presentation of a discrete stimulus provides a reliable measure of "the information content of the stimulus" (Dawson et al., 1990, p. 311).

In order to circumvent the ambiguity of the response onset criterion, the current study employed the level of skin resistance at the time of *stimulus presentation* as the baseline against which to calculate response amplitudes. Each SRR was measured with respect to a floating baseline that was determined individually for each conditioning trial at the point of stimulus presentation. Although commonly observed spontaneous changes in electrodermal activity may enhance or depress particular measures of electrodermal change, the cumulative total of such random effects should approach zero when calculated across an entire experimental session.

Point 4. Dawson et al. (1990) suggested three different electrode placement configurations commonly used in the assessment of electrodermal changes. The current study employed the distal phalanges electrode configuration because it is less susceptible to subject movement artifacts, thus yielding more reliable EDA measures than other electrode configurations.

Point 5. The number of conditioning trials was kept to a minimum for each individual subject because SRRs have been noted to decrease rapidly with successive exposures to stimuli of the same potency (Davis, 1930; Montagu, 1963). This is particularly the case when responses are recorded in terms of skin resistance using a DC amplifier, as was the case in the current study.

APPENDIX B

I consent that I am willing to participate in this study. I am aware that as a requirement of this study, I will be exposed to film clips containing sexually explicit scenes. The films from which these clips are taken are widely available in leading department stores and record shops in the Irish republic. I have not been coerced in any way to participate in this study and I understand that I may terminate my participation in this study at any stage if I so wish. I understand that my participation in this study has no bearing upon grades for academic work in the Department of Applied Psychology or in University College Cork, in general.