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Master of Science (Behavior Analysis), August, 1995, 65 pp., 3 tables, 6 illustrations, references, 17 titles.

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THE EFFECTS OF A POINT LOSS CONTINGENCY ON EQUIVALENCE

THESIS

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Andrea M. Peuster, B.A.
Denton, Texas
August, 1995
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CHAPTER 1

INTRODUCTION

Early work (Sidman, 1971) on reading comprehension triggered a line of research now known as stimulus equivalence. Researchers found that after training two related conditional discriminations a large number of untaught relations, derivable from the originally trained conditional discriminations, emerged. Specifically, Sidman (1971) taught a developmentally disabled youth oral naming and reading comprehension indirectly with a conditional discrimination training procedure. At the time training was initiated, the child’s repertoire included what may have been symmetrical relations; that is, given eight different pictures the child could both name the pictures and select the appropriate picture given the dictated name. The child was trained to select pictures given dictated words and to select printed words given dictated words. As a result of this training, the child could then match printed words to pictures (reading comprehension) and say (oral naming) the printed words without having been directly taught. The emergence of relations that characterize reading comprehension and oral naming in the absence of direct training was interesting and resulted in a series of experiments further investigating this phenomenon.

Initially such results were valued for their exciting implications for the teaching of reading comprehension and oral reading with those populations where standard
techniques had proven unsuccessful. As the research of Sidman and his colleagues lab evolved however, focus turned away from these educational applications and toward experimental investigation of those conditions both necessary and sufficient for emergent behavioral relations. Results similar to those reported with Sidman's original subject and reading comprehension were demonstrated repeatedly with various kinds of arbitrary stimuli and human subjects. So began the investigation of stimulus equivalence. This research area is considered important because it offers the possibility of extending the experimental analysis of behavior to complex repertoires.

In the laboratory stimulus equivalence in humans is generally observed after a particular history of conditional discrimination training. A series of conditional discriminations are trained among sets of arbitrary, usually visual, stimuli that are novel to the learner. The learner is presented with a stimulus to which she responds by touching. That stimulus is arbitrarily designated as A1 for purposes of discussion. Three comparison stimuli (arbitrarily designated B1, B2, B3) are then presented and touching of comparison stimulus B1 results in point delivery. A conditional discrimination (A1B1) is said to exist if the learner reliably selects comparison B1 in the presence of sample stimulus A1. The conditional discrimination B1C1 is trained in a similar manner.

In the above example when stimulus A1 or B1 is presented as sample it functions as a conditional stimulus. A conditional stimulus not only controls the touching of a comparison, but determines which of the comparison stimuli functions as discriminative stimulus. Conditional control by the sample stimulus A1 is ensured by
varying the stimuli presented as samples during training; sometimes A2 and A3 are the samples, in which case B2 and B3 respectively acquire function as discriminative stimuli.

After such training, untrained relations often emerge in the absence of experimentally arranged contingencies. These relations have been labelled reflexivity, symmetry, transitivity and symmetrical transitivity, because of the relation they have to the originally trained conditional discriminations (Sidman & Tailby, 1982).

Reflexivity is observed when, given A1 as sample and A1, A2, A3 as comparisons, a subject selects A1. This reflexive relation, often called generalized identity matching, introduces the notion of sameness in equivalence. Symmetry refers to the reversibility of sample and comparison functions. For example, if the original conditional discriminations are also symmetrical relations then, given C1 as the sample stimulus and B1, B2, B3 as comparisons, subjects will select B1; and given B1 as the sample stimulus and A1, A2, A3 as comparisons, subjects will select A1. Transitive relations are observed when given the sample stimulus A1 and comparisons C1, C2, and C3, C1 is selected. Symmetrical transitivity, also called the equivalence test, is a combination of the symmetrical and transitive relations, requiring all three properties (reflexivity, symmetry, transitivity) to make this derived relation possible. Symmetrical transitivity is observed when, given sample stimulus C1 and comparisons A1, A2, and A3, A1 is selected. Such performances evidence the existence of an A1B1C1 equivalence class (Sidman, 1986). Note that all four of the emergent relations are observed in the absence of any experimentally arranged contingencies.
In order to make the above summary more concrete, an example will be provided. Consider the following training procedures for a Spanish speaking subject. In the presence of a picture of a flower (A1) the subject is trained to select the written French word FLEUR (B1), rather than the French word CHAT (B2) or the French word BAL (B3). And, in the presence of the written French word FLEUR (B1) the learner is taught to select the written English word FLOWER (C1), rather than the English word CAT (C2) or the English word BALL (C3). Now, the subject will without further training given the written French word FLEUR (B1), select the picture of the flower (A1); given the written English word FLOWER (C1), select the French word FLEUR (B1); given the picture of the flower (A1), select the English word FLOWER (C1); and given the English word FLOWER (C1) select the picture of the flower (A1). Such performances suggest that the picture of the flower (A1), the French word FLEUR (B1), and the English word FLOWER (C1) are members of an equivalence class (A1B1C1). As members, each stimulus is interchangeable in function with all others. Note that training the AB and BC conditional discriminations are one of two training procedures typically used. Some researchers use an alternative in which AB and AC conditional discriminations are trained and transitivity is observed in the BC and CB emergent relations.

Sidman and his colleagues have extensively investigated stimulus equivalence and have established a rigorous definition of equivalence. For any conditional discrimination to be classified as an equivalence relation, reflexive, symmetric and transitive conditional relations must be demonstrated to exist among the stimuli in the
originally trained conditional discriminations. Sidman (1994) further described equivalence relations

as a kind of bag that contains all the ordered pairs of events that constitute the relation. To document the relation, all we have to do is reach into the bag (using our conditional-discrimination pincers) and pull out its member pairs. If even one of the defining pairs turns out to be missing, we have to conclude (assuming the absence of procedural artifacts) that the elements in the bag do not constitute an equivalence class. (1994, p. 381)

Since Sidman and Tailby's (1982) seminal article demonstrating equivalence in human children, several research programs have focused on the topic (e.g., Carrigan & Sidman, 1992; Dube, McIlvane, Mackay & Stoddard, 1987; Fields & Verhave, 1987; Hayes, 1991; Pilgrim & Galizio, 1990; Saunders & Green, 1992; Saunders, Saunders, Kirby, & Spradlin, 1988). This research has generated a plethora of descriptive information about the nature and stability of equivalence classes.

Some researchers have focused on the effects of training conditions for the originally trained conditional discriminations (the prerequisites for equivalence) on the resulting derived relations (e.g., Dube, et al., 1987; Saunders, et al., 1988). Saunders, Saunders, Kirby, and Spradlin (1988) trained two sets of conditional discriminations and then merged existing classes of equivalent stimuli by establishing, without reinforcement, a conditional relation between sample stimuli from one class and comparison stimuli from another class none of which members were related to any of the stimuli serving as samples. Following demonstration of class merger and equivalence class formation between the newly merged members, the unreinforced
conditional selection trials were reversed; that is, selections opposite to those made previously were reinforced. Although these subjects’ performances on the previously unreinforced selection reversed in accordance with the reinforcement contingency designed to produce the reversals, performances on probe trials remained consistent with prereversal selections. Such results speak to the durability and independence of derived relations once established; the derived conditional discriminations (indicating a larger class formation) were resistant to alteration. It appears that once equivalence is demonstrated, the very tests which provide evidence of equivalence become independent of the relations necessary for its emergence (Spradlin, Saunders, & Saunders, 1992).

Other research labs have also investigated the effects of baseline conditional discrimination reversal on derived relations probe performances and report inconsistencies between reversed baseline conditional discrimination performances and derived relations observed in probe trial performances. For example, a variation on the theme of re-arranging original relations was accomplished by Pilgrim and Galizio (1990). Pilgrim and Galizio (1990) investigated the effects on probe trial performances of reversing the originally trained conditional discriminations after derived relations emerged. Instead of reversing an unreinforced conditional selection (Saunders, et al., 1988), Pilgrim and Galizio (1990) reversed the originally trained conditional discriminations. Using the AB, AC training procedure, Pilgrim and Galizio established four conditional discriminations (A1B1, A2B2, A1C1, A2C2). Following testing for reflexive, symmetric and transitive relations among the two
classes of stimuli (A1B1C1 and A2B2C2), they reversed the original conditional discriminations. There were three reversal conditions. First, AC reversal was established by reinforcing selection of C2 when sample A1 was present, and C1 when sample A2 was present. Second, in the AC random condition, given A1 as sample selecting C2 and C1 were randomly reinforced. Third, in complete reversal conditions both the AB and AC conditional discriminations were reversed. After each reversal condition, probe trials were delivered to see if stimulus class memberships were altered; would subjects change their selections on probe trials demonstrating a rearrangement in class members? These contingency manipulations had inconsistent effects.

For instance, in the AC reversal condition, performances on the original conditional discrimination trials and CA symmetry trials adjusted to the reversed contingencies. However, reflexivity, BA symmetry, and transitivity (BC/CB) performances remained consistent with the earlier (prereversed) conditional discriminations. Similarly, in the AC random condition, three out of four subjects responded in a random fashion, alternating selections on the AC original conditional discrimination trials, while one subject’s selections continued according to the originally trained conditional discriminations. Performances on all three kinds of probe trials remained consistent with the originally trained conditional discriminations. In the complete reversal condition, subjects altered their performances on both AB and AC original conditional discrimination trials and BA and CA symmetry trials however,
transitive (BC/CB) and reflexive performances remained consistent with the originally trained conditional discriminations.

Overall, despite the fact that performances on the reversed original conditional discrimination trials were consistent with the reversed baseline contingencies, performances on probe trials were inconsistent. Namely, while transitive relations remained consistent with the originally trained conditional discriminations, symmetrical performances varied with the reversed baseline manipulations. If the original conditional discriminations are the necessary prerequisites for derived relations, then altering the original conditional discriminations should alter performances on all the derived relations, thus re-organizing the existing class to reflect the newly established conditional discriminations. For these subjects, the reversed contingency on original conditional discrimination trials appears to have destroyed the equivalence class, although some of its components appear intact. Pilgrim and Galizio (1995) later replicated this experiment, with a few procedural variations, and observed similar results again with adults.

In both the Saunders et al. (1988) and Pilgrim and Galizio (1990, 1995) studies, the reversal conditions were implemented after demonstrations of equivalence class formation. Their data suggested that manipulations of some portion of baseline conditional discriminations after equivalence relations had been observed, did not modify performances on all probe trials. This gives rise to a question relevant to the research reported here. What might have been the effect on the equivalence class had the reversal conditions occurred before probe trials were presented? Or what might
have been the effect on the equivalence class performances if contingencies on probe trials themselves were manipulated. For example, would an alteration in equivalence class membership occur if a point loss contingency were placed on the probe trial emergent (e.g., symmetry) relations?

Vaidya, Peuster, Reilly, and Glenn (1993) attempted to re-arrange class membership by placing a point loss contingency on probe trial performances. For one subject (S1), conditional discriminations AB (1,2,3) and BC (1,2,3) were trained in three different contexts (Thick-lined, Thin-lined, and Shaded sets of stimuli) totalling 18 original conditional discriminations. Next, symmetry, transitivity, and equivalence probes were interspersed in their respective contexts, among original conditional discrimination baselines. After equivalence relations were observed, a point loss contingency was placed on symmetrical trials only in one context while symmetry (and all other) probe trials in the remaining two contexts remained unconsequated. Another subject (S2) (with the same training history as S1, and the addition of reflexivity probe trials) received point loss for reflexivity probe trials and eventually for symmetrical transitivity probe trials. These two subjects had in common observed performances of the emergent relations before the point loss contingency was placed on the respective probe trial selection, thus permitting an examination of the effects of point loss on observed equivalence classes. Two other subjects (S3 and S4), with slightly different training histories (in terms of number of trials per session) received probe trials for derived relations in all three contexts with a point loss contingency on symmetrical relations in only one context. That is, from the very first symmetry probe
the subject encountered, responding symmetrically (as defined in accordance with the originally trained conditional discriminations) produced a point decrement. Both subjects received the point loss for symmetrical trials only in one of the three contexts; no other derived relation produced a consequence. These two subjects had in common no history of derived relations within the laboratory, thus permitting an examination of the effects of point loss on the establishment of equivalence classes. These manipulations had varied effects.

For S1 and S2 the point loss contingency produced a partitioning effect; for Subject 1 only the symmetrical derived relation was suppressed and only in the context where the point loss occurred, while performances on the original conditional discriminations and the other probe trials in all three contexts were unaltered. This same partitioning effect was seen with Subject 2’s performances on reflexivity trials. Reflexivity was suppressed while the original conditional discriminations and all other probe trials were unaltered. Following 2 consecutive sessions with no reflexive relations observed, the point loss contingency was removed, at which point reflexivity returned. After S2’s performance on all trial types stabilized, the point loss was placed on symmetrical transitivity probe trials and symmetrical transitivity was suppressed, while all other relations (derived and original) remained unaltered.

Point loss produced a different effect on the derived relation performances for Subjects 3 and 4. Subject 4 failed to respond equivalently in the context where point loss was in place, while responding equivalently in the other two contexts where this contingency was not in place. Subject 3 did not respond equivalently in any context
(point loss or no point loss). The above pilot research has implications about the formation of equivalence classes; however, it was not clear, given the different training and testing histories, whether the point loss contingency or some other procedural variable accounted for S3 and S4's failures to demonstrate equivalence.

In discussing the utility of his definition of equivalence, Sidman (1992) stated that a positive equivalence test (symmetrical transitive relations) could not coexist with a failure on any one of the other tests (reflexivity, symmetry, transitivity). If negative results were observed on any of the individual tests, then one would, in turn, expect a negative symmetrical transitivity test. If such negative results on the component performances were observed, then positive performances on those tests would have to be attributed to something other than equivalence class formation, and "our behavioral tests for equivalence relations do not define a real behavioral process" (1992, p. 20). Sidman's definition suggests that the relations that define stimulus equivalence are a package-like phenomenon, wherein all the derived conditional discriminations emerge if any emerge, and if one is missing then the stimuli in the originally trained conditional discriminations are not equivalent.

What has not been systematically addressed is the resilience of derived relation performances to manipulations on specific test (derived relation) trials. For example, what would happen if selections on a particular probe trial type consistent with the originally trained conditional discriminations resulted in a point decrement? Would the point decrement disrupt performances on that derived relation trial type? If so, would such suppression disrupt performances on all derived relations in an equivalence
class? Would performances on the original conditional discriminations be altered? Would suppression affect the emergence of derived relation performances in contexts where these performances had not yet been observed? Would such "negative" probe trial performances affect probe trial performances in other contexts where such contingencies did not exist?

The present experiment was conducted to examine the effects of point loss for performances on one type of derived relation (symmetry) on other derived relation performances in that same context, on the emergence of derived relation performances in a second context, and on all derived relation performances in a third context where point loss was not introduced. Experimental analysis was undertaken to answer the following research questions. First, will point loss for symmetrical responding in one context affect performances on other derived relation trials of an observed equivalence class in that context? Second, would point loss for symmetrical responding in another context affect the emergence of equivalence performances in that context? Third, would point loss in the above two contexts affect performances on derived relation trials already observed in a third context?
CHAPTER 2

METHOD

Participants

Nine University of North Texas students served as subjects. Eight subjects responded to a campus newspaper advertisement offering money for participation in a learning experiment. The ninth subject was a work-study student (with clerical duties in the departmental office), recruited 2 months after the beginning of the experiment. Subjects were paid for session attendance and for points earned in the experiment. Payment for attendance was made at conclusion of the experiment and subjects were told each day how money could be earned for completing a session. Initially they could earn $1.50 per session; when reinforcement rate was reduced to 40% subjects earned $2.00 per session. Throughout the study, subjects were paid at the end of each session for points earned during the session.

Three of the nine subjects completed the experiment and their data are reported below. Of the remaining subjects, one subject dropped out of school during the experiment. One subject was dropped because of conflicting work schedules and one for consistently missing scheduled sessions. One subject was dropped due to experimenter error in session set-up. Two subjects failed to respond equivalently, a prerequisite for participation in the remainder of the experiment. The three subjects whose data are included were among those recruited via newspaper ad.
Apparatus

All training and testing occurred on an IBM-compatible 80386 personal computer with a 640 x 480 resolution VGA monitor. Custom-designed software presented randomized trials, recorded latency, selections, and points delivered according to the experimenter’s specifications.

Stimuli. Three sets of 9, two-dimensional figures were used as stimuli. Each figure was enclosed in a 120 x 120 pixel frame. One 9-figure set was composed of figures with thick lines (K-cluster). Another 9-figure set was composed of figures with thin lines (N-cluster). The third set of 9 figures had figures that had shaded parts (S-cluster). Figures always appeared with the figures from the same cluster throughout an entire subsession. All the stimuli used, grouped by cluster, may be seen in Figure 1.

Response. Subjects’ responses were made with a Logitech mouse. Placing the mouse cursor within the pixel frame, then pressing the left-most button on the mouse registered the response and initiated the next stimulus presentation.

Experimental Design

To examine the effects of the point loss contingency for symmetrical responses on observed equivalence performances as well as on the emergence of derived relations, a single-subject experimental design was employed (see Table 1). A subject was concurrently taught six conditional discriminations (A1B1, A2B2, A3B3, B1C1, B2C2, B3C3) in each of three different contexts (thin cluster, thick cluster, shaded cluster). After extensive training on these 18 original conditional discriminations,
Fig. 1. Examples of stimulus figures from the thick, thin, and shaded clusters.
Table 1

A Representation of the Experimental Design for each Subject

<table>
<thead>
<tr>
<th>THICK</th>
<th>Original Relations</th>
<th>Subject JXJ</th>
<th>Probes</th>
<th>Probes</th>
<th>Probes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHADED</td>
<td>Original Relations</td>
<td>Probes</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
</tr>
<tr>
<td>THIN</td>
<td>Original Relations</td>
<td>Original Relations</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
</tr>
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</table>

<table>
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<tr>
<th>THIN</th>
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<th>Subject KKK</th>
<th>Probes</th>
<th>Probes</th>
<th>Probes</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Original Relations</td>
<td>Probes</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
</tr>
<tr>
<td>THICK</td>
<td>Original Relations</td>
<td>Original Relations</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>THIN</th>
<th>Original Relations</th>
<th>Subject BXF</th>
<th>Probes</th>
<th>Probes</th>
<th>Probes</th>
</tr>
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<tbody>
<tr>
<td>THICK</td>
<td>Original Relations</td>
<td>Probes</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
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<tr>
<td>SHADED</td>
<td>Original Relations</td>
<td>Original Relations</td>
<td>Probes and Point loss</td>
<td>Probes</td>
<td></td>
</tr>
</tbody>
</table>

Note. Original relation trial types were intermixed with probe trials during probe sessions and 25% of these trials produced feedback. The criteria for entering each phase of the experiment were (a) no more than 2 systematic errors on any original relation trial and/or (b) no more than 1 error on any probe trial type for 2 consecutive sessions.
probe trials (without point loss for symmetrical responses) were interspersed among original conditional discriminations in two of the three clusters of stimuli, while the third cluster continued to consist only of original conditional discrimination trials at a 25% reinforcement density. After derived relations were observed in both clusters having probe trials, the point loss contingency was introduced in one of those two clusters for symmetrical responses. During this session both derived relation probes and the point loss contingency for symmetry were simultaneously introduced in the third cluster. This experimental design permitted the introduction of the point loss contingency at different times in different contexts, and on different performances of a single subject. This single subject design also permitted possible disruptions on derived relations or on the emergence of derived relations to be attributed to the point loss contingency, instead of to other procedural variables. The experiment was replicated across 3 subjects.

Procedure

The experimenter read the following instructions to the subjects before they entered the lab for the first session:

Are you familiar with the mouse? You will use only the left mouse button to select. The only time you will use the computer's keyboard is when the message "Press any key to begin" appears on the screen. You may exit the lab when the message "Session complete, please exit lab and get attendant" appears. Are there any questions? {pause for questions} I cannot answer any questions once the experiment begins
{pause for questions}. I will answer any questions you may have at the end of the experiment.

No other information was provided by the experimenter regarding the nature of the task or the length of the experiment. Subjects were informed that they could discontinue participation in the experiment at any time.

When a subject entered the lab, the words "Press any key to begin" were displayed on the computer's monitor. A press on any key initiated the first trial of the session. Each trial consisted of the following events. First the sample stimulus was presented in the center of the top third of the screen. Then following a selection response to the sample, three comparison stimuli appeared in a v-shaped array in the bottom two-thirds of the screen. A selection response to one of the comparison stimuli was followed with a point delivery screen or a blank screen depending on the sample-comparison array and the stimulus selected. In all cases there was a 1-s intertrial interval from the offset of the comparison array to the presentation of the next sample stimulus.

Subjects participated in two sessions per day, five days a week, with at least a 15-minute break between sessions. Each session consisted of 216 trials. Sessions were divided into three sub-sessions of 72 trials each. Each sub-session presented one of the three clusters of stimuli. All three clusters were presented in each session in quasi-randomized order, so that no more than two consecutive sessions began with the same kind of subsession (same cluster of stimuli). Subsessions were separated with a "Session complete. You made ___ pts for this session. Press any key to continue....".
A press on any key presented the following statement "Preparing next session". After 2 seconds the first sample was presented. At the end of the third subsession, the message read "Session complete, you earned ___ points. Please exit the room and inform the lab attendant."

Original Relations Training

Subjects were taught six conditional discriminations (A1B1, A2B2, A3B3, B1C1, B2C2, B3C3) in each context. Thus, the cluster designated as "N" (thin lines in all stimuli) involved six conditional discriminations, as did each of the two other clusters (K and S). Criteria for advancement during original relations training were 1) 90% correct for all relations in all three clusters for two consecutive sessions and 2) no more than two errors on any particular original relation. Initial sessions presented the AB conditional discrimination trials only in each of three clusters. In subsessions where AB or BC original conditional discriminations were trained, each sample stimulus was presented 24 times in a randomized sequence. No sample appeared on more than three consecutive trials and no comparison stimulus appeared in the same location for more than three consecutive trials. When criterion performance on AB relations was reached, BC relations were trained under the same conditions. Subjects then entered a mixed baseline phase, where all six trial types were presented 12 times each during each sub-session (see Table 2).

Upon reaching criterion in the mixed baseline phase, reinforcement density was reduced. When reinforcement was reduced from 100% to 50%, subjects responded inconsistently on the original relations trials (JXJ & BXF); therefore, reinforcement
density was increased to 100%, then gradually reduced to 25%. Density changes were based on subjects’ performance in each phase. The reinforcement decrements varied across subjects (see Table 3).

**Probe Sessions**

After baseline performances on the original conditional discriminations were stable in all three clusters at 25% reinforcement density all types of probe trials (symmetry, transitivity, and symmetrical transitivity/equivalence) were introduced in two clusters only. Original conditional discriminations only were continued in the third cluster. Criteria for introducing point loss were (a) 90% correct for two consecutive sessions, (b) no more than two systematic errors on any original relation in a subsession, and (c) no more than one error on any probe trial type. Probe sessions consisted of 12 symmetry trials (2 of each BA trial type and 2 of each CB trial type), 12 transitive trials, 12 equivalence trials, and 36 original relations trials (6 of each) intermixed.
Table 2

All Possible Trial Types and the Number of Times Each Trial was Presented

<table>
<thead>
<tr>
<th>Sample</th>
<th>Comparisons</th>
<th>Number of presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AB TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>B1 B2 [B3]</td>
<td>24</td>
</tr>
<tr>
<td><strong>BC TRAINING</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>[C1] C2 C3</td>
<td>24</td>
</tr>
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<td>B2</td>
<td>C1 [C2] C3</td>
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<td>B3</td>
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<td>24</td>
</tr>
<tr>
<td><strong>ABBC MIXED</strong></td>
<td></td>
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<tr>
<td>All of above</td>
<td>All of above</td>
<td>12 of each trial type</td>
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<td>trial types</td>
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<td><strong>PROBE SESSIONS</strong></td>
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<td>C3</td>
<td>A1 A2 [A3]</td>
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*Note.* Brackets around the stimulus names identify the experimenter designated "correct" stimulus.
Table 3

Number of Sessions Subjects ran at each Reinforcement Density

<table>
<thead>
<tr>
<th>Percentage of reinforced trials</th>
<th>Number of sessions at each reinforcement density</th>
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The terms symmetry, transitivity, and equivalence refer to particular trial types delivered. These probe trial types refer to a particular sample-comparison arrays.

Derived relations refers to various types of conditional responding that emerge as a result of original relation training. For example, on a BA symmetry probe trial the B stimuli are presented as samples, and the A stimuli appear in the comparison positions. Given B1 as sample, and comparisons A1, A2, A3, selecting comparison A1 is often described as a symmetrical derived relation. The new relation B1A1 is derivable from the originally trained relation A1B1. When a subject's selections on these sample-comparison arrays were consistent with their selections on the originally trained conditional discriminations, these performances were considered "accurate." If a subject selects another comparison stimulus on these sample-comparison arrays, that is not consistent with the originally trained conditional discriminations, these performances were considered "errors." To reach criterion on derived relation trials means that at least 90% of all derived relations performances were consistent with the originally trained conditional discriminations.

Symmetrical responding describes the selection of a comparison stimulus previously presented as a sample in the presence of which the current sample appeared in the comparison array. For example if selecting B1 has received points when A1 was present, then selecting A1 when B1 is present is symmetrical responding.

Transitive responding describes the selection of a comparison stimulus that has never been presented as a comparison for the current sample in the comparison array. For example, if selecting B1 has received points when A1 was present and selecting C1
has received points when B1 was present, then selecting C1 when A1 is present is
transitive responding. Symmetrically transitive responding describes the selection of a
comparison stimulus that has never been presented as a comparison in the presence of
the current sample and has never been presented as a comparison in the comparison
array. For example, if selecting B1 has received points when A1 was present and
selecting C1 has received points when B1 was present, then selecting A1 when C1 is
present is symmetrically transitive responding. Symmetrically transitive responding is
also called "equivalence" because such performances require all other derived relations
(symmetry, transitivity) for its occurrence. All of the above descriptions refer to
selections that are consistent with an originally trained conditional discriminations.

Emergence refers to the occurrence of accurate selections on derived relation
trial types. If these performances are not initially consistent with the originally trained
conditional discriminations and slowly become consistent over sessions, they are
described as delayed or slowly emerging. If performances are immediately consistent
with the originally trained conditional discriminations, they are described as
immediately emerging.

Point Loss

After subjects responded symmetrically, transitively, and equivalently for two
consecutive sessions in the two clusters in which probe trial types occurred, a point
loss contingency was placed on symmetrical responding in one of these clusters while
no point loss occurred on the second cluster. In the same session, probe trials and the
point loss for symmetry trials were both introduced in the third cluster. In subsessions
where point loss occurred, the computer displayed a " -1 pt" after any symmetrical response. For example, now given B1 as sample, and comparisons A1A2A3, selecting comparison A1 resulted in a "-1 pt." These points were subtracted from the total number of points earned during the sub-session.

Removal of Point Loss Contingency

When subjects no longer responded symmetrically in a context where point loss occurred for two consecutive sessions, the point loss contingency was removed. Sessions continued until performances on all derived relations stabilized according to the original conditional discriminations. Two consecutive sessions of stable performances brought the experiment to a conclusion.
CHAPTER 3

RESULTS

The graphs in Figures 2, 3, and 4 allow us to examine the effects of point loss for one derived relation on several different kinds of performances. Point loss for symmetrical responding had varied effects on subjects' performances. For JXJ, point loss did not significantly disrupt observed probe trial performances, the emergence of probe trial performances, or probe trial performances in other contexts. For KXX, point loss disrupted only symmetrical responding and in all three contexts. For BXF, point loss disrupted observed symmetry and symmetrical transitivity probe trial performances in all contexts.

Subject JXJ

The three graphs in Figure 2 show JXJ's performances in the three clusters, thick (graph A), shaded (graph B), and thin (graph C) across sessions. Each graph shows performances on all trial types (original relations and three types of probe trials). Data points are represented by upper-case letters that refer to the specific trial type performances measured; Original conditional discriminations (baseline trials), Symmetry, Transitivity, Equivalence (symmetrical transitivity). For JXJ probe trials were introduced among baseline trials in the thick (graph A) and shaded (graph B) clusters during session 37. The thin cluster (graph C) continued with baseline trials only at a 25% reinforcement density until session 39. Within two sessions JXJ
ORIGINAL RELATIONS | PROBES | PROBES CONTINUE | NO POINT LOSS FOR SYMMETRY

PROBES CONTINUE | NO POINT LOSS FOR SYMMETRY

Consecutive Sessions
0 Original S Symmetrical T Transitive E Equivalence
Figure 2. JXJ's performances on all trial types in all three clusters.
The top graph shows performances in the thick cluster, the middle graph shows performances in the shaded cluster, and the bottom graph shows performances in the thin cluster. The dashed phase change lines mark the introduction of probe trials. The dotted phase change lines mark the introduction of point loss for symmetrical responding.
reached criterion on the probe/baseline mix in both the thick and shaded clusters (sessions 37 & 38).

Graph A shows immediate emergence of all derived relations in the thick cluster during the first session in which these trial types were introduced (session 37). Performances on all trial types (original relations and probe trials) were errorless in sessions 37 and 38.

Graph B (shaded cluster) shows emergent performances on probe trials similar to performances seen in graph A (thick cluster). All three derived relations immediately emerged, and were errorless in session 38. JXJ’s only error was on a C3B3 symmetry trial. Given C3 as sample, and B1, B2, B3, as comparisons, JXJ selected B1.

The point loss placed on symmetrical trials (session 39) in the shaded cluster (graph B), where equivalence had been previously demonstrated, slightly disrupted performances on all trial types (original and derived) over sessions 39 through 48. In session 49 the point-loss contingency for symmetrical responses was removed and performances on original relation trials and symmetry trials returned to 100% for the last two sessions (49 & 50). Performances on equivalence trials returned to 100% accuracy in session 50, while performances on transitivity trials dropped to 90% during session 50.

Graph C shows JXJ’s performances in the thin cluster, where point loss and probes were simultaneously introduced among baseline relation trials in session 39. Despite the point loss on symmetry trials, some derived relations emerged
immediately. JXJ’s performances were errorless on symmetry trials and transitivity trials, as well as on baseline relation trials, during the first two sessions in which probe trials were presented (sessions 39 and 40). Performances on equivalence trials were not errorless (session 39); 3 errors occurred on equivalence trials when the stimulus C3 was presented as sample. Specifically, given C3 as sample, and comparisons A1, A2, A3, JXJ selected A1 three times. JXJ’s performances on equivalence trials continued to fluctuate between 70% and 100% over sessions 39 through 48. An error analysis of selections on these trials revealed that the types of errors that occurred were systematic. Out of the 44 C3A3 trials presented over the 10 sessions (session 39-48) during which the point loss contingency was in place for symmetry, JXJ selected A1 given C3 as a sample on 10 of the 11 errors.

Performances on transitivity trial types also began to fluctuate during session 41 and continued to vary until session 50. An error analysis of selections on these trial types revealed systematic responding. A total of seven errors occurred on the 44 A1C1 transitivity sample-comparison arrays. Given A1 as a sample and C1, C2, C3 as comparisons, JXJ selected C3 all seven times.

When the point loss contingency was removed in the thin cluster during session 49, probe trial responding remained similar to that observed in previous sessions, ranging from 80% to 100% accuracy. In the next session (50) in graph C, equivalence and transitivity recovered and all probe trial responding occurred at 100% accuracy.

JXJ’s performances on symmetry trials in all three clusters showed little sensitivity to the point loss contingency (graphs A, B, C). Graph B shows the effect
of point loss for symmetry on all previously derived relations (symmetry, transitivity, symmetrical transitivity) in the shaded cluster. When the point loss was introduced observed symmetrical performances were only slightly disrupted. Performances on other derived trial types, which did not receive point loss, were also slightly disrupted and remained disrupted until the completion of the experiment.

Graph C shows the effects of the point loss contingency for symmetry trial types on the emergence of derived relations in the thin cluster. Performances on the symmetry trials emerged immediately despite the loss of points for such selections. However, performances on the transitivity and equivalence probe trial types were less consistently accurate, ranging between 70% and 100%. Finally, graph A shows performances in a context where no point loss occurred. Although performances on all trial types were slightly disrupted during sessions where point loss occurred in other contexts, derived relations remained intact.

Subject KXK

The graphs in Figure 3 represent KXK’s performance on each trial type (Original conditional discriminations, Symmetry, Transitivity, Equivalence) in the three clusters, thin (graph A), shaded (graph B), and thick (graph C) across sessions. For KXK probe trials were introduced among baseline trials in the thin (graph A) and shaded (graph B) clusters during session 17. The thick cluster (graph C) continued with baseline trials only at a 25% reinforcement density until session 27. Ten sessions (17-26) were required for KXK to demonstrate equivalence in both the thin and shaded clusters.
Figure 3. KXX's performances on all trial type in all three clusters. The top graphs shows performances in the thin cluster, the middle graph shows performances in the shaded cluster, and the bottom graph shows performances in the thick cluster. The dashed phase change lines mark the introduction of probe trials. The dotted phase change lines mark the introduction of point loss for symmetrical responding.
Graph A shows immediate emergence of all derived relations in the thin cluster, during the first session these trials were presented (session 17). Performances on probe trials remained accurate in the first four sessions during which these trials were presented (17-20). During session 21 performances on all probe trials dropped to chance levels but immediately recovered during the next session. Performances on symmetry and transitivity trial types were stable at high accuracy levels from sessions 21 through 26. Performances on equivalence trial types were more variable, fluctuating between 75% and 100%, until they stabilized at 100% in sessions 25 and 26.

Graph B shows performances on the shaded stimulus set. Performances on probe trials in this cluster were more sporadic than in the thin cluster. Accurate performances on all probe trials immediately occurred in session 17; however over sessions 18 through 27 performances became more varied, fluctuating between high accuracy levels and chance levels.

Note that performances on all probe trials in graph B vary together during sessions 17 through 26. During session 19 these performances dropped to below 65%, immediately recovered during the following session, and dropped again to below 45% in session 21. This type of performance, a flip-flopping between high and low levels of accuracy, occurred over sessions 18 through 25. In session 25 KXXK's performances met criterion on all probe trials and in session 26 those performances remained stable.
After performances on all trial types (original/probe mix) met criterion for two consecutive sessions (25 and 26) in both the thin and shaded clusters, the point loss contingency was placed on symmetrical trials in the shaded cluster. During this same session (27) probe trials (symmetry, transitivity, equivalence) along with the point loss for symmetry were introduced in the thick cluster. Note that the thin cluster continued to consist of all trial types and point loss was never introduced in that cluster. Point loss was introduced in this manner into the respective clusters to observe the effects of such a contingency on pre-existing derived relations (graph B) and on the emergence of derived relations (graph C).

The point loss placed on symmetrical trials in the shaded cluster (graph B) disrupted performances on symmetry trial types for the three sessions this contingency was in place (27-29) and three sessions after point loss was removed (30-32). Concurrent transitivity and equivalence performances were only slightly disrupted, and then only for one session each (27 and 29 respectively). For KXK, the point loss contingency on symmetry trial types produced a partitioning of symmetrical performances from performances on the other probe and original relations trials. That is, performances on transitivity and equivalence trial types were consistent with the originally trained conditional discriminations and performances on the symmetry trial types were inconsistent with original relations. Symmetrical performances remained partitioned from performances on all other trials for three sessions after point loss contingency was removed. They recovered in session 33 and remained accurate until completion of the experiment.
In session 30, where the point loss was removed from symmetry trials, performances on transitivity and equivalence trial types were disrupted in the shaded cluster. Equivalence performances dropped to 50% during session 31 and varied between 10% and 90% until session 41. Transitivity performances started to fluctuate during session 33, trailing equivalence performances, and recovered with equivalence performances during session 41.

Graph C shows KXK’s performances in the thick cluster, where point loss and probes were simultaneously introduced among baseline original relation trials. KXK’s performances in graph C are similar to performances in the shaded cluster (graph B). Symmetry immediately partitioned from performances on all other trial types. Transitivity and equivalence performances came in below accuracy criterion during the first session in which these trial types were introduced (27); however, they immediately thereafter reached 100% accuracy (sessions 28 and 29).

When the point loss contingency was removed beginning in session 30, symmetrical performances in the thick cluster remained partitioned. In session 33 they recovered and remained at accuracy until the end of the experiment. When point loss was removed from symmetry trials (graph C), transitivity and equivalence performances were disrupted.

Equivalence dropped to 70% during session 30, recovered during session 32, and immediately dropped to 10% in the following session (33). Equivalence performances fluctuated at chance levels until they recovered again during session 39. Equivalence performances remained accurate for the duration of the experiment.
Transitivity dropped to 40% during session 30, recovered during session 32, and dropped to 10% during session 33. Transitivity performances remained at chance levels until they recovered in session 39, remaining at or below 90% accuracy levels to the end of the experiment.

As the graphs in Figure 3 show, performances on symmetry trials in all three clusters clearly were sensitive to the point loss contingency, including in the cluster where the contingency was never introduced (graph A). For KXK, point loss produced a partitioning of symmetrical performances from performances on all other trial types in all three clusters.

In summary, graph B shows the effects (on all derived relations) of the point loss contingency on existing symmetrical relations. When the point loss was first introduced performances on symmetry trials immediately partitioned from performances on all other trial types and remained partitioned.

Graph C shows the effects of the point loss contingency on symmetry trial types on the emergence of derived relations. Performances on transitivity and equivalence trial types were only slightly affected by the point loss contingency. Performances on symmetry trial types followed a similar pattern as those in graph B, immediately partitioning and dropping to 0%.

Finally, graph A shows performances in a context where no point loss occurred. Even so, performances on symmetry probe trials immediately partitioned at the time the point loss was introduced in two other contexts. Performances on
transitivity and equivalence probe trials were also disrupted at the same time these performances were disrupted in the other clusters after the point loss was removed.

**Subject BXF**

The graphs in Figure 4 represent BXF’s performance on each trial type (Original conditional discriminations, Symmetry, Transitivity, Equivalence) in the three clusters, thin (graph A), thick (graph B), and shaded (graph C) across sessions. For BXF probe trials were introduced among baseline trials in the thin (graph A) and thick (graph B) clusters during session 45. The shaded cluster (graph C) continued with baseline trials only, at a 25% reinforcement density, until session 54.

BXF required nine sessions to reach criterion on the probe/baseline mix in both the thin and thick clusters (sessions 45-54). In session 53 probe trial accuracy was 100% in both clusters; in session 54, probe trial accuracy ranged from 90% to 100%.

Graph A shows performance on the thin cluster. BXF showed a gradual emergence of the derived relations. Specifically, the transitivity probe trial is the first probe trial to emerge and is errorless in sessions 48 through 53. Performances on symmetry and equivalence probe trials emerged more slowly and did not reach accuracy until sessions 51 and 52 respectively.

Graph B shows performances on the thick cluster. Performances on this cluster were similar to performances on the thin cluster in the gradual emergence of accurate probe trial responding. However, in this set transitivity fluctuated between 75-100% for eight sessions, reaching accuracy criterion in session 52. Symmetry fluctuated between 65-100% for 7 sessions, reaching accuracy criterion in session 51.
A 100
80
60
40
20
0

PROBES CONTINUE
NO POINT LOSS FOR SYMMETRY

- PROBES -|| NO POINT LOSS FOR SYMMETRY -||-LOSS-

45 50 55 60 65 70 75 80 85 90 95 100

Consecutive Sessions

PROBES CONTINUE
POINT LOSS FOR SYMMETRY

0 Original  S Symmetrical  T Transitive  E Equivalence
Figure 4. BXF’s performances on all trial type in all three clusters. The top graphs shows performances in the thin cluster, the middle graph shows performances in the thick cluster, and the bottom graph shows performances int the shaded cluster. The dashed phase change lines mark the introduction of probe trials. The dotted phase change lines mark the introduction of point loss for symmetrical responding.
Performances on the equivalence trials were lower in accuracy, fluctuating between 15-50% during sessions 46-50, reaching accuracy criterion in sessions 51-53.

After 90% accuracy criterion was met on all relations (probe and original) for two consecutive sessions in both the thin and thick clusters, the point loss contingency was placed on symmetrical trials in the thick cluster. During this same session (54) probe trials (symmetry, transitivity, equivalence) as well as the point loss for symmetry were introduced in the shaded cluster. Note that the thin cluster continued to consist of all trial types and point loss was never introduced in this cluster. The point loss placed on symmetrical trials in the thick cluster (graph B) disrupted performances on all three probe trial types (symmetry, transitivity, equivalence) from sessions 46-60. This disruption is noteworthy because neither the transitivity nor equivalence probe trials produced point loss. Note that the only trial type not disrupted was the baseline relation trials.

In session 61 performances on probe trials started to partition. Transitivity returned to accuracy while performances on symmetry and equivalence trials dropped to 50% and below. Equivalence performances remained disrupted from session 55 through session 99. By session 60, performances on the these trials fluctuated around even lower accuracy levels (0-10%), where they remained until session 99. Performances on equivalence trials recovered in session 100, five sessions after the point loss contingency for symmetrical responses was removed. In graph B, symmetry, the derived relation which directly produced a point decrement, was also immediately disrupted but not as dramatically as symmetrical transitivity. Note sessions 61-84
where accuracy fluctuated around 50% and eventually dropped to 0-25% levels during sessions 87 through 97.

Graph C shows BXF’s performances in the shaded cluster, where point loss and probes were introduced simultaneously among baseline relation trials. Symmetrical, transitive, and symmetrically transitive performances emerged in the first two sessions in which probe trials were presented (sessions 54-55). Note that the gradual emergence of derived relations observed in the thin and thick clusters did not occur in the shaded cluster. In fact, performances were accurate immediately on all probe trials in the shaded cluster.

After their initial appearance in sessions 54 and 55, performances on probe trials gradually dropped in accuracy in a similar manner as did probe performances in the thick cluster (graph B). Transitivity, although initially disrupted and then only slightly, returned to initial levels of accuracy by session 72. Equivalence trials were the trial types most dramatically affected in this cluster, dropping to below chance levels by session 64. Symmetry the trial type producing point loss, showed a gradual decrease to 50% during sessions 66-84 and finally to 0-10% during sessions 85-89.

As the graphs in Figure 4 show, performances on symmetry trials in all three clusters were sensitive to the point loss contingency, including the cluster where the contingency was never introduced (graph A). Of the three probe trial types presented, equivalence, rather than symmetry, showed the most sensitivity to the point loss contingency in all three clusters.
In summary, graph B shows the effects on derived relations of the point loss contingency on existing symmetrical relations. When the point loss was first introduced all probe trial types were slightly disrupted. Graph C shows the effects of the point loss contingency for symmetrical responding on the emergence of derived relations. Performances during the first two sessions of probe trials were unaffected by the point loss contingency, but in the succeeding 39 sessions, performances on probe trial types followed a similar partitioning as those in graph B. Finally, graph A shows performances in a context where no point loss occurred. Even so, performances on probe trials were disrupted at the time the point loss was introduced in two other contexts. After recovering for a few sessions (55-57) they gradually deteriorated, tracking performances on derived trial types in the two clusters where point loss occurred.

BXF’s performances on the symmetry trial types and symmetrical transitivity trial types suggest that BXF was no longer responding equivalently. It seems as if the relations that were once indicative of equivalence class formation are now independent of one another with some of the member relations intact (baseline and transitivity) while other member relations (symmetry and equivalence) are unobserved. But the performances on symmetry trials and equivalence trials occurred at well below chance levels, suggesting that some kind of systematic responding may have occurred. Had new relations formed on the symmetry and equivalence probe trials?

Figure 5 allows a closer examination of BXF’s performances on equivalence probe trials and the two types of symmetry trials BA and CB, in all three clusters.
Data points are represented with upper case letters that refer to the specific trial type performances measured; Equivalence, B for BA symmetry, C for CB symmetry.

Graph A in Figure 5 shows BXF’s performances on these trial types in the thin cluster, the cluster where point loss never occurred upon introduction of probe trials. CB symmetry fluctuated between 85-100% for five sessions, achieving accuracy criterion in session 50. BA symmetry fluctuated between 35-100% accuracy for seven sessions, reaching accuracy criterion during session 52. Performances on the equivalence trial types also gradually emerged, reaching accuracy criterion in session 52. In this cluster, performances on symmetry trials in one relation (CB) emerged before they emerged in the other (BA). Performances on equivalence trials were generally consistent with BA symmetry performances.

Graph B in Figure 5 shows BXF’s performances on both symmetry and equivalence trials in the thick cluster. CB symmetry was immediately accurate (session 46) and remained accurate through session 53. Performances on BA symmetry began at 50% in session 45 and increased to 100% by session 47. Then BA symmetry performances dropped to chance levels during sessions 48 through 50, and finally reached accuracy criterion during sessions 51-53. Equivalence performances fluctuated at chance levels during sessions 46-50, reaching accuracy criterion in sessions 51-53. In this cluster CB symmetry performances emerged immediately while BA symmetry and equivalence performances emerged gradually over sessions.

In session 54 the point loss contingency was introduced on symmetrical responding in the thick cluster (graph B). BA and equivalence probe trials were
Figure 5. BXF's performances on BA symmetry trials, CB symmetry trials, and CA Equivalence trials in all three clusters. The top graph shows performances in the thin cluster, the middle graph shows performances in the thick cluster, and the bottom graph shows performances in the shaded cluster.
immediately disrupted, fluctuating between 50-90% for 7 sessions. CB symmetry however, remained at 100% accuracy over sessions 54-68, dropping slightly only during session 59. During session 59, performances on BA symmetry and equivalence probe trials were at 100%. In session 60 BA symmetry and equivalence trials dramatically partitioned from CB symmetry. Not until session 82 did CB symmetry drop to 50%, steadily decreasing then to 0% (sessions 86 and 87). CB fluctuated at or below 50% from sessions 82 to 100.

Graph C in Figure 5 shows BXF’s performances on the symmetry and equivalence trial types in the shaded cluster. In this context performances on CB symmetry and BA symmetry, during sessions 54 and 55, were consistent with the originally trained conditional discriminations, despite the fact that such selections produced point loss from the first presentation of symmetry probes. Performances on CB symmetry trials remained at accuracy until session 68, where performances gradually dropped to 50%, and eventually to 0% in session 88 where they remained for the duration of the experiment.

Performances on BA symmetry fluctuated between 15-100% accuracy until session 60 where accuracy dropped even lower, ranging between 0% and 10% until session 100. Performances on equivalence trials occurred in a pattern similar to performances on BA symmetry trials, however fluctuating at lower accuracy levels (as low as 10% in session 58). Equivalence trials also remained at these low accuracies until session 100.
To recap, what appeared in Figure 4 (graphs A, B, C) to be chance-level responding on symmetry trials after the point loss contingency was introduced is actually a partitioning of the two symmetry trial types in each cluster. In each case, BA symmetry was immediately affected, while CB was suppressed slowly over sessions. Note that symmetry (BA and CB) and equivalence returned immediately to original accuracy levels shortly after the point loss contingency was removed (session 99 and 100) in all three clusters.

The data in Figure 4 could be read to suggest that the point loss contingency resulted in loss of symmetrical responding. But Figure 5 (an analysis of the particular symmetry sample-comparison arrays) shows that one set of symmetrical relations (CB) remained intact, while another (BA) was suppressed almost entirely. The apparently complete absence of symmetrical responding on the BA trial types prompted further analysis. Accordingly, Figure 6 was constructed to further refine the resolution by allowing a session-by-session examination of the selections on specific CB and BA symmetry probe trials.

For purposes of illustration, the graphs in Figure 6 show BXF's performance in the thick cluster only. Important to note is that similar patterns of responding occurred in thin and shaded clusters. The top graph (A) is from Figure 4, the second from the top (B) from Figure 5. The last six graphs show session-by-session performances on B1A1 symmetry trials (graphs C,D,E) and one C1B1 symmetry trials (graphs F,G,H). Because performances on B1A1 and C1B1 trials are representative of responding on the other relations (B2A2, B3A3, C2B2, C3B3), only these trials are
presented. Graphs C-H are aligned so that all performances pertaining to the two
different symmetry relations (BA & CB) can be considered in the context of graphs A
and B.

The black bars on graphs C, D, and E show how responding to comparisons
A1, A2, and A3, given sample B1, was distributed in each session. In each session,
there were two trials where A1, A2, and A3 appeared as comparisons with a B1
sample. To the left of each bar graph are the upper case letters representing the
particular stimuli presented as sample first, and the comparison selected second. The
first of the bottom six graphs (C) shows the number of times given B1 as sample, A1
was selected from the three A comparisons (A1, A2, A3). Selection of comparison
stimulus A1 would indicate a symmetrical relation with the originally trained A1B1
conditional discrimination. The height of a black bar indicates the number of times
that particular relation occurred in a given session. Bars reaching the number 2
indicate that out of the 2 possible trials presented for this relation during the session
this particular comparison was selected both times. Bars reaching the number 1
indicate that this particular comparison was selected only once. Scanning down to the
other two graphs (D & E), one can determine which inaccurate comparison stimulus
was selected. Just as graph C shows the pattern of responses to A1 when B1 was
sample, graph D shows the pattern of responses to A2 when B1 was sample and so on.

Note in Figure 6, graph A, at the black arrow symmetry drops to 50% and
fluctuates around 50% for 20 sessions. Graph B further specifies this disruption as a
partitioning of BA and CB symmetry. The two black arrows on graph B, identify the
Figure 6. BXF's performances in the thick cluster. Graph A shows performances on all trials. Graph B shows performances on BA symmetry, CB symmetry, and CA equivalence trials. Graphs C, D, and E, show the number of times a particular comparison was selected when B1 was presented as sample. Graphs F, G, and H, show the number of times a particular comparison was selected when C1 was presented as sample.
point at which the two trial types separate. CB symmetry is still fairly accurate, while
BA symmetry fluctuates around 20%, thus generating the combined symmetry test
score of 50% as seen in graph A. Graphs C, D, and E, allow a closer look at BXF’s
selections on these trial types. At the arrow on graph C, B1A1 dropped to 0 and
remained at 0 (with the exception of one B1A1 relation in session 81) until the point
loss contingency was removed. Also at the arrow occurrences of B1A2 and B1A3
began to fluctuate (graphs D & E), suggesting a vacillation between comparison A2
and A3, given B1. Note that BXF did not consistently select one of the other
comparisons while the point loss contingency was in place. Again, patterns of
responding were very similar in the case of B2A2, B3A3 relations.

Figure 6, graphs F, G, and H, show that BXF’s performances on the CB
symmetry trial type were disrupted in a similar manner as on BA trial types although
much later in the experiment. The third black arrow in graph B identifies the point at
which CB symmetry drops below 65%. The bottom 3 graphs show the C1B1, C1B2,
and C1B3 relations respectively. At the arrow, C1B1 dropped to 0 (graph F), 23
sessions after point loss was placed on this trial type. At this same point BXF’s
selections of B2 and B3 began to vacillate between these two comparisons,
performances similar to those on B1A1 sample-comparison arrays. This same pattern
of responding on symmetry and equivalence trials was also observed in the shaded and
thin clusters. Although not graphically presented, KXK’s performances on symmetry
trials were similar to BXF’s. When symmetrical responding dropped to 0% accuracy
levels, KXK was vacillating between the other two comparisons.
CHAPTER 4

DISCUSSION

This section will discuss the data described above in terms of the experimental questions. The data will also be discussed in the context of broader issues some of which were addressed in the introduction and some that have become relevant upon examination of the data.

To restate, the questions of interest in this experiment were:

1. Would point loss for symmetrical responding in one context affect performances on other derived relation trials of an observed equivalence class in that context?

2. Would point loss for symmetrical responding in another context affect the emergence of equivalence performances in that context?

3. Would point loss in the above two contexts affect performances on derived relation trials already observed in a third context?

In reference to the first question, point loss for symmetrical responding in one context can affect performances on other probe trials in that same context. Point loss for symmetry disrupted both symmetrical performances and symmetrical transitivity performances of BXF. All of JXJ's probe trial performances (symmetry, transitivity, symmetrical transitivity) were disrupted by the point loss contingency, even though only slightly.
Pilgrim and Galizio (1990, 1995) obtained similar results when they attempted to rearrange equivalence class membership through baseline contingency reversals. Baseline reversals altered subject's selections on both baseline trials and symmetry trials; selections on symmetry trials shifted and were consistent with the newly established baseline relations. Whereas in that experiment baseline reversals affected performances on the symmetrical probe trial, in the present experiment a point loss contingency for symmetry affected performances on symmetrical transitivity probe trials and, in one case, all other probe trial performances.

Pilgrim and Galizio (1990, 1995) also noted a dissociation in probe trial performances after baseline relation reversals. Symmetrical performances became consistent with the reversals, while transitivity/equivalence performances remained consistent with the pre-reversed equivalence classes. In the present experiment subject BXF's performances on symmetry and symmetrical transitivity probe trials shifted with the point loss contingency while transitivity performances remained consistent with original relation performances. It appears point loss for emergent symmetrical performances at least sometimes produces partitioning of performances on other probe trials.

The results of the present investigation may support Sidman's (1992) earlier notion of equivalence as a package-like phenomenon. Manipulations on one test trial performance functioned to disrupt performances on other test trials (JXJ & KKK). In these cases probe trial performances functioned as a package, with disruptions on one component affecting performances on other related components.
It is important to note that the present results were obtained by suppressing one probe performance which is not the same as a failing to respond equivalently on a test trial. Subjects demonstrated positive results on all test trials before point loss was introduced in two contexts. The point loss produced performances which, at a glance, would appear to resemble negative results, however finer analyses revealed that these performances were systematically disrupted in ways consistent with the originally trained conditional discriminations.

In reference to the second question, the point loss contingency did not affect the emergence of equivalence performances in the context where both probe trials and point loss were simultaneously introduced. The data from Vaidya et al. (1993) suggested that introducing point loss and probe trials simultaneously would disrupt the emergence of equivalence performances. Such disruptions were not observed in the present experiment; in fact, all subjects’ performances on probe trials met the accuracy criterion within 2 sessions, despite the point loss. The data in the bottom graphs of Figures 2, 3, and 4, represent performances in the cluster where probes and point loss were simultaneously introduced.

The conclusions of Vaidya et al. (1994) were drawn from a comparison between subjects; some subjects were given a history of probe trial responding while other subjects received the probes and point loss simultaneously. The present experiment was designed to examine such effects within the same repertoire; all three subjects were provided with both histories in the same experimental setting. This variation in procedures may account for the differences in the data from the two
studies. Given this experimental history it is not clear how point loss for symmetrical performances would affect other emergent performances if they had not been previously demonstrated in the same experimental setting.

In reference to the third question, point loss in two contexts did affect established probe trial performances in a third context in which point loss did not occur. The top graphs of Figures 2, 3, and 4 represent each subject's performances in the cluster where point loss was never introduced. For KKK and BXX (Figures 3 & 4) performances in this cluster fluctuated in a similar manner as performances in the two clusters receiving point loss. Subject JXJ's performances were also disrupted in this cluster although only slightly, as in the case of her performances in the other 2 clusters. Disruptions in probe trial performances in contexts where point loss was never introduced is interesting, given there were no formal similarities between the stimulus figures from each cluster (see Figure 1).

These results suggest that cluster type (thick-lined stimuli, thin-lined stimuli, and shaded stimuli) never acquired contextual function. If conditional control was exerted by cluster type, performances in the cluster where point loss was not introduced should not have been disrupted. These performances do share, however, a common experimental context.

So far researchers have been unsuccessful in undoing the entire package of derived relations by operating on one of those relations. The data presented here suggest that a point loss contingency for symmetrical responses can also be ineffective at altering the relations established during training and/or testing phases.
Pilgrim and Galizio (1990, 1995) found that reversing original relation contingencies were also ineffective in altering all the relations in an established stimulus class. Spradlin, Saunders, and Saunders (1992) concluded that such resistance of derived relation performances to manipulations on the trained conditional discriminations (which supposedly give rise to these performances) speaks to the stability of equivalence performances. The observed dissociations in related equivalence performances therefore indicate an independence of conditional discriminations (emergent or trained) from other related trained/derived performances. That is, once equivalence performances are demonstrated, individual derived relations may be altered without affecting other related relations/performances.

The issue of independence was examined more closely with regard to the data presented here. On first examination BXF's data did suggest that point loss produced some probe trial performances that were inconsistent with previously demonstrated equivalence performances. The partitioning of symmetry and symmetrical transitivity performances from original relation and transitivity performances appears to support the interpretation of independence (from the equivalence class) of some derived relations performances. However a trial by trial analysis of BXF's selections on these sample-comparison arrays revealed that the controlling relations were consistent with the equivalence class. For example, given C1 as a sample, and A1, A2, A3, as comparisons, BXF sometimes selected A2 and sometimes A3, but rarely A1. Such vacillations between the two "incorrect" comparisons suggested that the controlling relation C1A1 still existed. BXF's performances were still consistent with the
originally trained conditional discriminations and transitivity performances. Such an interpretation is consistent with previous analyses (Carrigan & Sidman, 1992; Johnson & Sidman, 1993).

Carrigan and Sidman (1992) discussed in great detail the two types of controlling relations that can exist in two comparison, conditional discriminations. They denoted these types of control as Type S and Type R; type S control referring to those conditional discriminations (sample-comparison relations) where the positive ("correct") comparison controls the subjects' performance and type R control where the negative ("incorrect") comparison controls the subjects' performance. They demonstrated that "even though the subject is recorded as having touched the positive comparison, the negative comparison, in being 'rejected' controls the recorded choice." (Johnson & Sidman, 1993, pp. 333-334)

BXF’s performances on BA, CA, and eventually CB probe trials (as well as KXX’s symmetry trial performances) indicate that point loss established a type R relation on these sample-comparison pairs instead of a new sample-comparison (conditional discrimination) relation and instead of unsystematic (random) selection. To describe these performances in the context of Carrigan and Sidman (1992) and Johnson and Sidman’s (1993) analyses of types of controlling relations a few clarifications need to be made.

First, in the experiments at issue (Carrigan & Sidman, 1992; Johnson & Sidman, 1993) only two comparison stimuli were presented on each trial. The present experiment displayed three comparison stimuli on each trial. The use of three
comparisons helped identify order in BXF's symmetry and symmetrical transitivity performances. In each case BXF vacillated between the two "incorrect" comparisons, and systematically avoided the "correct" comparison. If BXF reliably selected one "incorrect" comparison across sessions, one could conclude that a new relation had been established on these trials. However, because BXF did not reliably select one of the two "incorrect" comparison stimuli, and only once picked the "correct" comparison stimulus while point loss was in place, one could reasonably conclude that the "correct" comparison still had discriminative functions. BXF responded "away from" the symmetrical choice. "...[U]nlike the sample-comparison pairs that were to be expected from a select-control baseline, the comparison that was related to a particular sample was not the comparison that the subjects were recorded as having chosen in the presence of that sample" (Johnson & Carrigan, 1993, p. 346). In the present experiment, the point loss contingency did not rearrange class membership, then, for any subject. Selections on probe trials demonstrated control consistent with the originally trained conditional discriminations.

Perhaps the most interesting results from the present study were the performances of subject BXF once the point loss contingency was placed on symmetrical responding. Percent correct measures of symmetrical responding suggested that the point loss destroyed the symmetry relation, although performances on other derived relations remained consistent with the original conditional discriminations. Trial by trial examinations of the data indicated that systematic
responding consistent with the originally established conditional discriminations was occurring; however, percent correct measures were obscuring such order.

Vaidya (1994) pointed out that percent correct measures a subject’s performance "in terms of the conditional discriminations predicted by or of interest to the experimenter" or type S control only (pp. 102-103). The trial by trial analyses of BXF’s performances permitted an alternative where every selection response was measured regardless of whether or not it was predicted by the experimenter. As suggested by Vaidya, this strategy allowed the identification of orderly relations in the data that were obscured by percent correct measures. Like the study by Vaidya, et al., (1993) the present experiment provided another procedure for analyzing the relationship between conditional discriminations and emergent conditional discriminations.

Variations of these new procedures may permit further clarification of the nature of equivalence performances. For example, by presenting the baseline/probe trial mix without feedback, or by presenting probe trials in isolation (without original relation trials intermixed), several questions might be answered. Are the trained conditional discriminations and the emergent (derived) conditional discriminations functionally related? If so, under what conditions do these elements enter into functional relations and what conditions do they not?

One procedural variation could remove reinforcement for original relation performances during the probe and point loss conditions. Providing feedback for 25% of original relation responding may have continued to strengthen performances
consistent with the established equivalence classes. When point loss was introduced, reinforcement and punishment contingencies coexisted. These two processes in combination may have produced the partitioned performances (as in the case of BXF and KXK). If reinforcement for original relation responding is discontinued new conditional discriminations may be formed as a consequence of point loss for symmetrical responding. If new conditional discriminations are established by point loss for symmetrical responding the equivalence class may be re-organized.

Another variation could present probe trials in isolation. The current procedures intermixed original relation trials and probe trials. If point loss were introduced in a baseline of probe trials only, other derived relation performances may have been disrupted. For example, Spradlin, et al., (1992) noted that disruptions in one relation of an equivalence class may not affect other relations in that class. This disrupted component can be reestablished if mixed in a baseline with other trials in which performances are consistent with the established equivalence classes.

Limiting the types of trials delivered when manipulating a derived relation of an equivalence class should decrease the chances that the disrupted relation will be re-derived. Under these conditions, point loss may disrupt all derived performances and in this limited baseline, performances consistent with those originally observed may not be rederived.

Research investigating equivalence performances under changing contingencies will lead to clearer understandings of equivalence classes as behavioral units. Identifying those conditions in which such performances function as a unit and those
conditions in which the unit breaks apart may be the empirical data that present theories are lacking.
REFERENCES


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