The Role of the Defined Response in Equivalence Relations: An Extension of Braga-Kenyon et al. (unpublished)

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by

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Abstract

The present study involved 3 typically developing adults and sought to (a) extend the findings of Braga-Kenyon et al., (b) further investigate if defined responses are included as components of the equivalence class, and (c) determine whether equivalence relations can arise from 3-term contingencies. Participants were exposed to four conditions: pretest, training with feedback, training with no feedback, and posttest. The pretest confirmed that there were no pre-existing relations among the experimental stimuli used in this study. During training conditions (with & without feedback), matching to sample trials were presented to establish six pairs of arbitrary relations each involving one unique black and white figure and one polygon. For three of these relations, the color tone of the polygons used as comparisons remained constant, and participants had to choose one specific polygon according to the number of sides it displayed. For the other three relations, the number of sides of each polygon was held constant, and participants’ selections had to be based on the color tones of the polygons which varied systematically. All participants demonstrated all trained relations. Finally, participants were exposed to a test condition to evaluate whether the color-relevant symbols) would become equivalent to each other, and whether shape-relevant symbols would become part of a class. Results across all three participants showed that relations among color-relevant symbols and shape-relevant symbols did not emerge. It was concluded that the sole training of A-B relations was not enough to establish a color-relevant stimulus class and a shape-relevant class.
Sidman and Tailby (1982)* defined an equivalence relation as a conditional relation meeting three properties derived from elementary mathematics: reflexivity, symmetry, and transitivity. For a relation to be reflexive, it is required that each stimulus be matched to itself \((A=A, B=B, C=C)\). Furthermore, reflexivity should be based solely on identity without the use of differential reinforcement or instruction. Symmetry is defined as the reversibility of a sample and comparison stimulus. For a relation to be symmetric, it must hold true that the sample and comparison stimulus be interchangeable without the use explicit training procedures \((A=B, B=A)\). Transitivity involves emergence of a third, untrained conditional relation from two explicitly established relations \((if A=B, and B=C, then A=C)\). A conditional relation must be tested for all three properties if it is to be called an equivalence relation.

Sidman (2000) proposed that equivalence relations are made up of event pairs of stimuli the analytical unit’s conditional, discriminative and reinforcing stimuli. It has also been proposed that defined responses are included as components of the equivalence class and equivalence relations can arise from three-term contingencies or maybe more restricted contingencies (Figure 1). Sidman argued that if four-term contingencies could arise from three-term or maybe even two-term contingencies, then reinforcers and defined responses would have to be included as components of the relation.
Theoretical Limitations

There are several inherent limitations in the investigation of whether responses are included as members of the equivalence class. One fundamental problem is that it cannot be directly concluded that equivalence relations emerge from the three-term unit unless equivalence is demonstrated by means of three-term contingencies without resorting to conditional discriminations. It is impossible to determine by definition, however, if an equivalence relation exists unless it displays the three properties of equivalence: reflexivity, symmetry, and transitivity. The direct evaluation of these three properties to determine an equivalence relation requires a four-term contingency, making a direct conclusion that equivalence relations emerge from three-term units virtually impossible because it would require that responses and reinforcers were used as samples. Another vexing problem in the investigation of responses as members of the equivalence class is that one can never be sure whether it is the response and not its controlling stimulus that is the critical element. In other words, it is impossible to evaluate the response as a component in isolation from the stimulus that occasioned the response. A final limitation, which bears specific focus to the present study, lies in the difficulty of distinguishing a response from the environmental product the response may produce as individual events in the equivalence relation. Strict experimental control demands the use of an overt, discriminable response when investigating defined responses as members. It is impossible to identify, however, whether it is the response itself or some response product (visual, auditory, olfactory, and/or proprioceptive stimulus) resulting from the response, which becomes apart of the equivalence class. The limitation of stimulus and response distinction and possible solutions is examined below.
Braga-Kenyon et al. (unpublished) conducted a series of four experiments, which addressed some of the theoretical limitations when investigating whether responses can be included as members of the equivalence class. The procedures described in Experiment 1 investigated the problem of whether it is the defined response or its controlling stimulus that is the critical element in the equivalence relation. Braga-Kenyon et al. addressed the problem by requiring some but not a specific defined response to occur. It was concluded that if the four-term contingency did not require a differentiated response to the sample stimulus, then a differentiated response most likely resulted from some other contingency besides the four-term contingency itself. Experiment 1 included three phases, which will be explained in more detail.

In Experiment 1, Braga-Kenyon et al. investigated whether the defined responses taught during simple discrimination trials would transfer to conditional discrimination trials even if reinforcement contingencies did not require it. Four typically developing adults and one adolescent participated in Experiment 1. A computer using software provided by W.V. Dube and E. J. Hiris (Dube, 1991) managed stimuli presentations and consequences for all sessions. Experiment 1 consisted of three phases: simple discrimination training, conditional discrimination training with tests for transfer, and interspersed trials from both simple and conditional discrimination training. During the simple discrimination phase (see Figure 2), participants were taught defined responses (i.e., insert a coin in a can and flash a light on a wall) in the presence of sample colors (i.e., red and green). That is, in order to obtain reinforcement (i.e., points) the participants had to respond correctly to the related sample (i.e., when A1 respond with R1 and when A2 respond with R2). During the conditional discrimination (see Figure 3) and tests for
transfer phase, participants were taught two classes of form-color conditional relations—for example, in the presence of a star (B1), choose green (A1) and not red (A2) and in the presence of a cross (B2), choose red (A2) and not green (A1). In this phase, participants were also tested on the transfer of form-response relations. The participants had to respond to the sample forms with either flashing a light on the wall (R1) or inserting a coin into a can (R2) to produce the two comparison colors. The third phase included trials from both simple and conditional discrimination training to encourage maintenance of simple discrimination relations during conditional discrimination trials. The main purpose of Experiment 1 was to question whether sample forms would eventually control the same responses as their relational color comparisons independent of differential reinforcement.

Performances of all participants reached 100% accuracy for both simple (color-response relation) and conditional (shape-color relation) discrimination tasks. Three of the five participants responded differentially to the sample forms as they had to sample colors even though reinforcement contingencies did not require it. It was concluded that one of the two participants did not respond differentially to the sample forms due to either a lack of maintenance of simple discrimination tasks during the conditional discrimination phase or an inadvertent reinforcement of one response, which was overgeneralized to both forms. These concerns led experimenters to incorporate Phase 3 to insure the maintenance of simple discrimination performance during conditional discrimination trials. It was concluded that the other participant did not respond differentially because she never performed the form-color relations with consistent criterion for mastery.
Results from Experiment 1 offered convincing evidence that responses may be included as members of the equivalence class because the outcomes could have been established by five possible response patterns: always respond correctly; always respond incorrectly; always respond with R1; always respond with R2; or respond with both inconsistently. The unspecified conditions surrounding the defined responses could have established any of the five response patterns yet only one response pattern was replicated across five participants in accordance with Sidman’s theory. These results are consistent with the theory that defined responses are included as elements of the equivalence class and that equivalence relations can emerge from the three-term unit.

Despite the positive results, there were limitations to be addressed in order to make more definitive conclusions about responses in the equivalence class. The first limitation was that only two comparison stimuli were used during conditional discrimination trials. When using only two stimuli as comparisons, it can be difficult to determine whether the controlling comparison is the positive stimulus being selected or the negative stimulus being rejected (Carrigan & Sidman, 1992; Johnson & Sidman, 1993). The other limitation was that the manipulanda used (i.e., flashlight, coin, can, etc.) in order to engage in the response added extra visual stimuli. Thus, it was impossible to conclude whether the positive results were due to the visual stimuli present prior to engaging in the response or the response itself.

Experiment 2 addressed the limitations of Experiment 1 by including three classes of stimuli and teaching responses that did not require external, differential stimuli. Two typically developing adults participated in Experiment 2 (Participants 6 & 7). Both simple and conditional discrimination training (Phases 1 & 2) were the same as described
in Experiment 2, however included three stimulus classes and responses (see Figures 4 & 5). Also, instead of training responses that required manipulanda, the responses taught were clapping (R1), snapping with two fingers (R2), and tapping on the table (R3).

Both participants eventually responded differentially to sample forms as they had to sample colors even though reinforcement contingencies did not require it. Initially, Participant 6 did not respond differentially to sample forms. When presented with a session of simple discrimination trials, Participant 6 eventually responded differentially to the sample forms during successive conditional discrimination trials. Experiment 2 yielded positive results and addressed the two limitations of Experiment 1: the use of only two stimulus classes and possibility of manipulanda serving as visual stimuli as a part of the class instead of the response. However, concerns about the underlying problem of completely separating a response from relational stimuli continued to be a limitation of Experiment 2. It was mentioned that the classes could have formed due to the response product as result of the visual feedback of the motor responses. More specifically, the sight of observing one’s hands clap, snap, or tap a table could have been providing additional stimuli along with the response itself.

Braga-Kenyon et al. conducted a third experiment, which included a partial solution to the main concern of Experiment 2: whether it was the response or the sight of the response that became a part of the equivalence class. Two typically developing adults participated in Experiment 3 (Participants 8 & 9). Like Experiment 2, motor responses were used only visual-visual relations were tested at the end of the experiment. Both simple and conditional discrimination training (Phases 1 & 2) was the same as described in Experiments 1 and 2. A third phase was conducted, which tested for possible visual-
visual relations between color-response and form-response relations. In Phase 3, pictures of the responses appeared as comparison stimuli in the presence of sample color and form stimuli in order to partially test whether some visual feedback existed as a component of the responses in Experiments 1 and 2. Even though the pictorial representations of the defined responses were novel stimuli, a main purpose of the experiment was to test whether participants would respond correctly to the picture of the previously trained corresponding response in the presence of the corresponding, relational colors and forms (Figures 6 & 7). For example, whether participants would choose the picture of clapping hands (R1) in the presence of yellow (A1) and a star (B1), and so forth. The main focus of this experiment was to further investigate the limitation of whether it was the responses or the visual feedback of the responses that became a part of the equivalence class.

Both participants (Participants 8 & 9) eventually responded differentially to sample forms as they had to sample colors although initially, they did not. Like Participant 6 of Experiment 2, after presenting a session of simple discrimination trials, both participants responded differentially to the sample forms during successive conditional discrimination sessions. The visual-visual relation tests demonstrated emergence of relations between trained stimuli (colors and forms) and novel stimuli (pictures of the responses) for both participants. Because the tests yielded positive results, equivalence may have arisen from the sight of the response rather than the response itself. A fourth experiment was conducted to further investigate possible solutions to the vexing problem of separating response from response products.
In Experiment 4, Braga-Kenyon et al. attempted to minimize the visual response feedback by using vocal responses instead of motor responses. Two typically developing adults participated in Experiment 4 (Participants 10 & 11). Simple and conditional discrimination training (Phases 1 & 2) remained the same as described in Experiments 1 through 3 only vocal responses were taught and tested instead of motor responses. Phase 3 served as a test for the emergence of the relations between novel stimuli of the written word of the response to the relational color. In Phase 3, written words of the vocal responses appeared as the sample stimuli and colors appeared as comparison stimuli in order to partially solve the visual feedback existed as a component of the responses in Experiments 1 and 2.

Both participants (Participants 10 & 11) responded differentially to sample forms as they had to sample colors. The written depiction-color relation tests demonstrated emergence of relations between trained stimuli (colors) and novel stimuli (written depictions of vocal responses) for both participants.

Although the procedures described by Braga-Kenyon et al. provide a promising demonstration that three-term contingencies may be sufficient for equivalence relations, a great deal of the evidence depends on interpretation. Specifically, it cannot be directly concluded that equivalence relations emerge from the three-term unit unless equivalence is demonstrated by means of three-term contingencies without resorting to conditional discriminations (Sidman, 2000). A decisive conclusion would then require that defined responses demonstrate the three properties of equivalence: reflexivity, symmetry, and transitivity. Also, there still lies the problem of distinguishing a stimulus from a response as individual events in the equivalence relation. One example of this is the impossibility
of presenting a response as a sample to demonstrate equivalence. Another example, which is more relevant to the present study is the question of whether it is the response itself or some response product (visual, auditory, olfactory, and/or proprioceptive stimulus) resulting from the response, which becomes a part of the equivalence class.

Braga-Kenyon et al. offered partial solutions to the dilemma of distinguishing stimuli from responses by attempting to minimize the stimuli resulting from the response products. Although Braga-Kenyon et al. provided promising procedures for distinguishing responses from response products, there will always be a degree of environmental product resulting from any discriminable response, which may operate as an additional stimulus. In an effort to extend the research of Braga-Kenyon et al., the present study considers the possibility of using an even less discriminable response, which would further investigate the problem of whether it is the response or its response products that become members of an equivalence class. More specifically, it would be interesting to investigate responses like those involved in the process of abstraction.

From a behavioral standpoint, “if a group of things, events, or qualities is separated off (partitioned) from other groups, there must be some basis for the separation; with respect to that basis (identification by abstraction), the elements of the group are equivalent to each other.“ (Sidman, 1994, p. 417) Abstraction is the process by which concepts are formed in that it “requires the discrimination of elements, qualities, or properties that different instances possess in common.” (Keller & Schoenfeld, 1950, p.155) To abstract or form the concept of blue, for example, there must be generalization among other stimuli that are also called blue and a distinction between the stimuli called blue and other stimuli that are not called blue. Concepts are defined as generalization
within classes and discrimination between classes (Keller & Schoenfeld, 1950). Thus, if classification occurs according to color with differently shaped polygon images, all the images with respect to that color become equivalent to one another. If classification occurs with respect to shape with variously colored polygon images, the images categorized according to their shape become equivalent to one another. However, not all classification occurs on the basis of physical identity. For example, the results described by Vaughan (1988) showed that the pigeons classified the two sets according to function and not physical similarity or dissimilarity. Vaughan (1988) used a simple rather than conditional discrimination procedure to teach pigeons to discriminate between two sets of stimuli: one positive and one negative. The two sets of stimuli were photographic slides of trees that were arbitrarily divided to rule out the possibility of categorization based on physical similarities or dissimilarities between the stimuli. After training the pigeons to discriminate between the two sets of stimuli, the reinforcement contingencies were reversed; the positive set becoming negative and the negative set becoming positive. After repeated exposure to the contingency reversals, results showed that the pigeons generalized the reversal contingency to the stimuli in both sets after contacting the reversal contingency with just a few stimuli. It was concluded that the successful transfer of reversal contingencies indicated that the pigeons had demonstrated stimulus equivalence. It has also been noted that from a mathematical standpoint, a classification of stimuli implies an equivalence relation and an equivalence relation implies a classification of stimuli (Gellert et al., 1977). Therefore, the successful classification of the photographic slides into two sets indicated that the pigeons demonstrated equivalence from a mathematical standpoint.
A systematic evaluation of a response involved in the process of abstraction would benefit the investigation of whether it is the response or the response products which become members of an equivalence class. The use of such a response would decrease experimental control to a degree because the response in question involves attention towards stimuli and does not display as much discriminable properties as a more discrete response. Such responses are discussed below.

Figure 9 shows all the relations that were trained in the present study. Each arbitrary symbol in Class A would serve as a sample. Selections of each of the nine color-polygons in Class B were reinforced according to one of two dimensions. During symbol-color trials, the color dimension was relevant such that color as a dimension was held constant across trials and the selection was reinforced but shape as a dimension was systematically varied and the selection was not reinforced (see Figures 10a-10c). During symbol-shape trials, the shape dimension was relevant such that shape as a dimension was held constant across trials and the selection was reinforced but color as a dimension was systematically varied and the selection was not reinforced (see Figures 10d-10f).

Once the symbol-color and symbol-shape relations were established, tests were conducted. The major question of the present study was whether emergent relations would form (see Figure 11) among “color-relevant” symbols (A1-A2-A3) and “shape-relevant” symbols (A3-A4-A5). If the participants demonstrated the emergent relations, a possible way account for them would be that the procedures could have encouraged two distinct responses between observing a color-polygon when color was relevant and observing a color-polygon when shape was relevant. It could be partially concluded that the “observational” response common across color-relevant trials and shape-relevant
trials could have been the common basis, which caused color-relevant symbols to merge into a class and shape-relevant symbols to merge into a class (see Figure 12). The obvious concern of the present study was that the response in question implied a covert response, which was impossible to be measured directly. This concern is further examined in the discussion.

Method

Participants

Three typically developing adults participated in the present study. All participants were recruited through personal contacts. Participant Lada was a 25-year-old woman who worked as a teacher for children with autism while attending a graduate program in Applied Behavior Analysis. She completed her participation in this study after 33 sessions. Participant Mema, a 26-year-old woman, also worked as a teacher for children with autism, and attend a Master’s program in Severe Special Needs. She participated in 25 sessions to complete the experimental sequence. The third participant, Mabr, was a 29-year-old man, who worked as an accounts collector for a law firm (is this an advertisement?). He completed his participation in this study after 15 sessions. Participants were given a reinforcer of choice (sodas, restaurant gift certificates, candy, movie tickets, etc.) at the end of sessions for participation.

Setting and Materials

Sessions were conducted in a quiet 4.3 m by 1.5 m observation room. Participants sat at a table containing a laptop computer and a chair with the experimenter present during all sessions. During each session, the laptop computer
presented 18 trials in close succession to each other for all experimental phases. The duration of each session varied from 1 to 7 minutes with an average of 2 to 3 minutes per session.

**Apparatus.** A Macintosh® computer laptop was used to present stimuli, manage trial sequences, provide programmed consequences, and automatically record data during all sessions (see Figure 8). All stimuli were displayed on a 19 cm by 14 cm color monitor screen. The appropriate software was formulated and provided by W.V. Dube and E. J. Hiris (Dube, 1991). The software program (MTS v 11.6.7) presented the stimuli, preset by the experimenter, such that each sample stimulus appeared an equal number of times and comparison stimuli were presented in each location an equal number of times. Participants responded to the presented stimuli using a miniature external mouse.

**Stimuli.** Six arbitrary symbols and nine color-polygons were divided into two sets (Figure 9). The features of the visual stimuli and the configuration of the sets were determined to manipulate a combination of two stimulus dimensions: color and shape. Figure 9 depicts the symbols and color-polygons used and how they corresponded to each other across the chromatic (i.e. different tones of blue) and formal dimensions (i.e. number of sides in each polygon). Across trials, each symbol was associated with a stimulus that held constant one of the relevant dimensions: color or shape. Each stimulus was presented in a 2-inch square located in one of four possible locations on the computer screen: top center; lower left; lower center; and lower right. At the onset of each trial, participants had to click on the sample
using the mouse to produce the comparison stimuli. Once the comparison stimuli
were presented with the sample, the participants allocated responding by using the
mouse to click on the corresponding comparison stimulus.

**Conditional Discrimination Procedures.** Trial display during training
conditions consisted of a sample stimulus located on the center key and three
comparison stimuli located on the lower left, lower center, and lower right keys. For
test conditions, trial display consisted of a sample stimulus located on the center key
and two comparison stimuli located on the lower left and lower right keys. Each trial
began with the sample stimulus being presented on the center key. Participants had
to use the mouse to click on the sample to produce the comparison stimuli.

**Response Measurement and Differential Consequences**

Each session began with the presentation of the sample stimulus on the center
key. The selection of a comparison stimulus was recorded when participants manipulated
the mouse to click within any of the enclosed bottom keys. Correct responses were
defined as the selection of any color polygon (during training) or symbol (during tests),
which belonged to the same stimulus class as the sample. The software recorded correct
and incorrect responses, key location of response selection, response latency of
presentation of sample to observation response (clicking on the sample), and latency of
the presentation of comparison stimuli to a correct or incorrect response. The
programmed consequences delivered varied across conditions. For pretest, posttest, and
training with no feedback conditions, all correct and incorrect responses were followed
by a 1.5-s intertrial interval and the presentation of a sample stimulus for the next trial.
There was no differential feedback for correct versus incorrect responses. For the training with feedback condition (symbol-color polygon relation training), correct responses were followed by a beep with the word “correct,” and a 1.5-s intertrial interval. Incorrect responses were followed by a loud buzz and a brief time-out. The computer managed all trial sequences and programmed consequences.

**Instructions to Participants**

All participants received minimal verbal instructions before the onset of each condition. At the beginning of the experiment, participants were told, “Sometimes you will receive audible feedback in the form of bells or buzzers and visual feedback in the form of the word ‘correct’ and sometimes you will not.” The participants were also told that the absence of feedback during the training with no feedback condition did not indicate an error in performance and that the chosen reinforcer would be delivered at the end of the experiment independent of performance. During the first few trials of the first exposure to the program, participants were instructed to use the mouse to “Click on the sample” located in the middle of the screen. Once the comparison stimuli were presented, the participants were instructed to “Use the mouse to choose.” All participants became familiar with the conditional discrimination procedure within the first few trials.

**Experimental Phases**

The relations that were trained in the present study are shown in Figure 9. During symbol-color trials, color was the relevant dimension for participants’ selection. Within each trial, a set of three polygons containing the same number of sides was used as comparisons. The color of each polygon, however, varied and the correct color depended
on the symbol that was displayed as sample. The purpose of such trials was to teach that, given certain symbols (A1, A2 and A3), participants had to select the shape that displayed a specific color regardless of the number of sides. Figures 10a through 10c show the possible configuration of trials that were used to teach the symbol-color relations. During symbol-shape trials, shape was the relevant dimension of the participants’ selection. Within each trial, a set of three polygons containing the same color was used as comparisons. The number of sides of each polygon, however, varied and the correct number of sides depended on the symbol that was displayed as the sample. These trials taught the participants to select the shape that displayed a specific number of sides regardless of the color, given the “shape-relevant” symbols (A3, A4 and A5) (see Figures 10d-10f).

Tests were conducted to assess whether (see Figure 11) “color-relevant” symbols (A1-A2-A3) and “shape-relevant” symbols (A3-A4-A5) would become equivalent to each other. Specific procedures of each condition are explained below.

**Pretest.** During the pretest condition, six arbitrary symbols were tested for emergent relations between the three color-relevant symbols (A1, A2, and A3; see Figure 11) and the three shape-relevant symbols (A4, A5, and A6; see Figure 11). Pretests were conducted with two of the three participants (participants Lada and Mema) to confirm that no preexisting preferences or relations existed between the symbols of each class before training. One of the three participants (participant Mabr) did not participate in the pretest due to the concern of exposure to error histories with the same conditional discriminations trials included in the posttest. Participants had to click on the sample
stimuli to produce the comparison stimuli in order to choose between the correct stimuli of the corresponding class or the incorrect stimuli.

**Training with Feedback.** During the training with feedback condition, participants received differential reinforcement for selecting one of the nine color polygons in the presence of a symbol based on either color or shape as described previously (see Figures 10a-10f). Procedures encouraged attention to either color or shape by delivering differential reinforcement and by holding one dimension constant and varying the other across trials. For example, the relation: A1 (arbitrary symbol)-B1 (Navy blue) was taught using three trial types: A1-Navy blue Heptagon, A1-Navy blue Octagon, and A1-Navy blue Decagon (Figure 10a). Participants were taught the following conditional discriminations: when sample A1 was presented: touch the Navy blue comparison regardless of the type of polygon it is displayed (B1); when sample was A2, touch the Royal blue comparison (B2), regardless of the polygon; when sample was A3, touch the Light blue comparison (B3), regardless of the polygon; when sample was A4, touch the Heptagon (B4), regardless of the colors; when sample was A5, touch the Octagon (B5), regardless of the colors; and when the sample was A6, touch the Decagon (B6). Sessions were conducted successively until criteria for mastery was met for the participants. The mastery criteria were based on both accuracy and latency between the presentation of the comparison stimuli and the selection of the comparison. All participants had to respond with 100% accuracy and an average latency of 1.5 sec or less for three consecutive sessions to meet mastery criteria.

**Training without Feedback.** Procedures during this condition were the same as the training with feedback condition only differential reinforcement was not delivered
during this condition. All correct and incorrect responses were followed by an intertrial interval. Mastery criteria for this condition required performance with 100% accuracy and an average latency of 1.5 sec or less for two consecutive sessions.

**Posttest.** Procedures during this condition were the same as described during the pretest condition. The major question of interest was whether the relations of color-relevant symbols (A1, A2, and A3) and shape-relevant symbols (A4, A5, and A6) would become stimulus classes.

**Results**

**Lada.** Figure 9 displays the results for Lada. During the A-A pretest condition (symbol-symbol pretest), Lada scored 56%. It was concluded that Lada displayed no pre-existing relations between the arbitrary symbols. When introduced to the A-B training condition (symbol-color polygon training), Lada required 18 sessions to reach mastery criterion. When exposed to the A-B training with no feedback condition (symbol-color polygon training with no feedback), Lada continued to consistently respond with 100% accuracy even without feedback (bell with correct for correct responses and a buzz with a time-out for incorrect responses). That is, the participant consistently chose B1 to A1, B2 to A2, and B3 to A3 for the color constant symbol-color polygon relations and B4 to A4, B5 to A5, and B6 to A6 for the shape constant symbol-color polygon relations. When introduced to the A-A posttest condition (symbol-symbol posttest) for two sessions, Lada scored 50% and 20%. It was concluded that despite learning the trained A-B relations, no color-relevant or shape-relevant relations emerged among the arbitrary symbols.
**Mema.** Results for Mema are depicted in Figure 10. During the A-A pretest condition, Mema scored 67%. It was clear that no pre-existing relations existed between the arbitrary symbols. When introduced to the A-B training condition, Mema required 12 sessions to reach mastery criterion. When exposed to the A-B training with no feedback condition, performance remained at 100% accuracy even without feedback. When introduced to the A-A posttest condition for two sessions, Mema scored 72% and 56%. It was concluded that the color-relevant symbols and shape-relevant symbols did not form two distinct stimulus classes.

**Mabr.** Figure 11 displays the results for Mabr. During the A-B training condition, Mabr only required 6 sessions to reach mastery criterion. When exposed to the A-B training with no feedback condition, Mabr continued to consistently respond with 100% accuracy even without feedback. When introduced to the A-A posttest condition for two sessions, Participant Mabr scored 61% and 44%. Despite learning the trained A-B relations, it was concluded that no color-relevant or shape-relevant relations emerged between the arbitrary symbols.

**Discussion**

Braga-Kenyon et al. (unpublished) offered convincing evidence that responses can be included as members of the equivalence class and that three-term contingencies may be sufficient to form equivalence relations. A major limitation of their study, however, was that no definitive conclusions could be made due to the impossibility of determining whether it was the response or the response’s environmental products that became members of the equivalence class. The present study provided a partial solution
to the limitation by encouraging two possibly distinct “observation” responses between observing a color-polygon when color was relevant and observing a color-polygon when shape was relevant. It was replicated across all three participants, however, that no color-relevant or shape-relevant relations emerged between the arbitrary symbols even though all three participants learned all A-B training relation. These results offer strong evidence that the sole training of the A-B relations was not sufficient to form equivalence classes among the color-relevant and shape-relevant symbols. It is possible that the sample-comparison relations were simply operating under strict contextual control and did not necessarily become members of an equivalence class. After all, the contingencies themselves only outlined conditional relations: if A1, then Light blue (B1); if A2, then Royal blue (B2); if A3, then Light blue (B3); and so forth. Also, it is possible that because the participants had not contacted much of a history with the symbols as comparison stimuli before the post test that the procedures could have affected the participants’ performances. A procedural alternative to eliminate this possible confounding variable in future research would expose the participants to the symbols as comparison stimuli and conduct symmetry training of the color-symbol and shape-symbol relations prior to the symbol-symbol tests.

There were many limitations to be noted in the present study. A major limitation of the present study was the nature of the possible “observation” responses. Because these responses were not be measured or directly observed, interpretation of the procedures was fragile to begin with. Future research should focus on providing more control over the supposed covert responses, which cause the equivalence classes between color-relevant and shape-relevant symbols to form. Specifically, if it could be determined
exactly how and what portion of the stimuli the participants were attending to, stronger conclusions about the data could be made. Another limitation was that only two comparison stimuli were presented during test conditions increasing possibility of selecting a correct comparison stimulus by chance and not an acquired relation. Also, the procedures used in the present study involved four-term contingencies when direct evidence calls for the use of three-term contingencies without resorting to four-term. However, direct evaluation of the three properties of equivalence relation requires a four-term contingency, which makes a direct conclusion that equivalence relations emerge from three-term units virtually impossible. Finally, a fourth limitation of the present study is that the procedures did not demonstrate symmetry or transitivity among its ordered pairs. A future extension of the present study should focus on explicitly training symbol-symbol relations to familiarize participants with the procedures and evaluating performance of other untrained symbol-symbol relations once a procedural history has been established. It could possibly be concluded that after establishing such histories, test performances will be operating under the correct contextual control. Training new relations with the color polygons using multiple exemplars could also be evaluated.

Sidman (2000) mentioned that a distinction between stimulus and response on the subject of their locus is pragmatic when trying to define the subject matter. However, it was also mentioned that when discussing this issue in terms of equivalence class membership, the distinction loses significance. Equivalence classes are comprised of ordered pairs of these events. It may be the case that the covert nature of the response was not discriminable enough for the equivalence classes to form. The extent in which a response can be included as a part of the equivalence class may depend on how
discriminable the response products are. It is likely that using class-specific reinforcers may produce distinguishable properties. Future research may evaluate using class-specific reinforcers.
References


Figure 1. The formation of equivalence relations from a four-term contingency (on the left) and a three-term contingency (on the right).
Figure 2. Experiment 1: Simple Discrimination Tasks. Participants were taught defined responses in the presence of sample colors.
Figure 3. Experiment 1: Conditional Discrimination Tasks. Participants were taught to select corresponding colors in the presence of symbols. They were also tested for differential defined responses even though reinforcement contingencies did not require it.
Figure 4. Experiment 2: Simple Discrimination Tasks
Figure 5. Experiment 2: Conditional Discrimination Tasks
Figure 6. Experiment 3: Visual-Visual Test (Color-Picture)
Figure 7. Experiment 3: Visual-Visual Test (Form-Picture)
Figure 8. Experiment 4: Written word of response-color test
Figure 9. A-B Relations Tables. The tables below show all relations that were trained in the present study.

Class 1: Color-relevant

<table>
<thead>
<tr>
<th>A1-</th>
<th>B1- Navy Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2-</td>
<td>B2- Royal Blue</td>
</tr>
<tr>
<td>A3-</td>
<td>B3- Light Blue</td>
</tr>
</tbody>
</table>

Class 2: Shape-relevant

<table>
<thead>
<tr>
<th>A4-</th>
<th>B4- Heptagon</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5-</td>
<td>B5- Octagon</td>
</tr>
<tr>
<td>A6-</td>
<td>B6- Decagon</td>
</tr>
</tbody>
</table>
Figure 10a. Navy blue specific relations.
Figure 10b. Royal blue specific relations.
Figure 10c. Light blue specific relations.
Figure 10d. Heptagon specific relations.
Figure 10e. Octagon specific relations.
Figure 10f. Decagon specific relations.
Figure 11. Equivalences Classes 1 & 2

<table>
<thead>
<tr>
<th>Class 1-color-constant symbols</th>
<th>(A1)</th>
<th>(A2)</th>
<th>(A3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 2-shape-constant symbols</td>
<td>(A4)</td>
<td>(A5)</td>
<td>(A6)</td>
</tr>
</tbody>
</table>
Figure 12. Two possible distinct observation responses, which could lead to emergent relations between color-relevant and shape-relevant symbols.
Figure 13. A Macintosh computer laptop was used to present stimuli, manage trial sequences, provide programmed consequences, and automatically record data during all sessions.
Figure 14. Percentage Correct per session during each condition for Lada.
Figure 15. Percentage Correct per session during each condition for Mema.
Figure 16. Percentage Correct per session during each condition for Mabr.