The Establishment of Stimulus-Stimulus Relations without Differential Reinforcement

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Abstract

The purpose of this study was to evaluate whether stimulus-stimulus relations (AB) could be established without differential reinforcement and to assess these relations for symmetry. Two typically developed individuals, ages 7 and 26 participated in this study. Participants were first presented with a series of matching to sample tasks using familiar stimuli, and accurate performance on these tasks was maintained without any differential consequences. Target stimulus-stimulus associations involving three pairs of visual arbitrary symbols were then introduced through sequences of matching to sample trials in which two random stimuli served as incorrect comparison (S-) in every trial. During this phase, the only response that could occur consistently across trials was towards the stimulus designated as correct (S+). Each Participants’ responses varied in the absence of differential reinforcement of each selection (i.e. always choosing the stimulus that appeared consistently on the array). Changes in trial configuration were systematically and gradually carried out so that the random comparison stimuli were replaced by target stimuli belonging to the other association pairs for Todd. Changes in trial configuration were carried out more abruptly, not gradually fading in the random S-'s for Angelina. Results are consistent with the hypothesis that stimulus-stimulus relations can be established in the absence of direct training involving differential consequences for correct responses.
The Establishment of Stimulus-Stimulus Relations without Differential Reinforcement

Stimulus equivalence is a behaviorally based approach to exploring and understanding how humans process the relationships between two or more stimuli (Plaud, Gaither, Franklin, Weller, & Barth, 1998). Progress in the area of stimulus equivalence research may lead not only to a better understanding of phenomena typically treated in terms of cognition (Sidman, 1986/1994), but also to the development of more effective teaching technology (Sidman, 1994).

Sidman (1971/1994) conducted what was considered to be the first experiment that demonstrated that matching auditory words to pictures and to printed words were sufficient prerequisites for the emergence of both types of stimulus-response relations, reading comprehension and oral reading. He explained that the emergence of reading comprehension might be that the visual words and pictures became equivalent to each other because each, independently, had become equivalent to the same auditory words. Sidman and Tailby (1982) defined this type of emergent performance as stimulus equivalence. According to the authors, to meet the definition criteria, a set of stimuli must exhibit three properties: reflexivity, symmetry, and transitivity. Briefly, reflexivity is evaluated by tests for generalized identity matching, which requires the participant to match each stimulus to itself without explicit training. Symmetry requires the participant to reverse the comparison and sample function of stimuli in the conditional discrimination. Transitivity is demonstrated when a new conditional relation (e.g. AC) emerges without direct training after two other relations, (e.g. AB and BC) have been directly trained. (Sidman, Kirk, & Willson-Morris, 1985).
Stimulus Equivalence and Language

The ability of nonhuman or nonverbal subjects to demonstrate the emergence of stimulus equivalence has been the center of great debate and research interest (Dube, Mcilvane, Callahan, & Stoddard, 1993).

Several investigators have attempted to demonstrate stimulus equivalence in nonhumans by using different methodologies. D’Amato, Salmon, Loukas, and Tomie, (1985) assessed whether or not monkeys were capable of demonstrating transitivity across two sets of conditional relations. The monkeys were presented with two types of transitivity tests, positive (T+) and negative (T-) tests. During a T+ tests, if the monkey pressed a key that revealed a plus sign when the triangle stimulus was the sample, his pressing was reinforced, whereas such responses resulted in a timeout when the dot stimulus was the sample. If the monkey pressed a key on which a circle appeared when the dot stimulus served as a sample stimulus, his pressing of the key was reinforced. In the T- tests, the reinforcement relations were reversed. Without explicit training, all four monkeys performed at a much higher level on the T+ test than on the T- tests, indicating that they were capable of associative transitivity. D’Amato et al. (1985) also assessed whether or not pigeons would be capable of demonstrating transitivity by performing the same tests that were provided to the monkeys, however, they failed to demonstrate this relation.

Sidman, Rauzin, Lazar, Cunningham, Tailby, and Carrigan (1982) proposed that the emergence of stimulus equivalence is a basic behavior process and the failure to demonstrate stimulus equivalence in non-humans may be due to procedural inadequacies. One study with primates (Oden, D. L., Thompson, R. K. R., & Premack, D., 1988) and one with dolphins (Pack, Herman, & Roitblat, 1991) demonstrated generalized identity matching under conditions
comparable to the reflexivity tests used with human subjects. It is unclear; however, what conditions are necessary for the development of equivalence. It could be that stimulus equivalence is simply an emergent property of conditional discrimination training (Sidman et al., 1982).

McIntire, Cleary, and Thompson (1987) claimed to have demonstrated stimulus equivalence with nonhumans. During discrimination, a sample (color) was displayed on the center key until the monkey emitted either an “Odd” or “Even” response. An Odd response was correctly emitted when an odd numbered color was displayed as the sample and the monkey pressed and held a key for 3.5s. The “Even” response was correctly emitted when an even numbered color was displayed as the sample and the monkey pressed and released the key seven times before the final press. Reinforcement was given for correct responding and a correction procedure was intermittently used for incorrect responses. During testing for equivalence, reinforcement and correction procedures were discontinued but the rest of the procedure remained the same as in discrimination training. Results indicated that by establishing differential response patterns that appeared to share properties with a two-word naming system (Odd-Even) facilitated the establishment of equivalence classes where previous procedures had met with limited success (McIntire et al., 1987).

Vaughan (1988) also conducted a study that supports the formation of stimulus classes in pigeons. He presented pigeons slides of trees that were randomly divided into two sets of stimuli. The pigeons were trained to discriminate between the two sets of stimuli, one being designated as positive and the other being designated as negative. Vaughan (1988) reinforced the pigeon’s pecking when the set of stimuli designated as positive were present and did not reinforce the pigeon’s pecking when the set of stimuli designated as negative were presented. When a few
stimuli in the positive set became discriminative for pecking, and some stimuli in the negative set became discriminative for not pecking, responding to the rest of the stimuli in both sets also changed accordingly. Vaughan (1988) then reversed the reinforcement contingencies for both sets of stimuli. After repeated reversal training, the pigeons generalized the reversals to all stimuli in each set after being exposed to only a few stimuli in each set. Although it is debated among professionals, some say that this transfer of reversals demonstrates an acquired functional equivalence among the stimuli of the same set.

Hayes (1989) criticized both McIntire et al. (1987) and Vaughan (1988) for not truly demonstrating equivalence in non-humans according to Sidman and Tailby’s (1982) definition. Hayes (1989) states that, “the most straightforward problem with McIntire et al.’s (1987) demonstration is one of method. A detailed examination of their procedure shows that they directly trained all components of all tested relations. Because no relations were derived, there are no grounds to conclude that these animals showed Sidman equivalence” (p.386). Hayes (1989) says that the primary problem with Vaughan’s (1988) study was not one of methods but one of definition. Vaughan (1988) defines an equivalence relation as any partition or a subset. Hayes (1989) states that, “this type of equivalence requires only a stimulus set or partition, and Vaughan’s procedure clearly yielded a stimulus set. Any functional class of stimuli is a partition, and if that alone defines equivalence, then any demonstration of a discriminated operant will show it” (p. 389). This definition however, does not agree with what Sidman has shown to be equivalence.
Sidman, Wynne, Maquire, & Barnes (1989) examined whether or not relations among members of a functional class meet the reflexivity, symmetry, and transitivity criteria that define equivalence relations. Three adults participated in the study. Each adult was taught a set of two-choice simultaneous discriminations, including three positive and three negative stimuli. The discriminations were repeatedly reversed, meaning that the positive stimuli became the negative stimuli and the negative stimuli became the positive stimuli. Sidman et al. (1989) found that “with all subjects, a reversal of the contingencies for one pair of stimuli became sufficient to change their responses to all of the other pairs. The reversals had produced functional stimulus classes” (p. 422). The participants were then presented with a sample from one class and comparisons from both classes. All participants selected the comparison that was in the same class as the sample that was presented to them, demonstrating that conditional discriminations emerged between the members of the functional classes (Sidman et al., 1989). Next, two of the three participants had been taught to relate new stimuli to the already established class members, the participants then matched other class members to the new stimuli showing that the within-class conditional relations had symmetric and transitive properties of equivalence relations. The third participant in the study formed functional classes without being able to demonstrate equivalence relations between class members. These findings suggest that “a set of stimuli partitioned into subsets of functionally equivalent members does not represent the same behavioral process as conditional-discrimination tests for equivalence relations, even with human subjects” (Sidman et al., p.446).

The possible dependency between language and equivalence was also examined by Devany, Hayes, and Nelson (1986). The authors studied three groups of children that ranged in chronological age and were matched on their mental age: typically developed preschoolers,
children diagnosed with mental retardation who used signs appropriately, and children diagnosed
with mental retardation who did not use signs appropriately. All the children in each group were
taught a series of four relations across 8 stimuli referred here by letters A through F (i.e. A, then
B; if D, then E; if A, then C; if D, then F). The tasks consisted of matching made-up animal-like
figures using a matching-to-sample procedure. On each trial, the A or D stimulus was presented
as a sample with either B and E or C and F as the two comparison stimuli. Each child was trained
and tested with different stimulus sets. During the testing phase, the same stimuli were used but
the role of the sample stimuli and comparison stimuli during training were reversed. Equivalence
was demonstrated by both the typically developed preschoolers and the children diagnosed with
mental retardation that used signs appropriately which was indicated by matching B and C, as A
was the common stimulus for both, and between E and F, both of which had been matched to D
(Devany et al., 1986). None of the children diagnosed with mental retardation that did not use
signs appropriately demonstrated equivalence relations. Although correlational, the data provide
support for the view that the use of language and the ability to form equivalence classes are
closely related.

Shcusterman and Kastak (1993) demonstrated that the use of language may not be a
prerequisite to establishing stimulus equivalence classes but rather equivalence class formation
may be a prerequisite for learning language. Unlike other scientists investigating equivalence
thinking in animals, the authors exposed a California sea lion (Rio) to training and testing that
gradually increased in complexity. Shcusterman and Kastak (1993) came up with 30 equivalence
classes, each consisting of three different objects. For each class, Rio was trained on AB
relations excluding 12 exemplars. The authors then tested BA symmetry for the 12 exemplars
that were removed and trained Rio on them. Rio was then trained on BC relations. The authors
again removed the same 12 exemplars and tested for CB symmetry. Equivalence did not emerge so the authors trained Rio on the CB symmetry relations. AC and CA relations were then trained and tested for. The authors found that AC transitivity and CA equivalence did emerge for Rio without reinforcement.

Lazar, Davis-Lang, and Sanchez (1984) also examined the role of language in the development of stimulus equivalence. They presented a series of matching-to-sample tasks to typically developed children, including five sets of visual stimuli (A, B, C, D, and E), each consisting of three stimuli. Subjects were first taught the relation AD and DC, and were then able to demonstrate the relations AC/CA without direct training. The relation ED was then taught directly, and the CE/EC and AE/EA performances emerged. Following CB training, three new equivalences were demonstrated: AB/BA, EB/BE, and DB/BD. According to the authors: “Oral naming of each stimulus showed that subjects had not assigned a common label to stimuli in the same class, indicating that naming is not necessary for the formation of stimulus equivalences” (p.263).

The debate on whether or not language is a necessary prerequisite for the formation of equivalence classes is still ongoing but Shcusterman and Kastak (1993) and Lazar et al. (1984) provide convincing evidence that equivalence can emerge in the absence of language.

Differential Reinforcement and Stimulus Equivalence

Most studies examining the emergent relations of stimulus equivalence involve differentially reinforcing correct responding during training (e.g. AB and BC) and then testing for transitivity (e.g. AC) and equivalence (e.g. CA) in extinction (Sidman & Tailby, 1982). Training involves establishing a set of stimuli into functional classes by reinforcing the participant’s responding. Testing on the other hand does not involve teaching of new stimuli. It
rather involves introducing stimuli in new sequences to determine if properties such as symmetry, transitivity, and equivalence exists (Sidman et al., 1985).

Sidman et al. (1985) found that tests that were initially negative—did not indicate equivalence—became positive with continued repetition (no reinforcement). Several others have replicated this finding (Devany, Hayes, & Nelson 1986; Fields, Adams, Verhave, & Newman 1990; Lazar, Davis-Lang, & Sanchez 1984; Sidman, Willson-Moris, & Kirk 1986; Sigurdardottir, Green, & Saunders 1990). This suggests that the testing sequence may help determine whether new conditional discriminations emerge (Sidman, 1994). Sidman (1994) refers to this phenomena as delayed emergence. Delayed emergence refers to the fact that stimulus class membership would inevitably come under contextual control. He explained that every stimulus is a member of many different classes in addition to the classes our tests are designed to test for. Each stimulus will belong not only to the equivalence class for which the experimenter is explicitly training for, but will also be a member of other classes. During the test trials, each sample-comparison pair may belong to a different relation. For example, a participant could choose a comparison on the basis of any one of these relations. The aspects of the environment, the context, will select the prevailing class to which a particular sample will belong in common with the comparison.

Contexts can be anything in the environment and may be historical, present, or both and there may need to be many test trials required before one of the possibilities proves to be relevant on every single test trial. The relation that is possible on every trial, because of its presence, will come eventually to provide the basis for the correct choice and is termed delayed emergence (Sidman, 1994). Participants will come to only respond to those stimuli that are related in a consistent manner solely because they have a particular history with matching-to-sample procedures that have taught them that (a) each trial has a correct response and that (b) each trial
only has one correct choice. Without this history, there is no reason why the participant should show any consistency in their performance in a test without reinforcement (Sidman et al., 1985). Sidman et al. (1985) suggests that even without explicitly teaching any prerequisite conditional relations (no differential reinforcement), one should be able to produce the emergence of any kind of stimulus class or any relation one wants between samples and comparisons during the test under extinction.

Harrison and Green (1990) demonstrated that the formation of stimulus classes were possible without differential reinforcement during training trials. The experimenters presented participants with a series of two choice conditional discrimination trials. On each trial, one of two stimuli (S1 or S2) was presented as the sample or the comparison array included a stimulus designated correct (either C1 or C2, depending on what sample was presented) and one stimulus designated incorrect which was an abstract stimulus. The participants came to select C1 when S1 was presented as the sample stimulus and to select C2 when S2 was presented as the sample stimulus without differential consequences for their selections. Harrison and Green (1990) then demonstrated emergent relations with most of the participants to show that the sample and the comparison chosen on each trial were related by equivalence. It is still unclear, however, if emergent relations that define stimulus equivalence can consistently be produced without differential consequences during training trials.

The purpose of the current study was to systematically replicate Harrison and Green (1990) to further evaluate whether or not we can establish stimulus-stimulus relations (e.g. AB) without differential reinforcement and, if so, will symmetry emerge?
Method

Participants. Two typically developed individuals that were recruited from personal contact participated in this study. Todd was a 7-year-old boy who attended a typical elementary school and Angelina was a 26-year-old woman who worked as a teacher for children diagnosed with an Autism Spectrum Disorder (ASD) while attending a master’s program specializing in special education and severe special needs. Both participants were able to demonstrate all pre-requisite behavior, including: sitting, using a computer mouse, and attending to pictures on a computer screen.

Setting. Sessions were conducted in a quiet room furnished with a table, four standard chairs, a bookshelf, and a computer. The experimenter was present during all sessions. At the beginning of each session, the experimenter brought the participant to the table, sat behind them, and then cued them to start the session.

Apparatus. An Apple iBook with a standard monitor, a mouse, and specially designed software (match-to-sample software v 11.6.7) controlled all experimental sessions (i.e., presented trials, programmed consequences, and recorded the participants’ performance) (Dube, 1991). The participants were shown how to maneuver the mouse and how to complete a session.

Stimuli. Three pairs of visual stimuli were used during phases 1 through 4 (Figure 1). Each pair of stimuli consisted of a combination of a color, and a shape. Colors included red (C1), yellow (C2), and blue (C3). Shapes included the outlines of a cross (S1), a circle (S2) and a triangle (S3). The stimuli were displayed in 1.69 X 1.69 inch-squares. In addition, 109 nonsense symbols (X1 through X109) were used as non-target stimuli throughout the study. A
sample of these non-sense symbols is available in Figure 2. The target relations (i.e. trained and tested) were the same for both participants, and they were as follows: C1-S1, C2-S2, and C3-S3.

Matching-to-Sample Trials. Each trial consisted of one sample stimulus displayed in the center of the screen and three comparison stimuli displayed on the bottom of the screen. The sample stimulus was presented first, and the participants had to touch the sample in order to be presented with the comparison array. During trials with differential consequences, an auditory-visual feedback followed the selection of comparison stimuli designated correct. During trials without differential consequences, the selection of any comparison stimuli terminated the trial and was followed simply by a short inter-trial interval and the presentation of the next trial. This procedure remained the same across all phases of this study, including the pre-experimental phase. Trial types for each of the phases are described in more detail below.

Response measurement. The dependent variable, selection of comparison stimuli, was defined as any instance of the participant choosing a comparison stimulus in the presence of a sample stimulus by using computer mouse to click within the area of the stimulus. The computer recorded the exact configuration of each trial, the latency of responding towards the sample stimulus, the latency of responding towards the comparison stimuli, and what stimulus was selected in each trial. Independent variables included the configuration of the trials and the type of feedback following selection responses.

Trials were presented in blocks of 18 (pre-experimental phase) or 9 (Phases 1 through 4) trials. The position of the correct comparison stimulus was balanced across trials within a block of trials; the same stimulus was not designated correct more than two consecutive times, nor was it presented in the same position more than twice in a row.
Procedures. Sessions were conducted 2-3 times a week for each participant. During each session, participants completed from 1 to 3 blocks of trials. A 3-minute break was offered in between blocks. On break, the participants could engage in any activity that was accessible to the participant without leaving the room.

Pre-experimental phase. This phase was conducted to provide each participant with a history of matching-to-sample tasks. The purpose of such history was to make sure the participants would respond consistently (i.e. select only one stimulus per trial, and select the same comparison across identical trials) across trials even in the absence of differential feedback.

Without such a history, there would be no reason to expect the participants to come to respond consistently to the novel stimuli during the experimental trials. The Pre-experimental phase consisted of sessions including blocks of 18 trials involving familiar similar stimulus-stimulus pairs. These familiar stimuli included pictures of monkeys, cats, fish, and birds. Each trial started with the presentation of one of the animal pictures as sample stimulus, and three animal pictures as comparison. One of the comparison stimuli was a non-identical picture of the same animal presented as sample. Initially, selecting the correct comparison produced a sound, and a visual feedback that indicated the response to be correct. Incorrect responses did not produce any differential consequence. Following each trial, a brief inter-trial interval lasting 2s preceded the presentation of the next trial. Once the participants demonstrated 100% accuracy across one block of trials, blocks of trials without differential consequences were presented. The participants were told that the stars would no longer be displayed on the computer screen despite them selecting the correct comparison. All selections of the comparison stimuli resulted in the presentation of the inter-trial interval and the next trial. Once the participant selected the correct
comparison 100% of the time for three consecutive sessions, the next phase was introduced. This same mastery criterion was used during the experimental phases.

The purpose of phases 1 through 3 was to establish 3 sets of stimulus-stimulus relations - without using differential outcomes for correct and incorrect responses- each involving a color stimulus (C1, C2, and C3) and a shape stimulus (S1, S2, and S3). During all the experimental phases, blocks included 9 trials, 3 with each target sample.

**Phase 1.** During this phase, the sample stimuli consisted of a target color stimulus (C1, C2, C3) and the comparison stimuli included one target shape (S1, S2, S3) and two arbitrary symbols (X1-X109) from a lengthy list that was never repeated (see Figure 2 for examples). Each target sample was presented with a corresponding target comparison and two novel incorrect comparisons. The only selection response that was possible across all trials was towards the comparison stimulus designated correct. Trials were set up so that no differential consequences were provided for the participants’ selection of comparison stimuli. Once the participant met the same mastery criteria described above, the next phase was introduced. An example of a block of trials used during this phase is displayed in Figure 3.

**Phase 2.** Procedures used during this phase were the same as in Phase 1 except for the configuration of comparison stimuli. During the previous phase, only one shape – the correct one- was displayed in the comparison array across all trials. During this phase, 33% of the trials in each block included one of the shapes as an incorrect comparison as it is displayed in Figure 4.

**Phase 3.** The procedure was the same as in phases 1 and 2 except that all of the arbitrary incorrect comparison stimuli were now replaced by target shapes that function as correct stimulus in some trials and incorrect stimulus in other trials (see figure 5). Only if a conditional relation between the target sample stimulus and the corresponding target comparison was
established would the participant come to consistently select the correct comparison stimulus. Once the participant met mastery criteria, a test to determine whether or not symmetry emerged was conducted.

Phase 4 (Symmetry). During this phase, the matching-to-sample procedure was the same as used in phase 3 however, colors were used as comparison stimuli and shapes served as samples.

The exact experimental sequence, as well some of the procedures that were used, were adjusted according to the participants’ performance. These modifications are described under the participants’ results.

Results

Both Angelina and Todd participated in every session until completion. Angelina required 24 sessions to complete all phases and Todd required 23 sessions to complete all sessions to determine if it was possible to learn stimulus-to-stimulus relations without differential reinforcement and whether or not symmetry would emerge. The experimental sequence was different across the participants.

Angelina

The results for Angelina are displayed in Figure 6. The X axis indicates session number and the Y axis represents the proportion of correct responding per block of trials. The experimental sequence for Angelina consisted of the following: (a) pre-experimental phase, (b) Phase 1, (c) phase 2, (d) Phase 1, (e) Phase 3, (f) Phase 1, (g) Phase 3, (h) Phase 1, (i) Phase 3, (j) Phase 4. The rationale for this sequence, as well as performance data, is described below.

Pre-experimental. Trials in the phase consisted of familiar pictures of animals as samples and similar pictures as comparison stimuli. During both the feedback and no-feedback portions
of the pre-experimental phase (first three columns in Figure 6), Angelina selected the correct comparison stimulus in 100% of the trials across three consecutive blocks of trials.

*Phase 1.* Trials in the phase consisted of a color stimulus as a sample and the corresponding correct shape and two non-sense stimuli as comparisons. The first time the procedures of this phase were introduced, Angelina selected the correct comparison stimulus in 100% of the trials for three consecutive sessions. Procedures of phase 1 were reintroduced again during sessions 11, 14, and 17 following Angelina’s failure on performing accurately in trials of phase 2 and 3. Her performance on phase 1 trials remained at 100% accuracy.

*Phase 2.* Trials in the phase consisted of a color stimulus as a sample and two corresponding correct shapes and one non-sense stimulus for a third of the block of trials. Data during this phase suggest that Angelina did not learn the stimulus-to-stimulus relations presented in phase 1, and likely her accurate performance was under control of other dimensions of the stimulus configuration. During Sessions 8, 9, and 10, Angelina selected the correct comparison in no more than 45% of the time. Since the sudden decline in Angelina selecting the correct comparison, the experimenter asked Angelina the reason she selected particular comparison stimuli. Angelina reported that she was selecting the comparison that was different (arbitrary symbol) in trials that consisted of two target shapes and one arbitrary symbol. As a result, the stimuli fade in procedure scheduled for Phase 2 was discontinued.

*Phase 1/Phase 3 Reversals.* Trials in the phase consisted of blocks of trials consisting of a color as the sample stimulus and one corresponding correct shape and two non-sense stimuli as comparison stimuli (Phase 1) or three shapes as comparisons (Phase 3). Before introducing the procedures programmed for Phase 3, Angelina completed another two blocks of trials using Phase 1 configuration. This was done to ensure her performance in those trials remained at 100%
before introducing the final trial configuration. The first time Phase 3 trials were presented, in session 13, Angelina selected the correct comparison stimuli in only 35% of the trials. Another reversal to Phase 1 trials was carried out, and she again selected the correct comparison stimuli in 100% of trials for sessions 14 and 15. A return to Phase 3 in session 16 shows that Angelina still did not learn the target stimulus-to-stimulus relations. An additional reversal to phase 1 was implemented, and Angelina’s performance in those trials remained at 100% (see sessions 17 and 18 in Figure X). When procedures of Phase 3 were presented for the third time, following three reversals to Phase 1, (sessions 19, 20, and 21), Angelina performed with 100% accuracy across all three blocks of trials, suggesting that she had learned the stimulus-to-stimulus relations.

Phase 4 (Symmetry). During this phase, Angelina selected the correct comparison stimulus in 100% of trials for sessions 22, 23, and 24, demonstrating that symmetry did emerge.

Todd

The results Todd are displayed in Figure 7. The X axis indicates session number and the Y axis represents the proportion of correct responding per block of trials. The experimental sequence for Todd consisted of the following: (a) Pre-experimental phase, (b) Phase 1, (b) Phase 2, (c) Phase 3, and (d) Phase 4. The rationale for this sequence, as well as performance data, is described below.

Pre-experimental. As it was mentioned before, trials in the phase consisted of familiar pictures of animals as samples and similar pictures as comparison stimuli. During both the feedback and no-feedback portions of the pre-experimental phase (first three columns in Figure
Todd selected the correct comparison stimulus in 100% of the trials across three consecutive blocks of trials.

**Phase 1.** Trials in the phase consisted of a color stimulus as a sample and the corresponding correct shape and two non-sense stimuli as comparisons. The first time the procedures of this phase were introduced, Todd’s performance immediately deteriorated and he was selecting the correct comparison at chance levels. Although Todd chose the correct comparison for 100% of trials for the first three sessions of the Pre-experimental phase, these data suggest that it did not provide him with the necessary matching-to-sample history during the pre-experimental phase, therefore the experimenter added an antecedent intervention in session 9 by pointing to the correct target comparison stimulus but still not providing feedback. Todd then selected the correct comparison stimulus in 100% of trials for sessions 10, 11, and 12.

**Phase 2.** Trials in the phase consisted of a color stimulus as a sample and two corresponding correct shapes and one non-sense stimulus for a third of the block of trials. Todd selected the correct comparison stimulus in 100% of the trials for the next three consecutive sessions.

**Phase 3.** Trials in the phase consisted of blocks of trials consisting of a color as the sample and the three target shapes as comparison stimuli. Todd selected the correct comparison stimulus in 100% of the trials for the next three consecutive sessions.

**Phase 4 (Symmetry).** During this phase, Todd selected the correct comparison stimulus in 100% of trials for sessions 19 and 20. In session 21, Todd’s performance began to deteriorate. While selecting the incorrect comparison stimulus, Todd vocalized that he had made a mistake.

Todd chose the correct comparison stimulus in 100% of trials for sessions 22 and 23 more sessions 22 and 23 demonstrating that symmetry did emerge.
Discussion

This study’s results support the findings of Harrison and Green (1990) that it is possible to teach stimulus-to-stimulus relations without differential reinforcement and that symmetry can emerge. Angelina selected the correct comparison stimuli in 100% of the sessions until phase 2, where she began to select the comparison that was different or “stood out.” This indicates that Angelina did not promptly learn the stimulus-to-stimulus relations that were expected (C1-S1, C2-S2, and C3-S3). Angelina’s accurate performance on critical experimental trials (i.e. trials involving all three target stimuli in the comparison array) only came about after three reversals to Phase 1 procedures. It is possible that such reversals functioned as a correction procedure – and therefore a differential outcome- for the response pattern that she had demonstrated during the first times critical trials had been presented. That being the case, it is not possible to conclusive state that she acquired new stimulus-stimulus relation without differential feedback. It is still possible to affirm, however, that such relations did occur in the absence of trial-by-trial feedback. In addition, once she learned the target stimulus-to-stimulus relations, she was able to promptly demonstrate symmetry among all the target stimuli.

Todd selected the correct comparison 100% of the trials in the pre-experimental phase with familiar stimuli but began to select random comparison stimuli in phase 1. Based on these results, it is possible that Todd did not develop the necessary matching-to-sample history needed to be able to respond consistently to one comparison stimulus without differential reinforcement. It is unclear what aspect of such history he may have lacked. Would it have been enough if more blocks of reinforced and unreinforced trials had been presented? Would it have been enough if other exemplar sets had been introduced? In Todd’s case, an antecedent intervention (i.e. 
prompting of responses during session 9) was sufficient for him to learn the target relations, and to demonstrate symmetry among the stimuli in each relation.

Data from both participants indicate that stimulus-to-stimulus relations can be learned without trial specific differential consequences, and, that these relations are symmetric.

Future research should consider what variables are responsible for the establishment of stimulus-to-stimulus relations under similar conditions. Also, applied research should go further to examine whether other relations besides symmetry would emerge from such a matching-to-sample procedure. In other words, would transitivity and equivalence emerge?
References


Figure Captions

*Figure 1.* Target Stimuli used during phases 1-4.

*Figure 2.* An example of the non-sense stimuli used as incorrect stimuli in phases 1-3.

*Figure 3.* An example of a block of trials in phase 1.

*Figure 4.* An example of a block of trials in phase 2.

*Figure 5.* An example of a block of trials in phase 3.

*Figure 6.* Proportion correct of Angelina selecting the correct comparison stimuli in each session.

*Figure 7.* Proportion correct of Todd selecting the correct comparison stimuli in each session.
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The figure shows the progression of proportion correct over sessions for Todd, across different phases of an experimental study. The x-axis represents session numbers, ranging from 1 to 23. The y-axis represents the proportion correct, ranging from 0 to 1.

- **Pre-experimental** phase is represented at the start with both F (Fear) and NF (No Fear) conditions showing high proportion correct, indicated by the bars reaching nearly to the top of the chart.
- **Phase 1** starts with a sharp drop in proportion correct, then increases gradually, with a marked drop in the last session.
- **Phase 2** shows a steady increase in proportion correct from the first session to the last, with a slight dip in session 12.
- **Phase 3** maintains a high proportion correct throughout, with a slight dip in session 16.
- **Phase 4** shows a consistent high proportion correct, with a slight dip in session 20.

**Promoted** sessions are indicated by a different marker, suggesting specific points of interest or changes in the experimental protocol.