The Development of Stimulus Equivalence in Young Children

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The current study investigated if children at early stages of language development promptly demonstrate the emergence of stimulus equivalence. Procedures were similar to the ones described by Schusterman and Kastak (1993) which found evidence of equivalence in sea lions. Two typically developed children, ages 3 to 5, participated in this experiment. Eighteen visual stimuli were divided in six sets containing three stimuli each (A, B, and C). All stimuli were previously unknown to the participants. Participants were directly trained to match stimuli A to stimuli B and stimuli B to stimuli C using one of the sets. After showing inconsistent results in transitivity and symmetry tests, participants were trained to perform the matching tasks corresponding to these properties. Once mastery criteria were met, a new set of stimuli was introduced and the same training and testing sequence was implemented. Results indicate that the presence of basic language and naming skills may not be sufficient for the prompt emergence of stimulus equivalence, and that a history of performing such tasks under training conditions may contribute to the phenomenon.
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Stimulus Equivalence in Young Children

As defined by Sidman (1982), stimulus equivalence occurs with stimuli that are reflexive, symmetrical, and transitive. Reflexivity involves the identity matching of a stimulus to its self (A=A, B=B, C=C). For a relation to be reflexive, it must hold true for each individual stimulus, without differential reinforcement. Symmetry involves the reciprocal relation between a sample stimulus and a comparison stimulus. When sample and comparison are interchanged, each relation must hold true without explicit training, for the relation to be considered symmetric (A=B, B=A). When two relations are directly trained (A=B and B=C), and a new one emerges (A=C), the emergent relation is called transitive (if A=B, and B=C, then A=C). Equivalence is established when untrained relations among stimuli emerge from reinforced trials with individual stimuli, thus forming equivalence classes that are reflexive, symmetrical, and transitive.

In the years since Sidman’s original studies in 1971, the process of equivalence class formation has been heavily investigated, and debated by a number of authors (e.g., Hayes, S., 1989; Horne, P. and Lowe, F. 1996). For Sidman (1994), equivalence relations are stimulus-stimulus relations that arise from contingencies of reinforcement. Hayes (1989) suggests that extensive training with symmetrical responding creates a history with conditional discriminations, from which equivalence class formation develops. Horne and Lowe (1996) suggest that equivalence relations are formed as a result of a history of naming and hearing named relations. These three conflicting interpretations are examined below.
Relational Frame Theory

Hayes (1989) suggests the phenomenon referred to as “Sidman equivalence” are relational associations involving language. This process involves extensive training with symmetrical responding to form a history with conditional discriminations, and equivalence is only one of these possible relations. The author also challenges experimental evidence suggesting that non-human subjects have been able to demonstrate stimulus equivalence. According to Hayes, a study by McIntire, Cleary, & Thompson (1987) showing equivalence in monkeys fails on meeting all the requirements of a true equivalence demonstration because the authors used specific response requirements, and direct reinforcement contingencies in their study. Hayes and Barnes (1997) further clarified relational frame theory (RFT), labeling stimulus classes as “arbitrarily applicable stimulus relations”. The authors criticized an equivalence account as described by Sidman (1982), stating that it is too narrow, and it misses components of the behavioral process underlying the phenomenon observed. The authors conclude that equivalence involves the relations among stimuli rather than class membership.

Applied support for RFT is provided by Devany, Hayes, and Nelson (1986). This study compared the performance of three groups of children (normal functioning levels, retarded with speech capabilities, and retarded with a language deficiency) to determine whether language capabilities influence an individuals’ ability to form equivalence classes. Language-able children performed better on the stimulus equivalence test than those without language, supporting a positive correlation between ability to speak and performance on equivalence tests.
Opposing the RFT theory, McIlvane & Dube (1996) point out that one of the limitations of such theory is that it relies partially on the fact that studies have failed to demonstrate equivalence class formation in humans, and future results of positive equivalence class formation in non-humans could pose problems for RFT. Also questioning the RFT, Sidman (1997) says:

I do not understand how any number of examples can give rise to generalized arbitrary relations like reflexivity, symmetry, transitivity, and so on. Because the exemplars would possess no measurable feature in common, it is not at all evident that one might be able to generalize an arbitrary relation solely from exemplars” (Sidman, 1997, p.364-365).

Naming Theory

Horne and Lowe (1996) outline an alternate interpretation to explain the type of responding observed in equivalence studies. According to these authors, names relate to classes of objects. During the process of class formation, instead of establishing a direct relation between each stimulus and another stimulus, a common name is used to describe each stimulus and such a common name is sufficient to establish a stimulus class. The emergence of new stimulus-stimulus relations derive from such common names. In other words, a common name is used for different members of a class – in the context of being both spoken and heard by the individual - and each stimulus is then treated in a similar way, as if the stimuli were functionally equivalent.

The focus of naming theory is on verbal processes. Verbal repertoires allow positive performances on equivalence tests; these successes are a secondary outcome
of naming. In terms of “Sidman equivalence”, Horne and Lowe suggest that language emerges and leads to the development of stimulus classes, and consideration of the process of equivalence class formation as emergent is based on assumptions of internal processes.

A number of authors have presented opposing arguments to the naming theory. According to McIlvane and Dube (1996), Horne and Lowe’s account does not consider all the ways naming could be involved in tests of equivalence. McIlvane and Dube criticize the lack literature to support naming as a fundamental process in class formation. It is convenient to suggest verbal behavior as a causal variable in class formation, given the familiarity of verbal repertoires, but unsubstantiated in research.

Schusterman, Kastak, & Reichmuth, (1997) also support that naming is unnecessary for the formation of equivalence classes, and the authors conversely claim that it may be that equivalence class formation is in fact what facilitates naming. To support this view, these authors cite field studies of non linguistic animals such as sea lions and primates, showing that such populations are capable of forming equivalence classes (Shusterman, Kastak, & Reichmuth, 1995; Cheney and Seyfarth, 1990; Hanggi & Shusterman, 1990). Schusterman et al. (1997) conclude that “The most parsimonious explanation for the appearance of equivalence in both humans and other animals is that the ability evolved in a social or ecological context, rather than as a result of linguistic competence” (p.257).

Applying another approach to discredit naming theory, Pilgrim (1996) claims the arguments by Horne and Lowe are based on facts that cannot be directly measured.
Therefore, it is hard to disconfirm components of the theory, and is so ambiguous it is hard to disprove. Even when criteria are suggested by the authors that may change or disprove the influence of naming, that same criteria is later justified and used to support the influence of naming. For example, due to animals’ lack of naming repertoires, they should not be able to demonstrate equivalence. However, they also claim that if an animal was able to accomplish this, it would not affect the determinants of equivalence in verbal humans.

**Equivalence as a Basic Process**

Equivalence class formation was first demonstrated by Sidman (1971) and later (Sidman and Talby, 1982) defined in terms of its properties (i.e. reflexivity, symmetry, and transitivity). The author described procedures used to establish reading comprehension skills in a boy with mental retardation using a matching-to-sample procedure. The individual was able to match words spoken to him to visual pictures and could name (tact) the visual pictures presented to him. Through differential reinforcement procedures, the individual was taught to match words spoken to him to the corresponding visual words. The individual then could match pictures to words, words to pictures, and orally name visual words presented to him, skills that were not directly taught. Reading comprehension and oral reading emerged through the reinforced selection of the relations among visual stimuli (words) to auditory samples.

Since this seminal study, several experiments followed, and have provided support to the notion of stimulus equivalence as a basic behavioral process (e.g.
Saunders, Saunders, Kirby, & Spradlin, 1988; Fields et al., 2009; Sidman, 1935/1938; Sidman, 1994).

Saunders and Green (1996) lend additional support to equivalence as a fundamental process, as opposed to naming. Naming is made possible by contingencies that establish prerequisites for equivalence relations. The arrangements in naming experiments allow the generation of equivalence classes. Saunders and Green (1996) explain: “If naming is not required in order for stimulus equivalence to be demonstrated, than nonhumans can demonstrate equivalence” (p.313).

The paradigm of stimulus equivalence as a basic process depends in part of successful equivalence outcomes with non-human or nonverbal individuals. Studies supporting equivalence class formation in non-humans are few, and many positive findings do not rule out potentially mediating variables, such as the use of class-specific reinforcement. Kastak and Schusterman (2001) provided one example of such demonstration. The authors taught two California sea lions (Rio and Rocky) to classify stimuli in to functional classes through the use of simple discrimination, match-to-sample, and equivalence training procedures. While the use of common reinforcers expanded the emergent relations, these findings do not rule out naming. However, the authors suggest that common reinforcers are incorporated as additional class members which actually strengthen new equivalence relations.

Another study by Kastak and Schusterman (2002) provided stronger evidence for equivalence demonstration. The purpose of this study was to determine if equivalence classes could be expanded using an exclusion procedure with 2 sea lions
(Rio and Rocky). The results deemed language as unnecessary for exclusion performances as well as symbolic learning.

The present study is based on Schusterman and Kastak (1993). Their demonstration of equivalence class formation with a California sea lion provided evidence that such relations do not require language or class-specific reinforcement. The authors arrived at such conclusions by using programmed instructional sequences, using a protocol where trained responses are based only on relevant information learned through history with forward and reverse pairings. The key to the obtained results rely on the training of many relational exemplars to a pre-determined criterion before testing relations with new stimuli.

Specifically, Schusterman and Kastak (1993) trained AB relations for 30 potential classes, then removed 12 exemplars. They then tested BA symmetry for the 12 exemplars that were removed and trained them to criterion. Next, they trained BC relations for 30 classes and removed the same 12 for CB symmetry tests. Negative results on equivalence tests led to training of CB symmetry for the 12 exemplars. Finally, these authors tested and trained AC transitivity for 12 classes and tested CA equivalence on the remaining 18 classes.

McIlvane and Dube (1996) support Schusterman and Kastak (1993). According to McIlvane and Dube, Shusterman & Kastak have provided the most convincing evidence of equivalence class formation by nonhumans. Shusterman and Kastak accomplished this by providing multiple opportunities for the sea lions to experience stimuli. McIlvane and Dube also suggested that more research in the area of stimulus equivalence, specifically with children between the ages of 18 and 36
months should be conducted to add to the data supporting that equivalence classes can be demonstrated prior to the development of language. At this age, children experience a sudden burst of new language. The authors suggested that more research with this population would benefit knowledge of stimulus equivalence underlying behavioral process.

Equivalence demonstration by a pre-verbal human, near the ages suggested by McIlvane and Dube, would lend support to the account that equivalence is an emergent process resulting from contingencies of reinforcement rather than language development. Replications of Schusterman and Kastak (1993) with very young, pre-verbal humans would contribute greatly to the growing body of literature in this arena of research.

The current study investigated whether children at early stages of language development would promptly demonstrate the emergence of stimulus equivalence and assessed whether training symmetry, transitivity and equivalence would lead to the emergence of these properties with untrained relations.

**Method**

**Participants**

Two typically developing children were selected from a group enrolled in a preschool. Rico and Isabelle were both 4 years old at the beginning of this study.

**Setting and Materials**

Sessions took place in a 4.3 m by 1.5 m room near the participants’ classroom. During each session, participants sat at a small table, facing the apparatus. In addition to basic office furniture, the room contained a bin filled with toys.
(Transformers®, Lite-brite®, remote-control spider, coloring books, markers, toy cars, spin toys, and disc throwers), stickers, and a digital video recorder.

**Apparatus.** As shown in Figure 1, the apparatus used for experimental sessions consisted of a Macintosh® computer laptop and an external mouse. The screen (19 cm by 14 cm) displayed stimuli on a color monitor. A program (MTS v 11.6.7) controlled the presentation and position of all sample and comparison stimuli, as programmed by the experimenter, balanced so that each comparison stimulus appeared in each position the same number of times. This program permitted automatic data recording, and a complete description of the software is provided by Dube (1991).

**Stimuli.** Eighteen visual stimuli were divided into six sets of three stimuli each (Figure 2). Each set – identified in this report by numbers 1 through 6 - were composed by the shape of one American state, the flag of that state, and a landmark associated to it. Each stimulus within each set is identified in this report by the letters A (state map), B (state flags), and C (state landmarks). Pretest procedures were conducted, and the results determined that relations among stimuli within each class were unknown for both participants.

**Match-to-sample procedures.** The match-to-sample display consisted of four keys on a white background. One key was presented in the center of the screen (sample stimulus) and three keys (comparison stimuli) were centered on the screen below the sample (see Figure 2). During each phase, different combinations of sample (displayed in the center) and comparison stimuli (presented on the bottom of the display) were used. A detailed description of the trial types used in each phase is
provided below. Each trial started with the presentation of a sample stimulus. Once the participant clicked the mouse on the sample stimulus, three comparison stimuli appeared on the screen. A selection response was defined by the participant clicking the mouse on one of the stimuli used as comparison.

**Response Measurement and Differential Consequences**

Selection of the comparison stimuli was recorded when the participant clicked the mouse within the boundaries of a comparison stimulus, displayed on the monitor. Clicks anywhere other than on a stimulus were not recorded and the screen did not advance. Correct responses were defined by the participants’ clicking on the comparison stimulus that belonged to the same set as the sample stimulus. Each correct response was followed by praise from the experimenter and star shapes displayed on the screen, accompanied by brief tones. Overall participation produced access to stickers and a bin of toys at the end of the session. Incorrect responses were followed by a blank screen on the apparatus and no comment from the experimenter.

Each session consisted of nine trials, each defined as the presentation of a sample stimulus on the computer screen. A click with the mouse on the sample stimulus was required in order for the comparison stimuli to be presented. The trial ended when the participant selected a comparison stimulus. Each comparison stimulus in a set was designated correct the same number of times, and stimuli appeared in each position the same number of times (right, center, and left).

**Prompting Procedures**

Gesture (point) cues were used during prompted sessions. During these sessions, presentation of the comparison stimuli on the monitor was followed immediately by
the experimenter’s finger pointing to the comparison stimulus that correlated with the sample stimulus. The experimenter stood behind the participant to present prompts.

A prompted session followed an initial test session were the score was less than 100% accuracy. Prompted sessions also occurred after three sessions without an increase in accuracy. All prompted sessions consisted of nine trials.

**Procedures**

A summary of training and testing procedures is shown in Figure 3. In this figure, the solid black arrows indicate relations that were trained, and the dashed grey arrows indicate the relations that were tested. The numbers attached to each letter correspond to the order in which these relations were trained and tested. The three pictures to the left of the solid black dividing line represent one example of stimulus A, B, and C from classes 1-3. The pictures to the right of the solid line divider represent one example of stimulus A, B, and C from classes 4-6.

As indicated by the solid arrow marked as 1 on the left portion of Figure 3, the first trained relations involved stimuli A1 through A3 as samples and B1 through B3 as comparisons stimuli. Mastery criteria required the participants to complete three consecutive blocks of nine trials with no more than one error per block. Once participants met mastery criteria for AB relations with stimulus set 1 through 3, AB relations 4 through 6 were trained using the same procedures and mastery criteria used earlier (indicated by arrow 2 in Figure 3). After all AB relations were trained, maintenance sessions were carried out with all six sets of stimuli.

The dashed grey arrow marked with a number 3 on the left portion of Figure 3 indicates the first symmetry test, with stimuli B1 through B3 as samples and A1
through A3 as comparisons stimuli. All tests throughout the study included reinforcement, so only the first three trials were counted as a performance probe. In order for positive results to be reported, the participants had to select the corresponding stimulus in each relation the first time it was presented. If the participants responded incorrectly the first time a stimulus relation was presented in a test session, training was re-implemented, and training continued until mastery criteria was met. If the participants responded correctly during the first three probe trials, the session continued through nine trials.

As indicated by the solid arrow marked with a number 4 on the left portion of Figure 3, the next trained relations involved stimuli B1 through B3 as sample stimuli and C1 through C3 as comparison stimuli. When mastery criteria were met, training of relations with stimuli B4 to B6 as sample stimuli and C4 to C6 as comparison stimuli began (indicated by arrow 5 in Figure 3). After all BC relations were trained, maintenance sessions were carried out with all six sets of stimuli.

The dashed grey arrow marked 6, on the left side of Figure 3 indicates the second symmetry test. Stimuli C1 through C3 served as sample stimuli with B1 through B3 serving as comparison stimuli. If symmetry relations were not demonstrated, these three relations were trained to mastery criteria.

Six maintenance sessions were run for previously trained AB relations 1-6 (solid arrows 1 and 2 in Figure 3). With demonstrated maintenance of relations A1 through A3 stimuli as sample to B1 through B3 stimuli as comparisons, and B1 through B3 stimuli as sample to C1 through C3 as comparisons, the relations AC (transitivity) were tested for stimulus sets 1-3 (indicated by dashed grey arrow 7 in Figure 3).
Stimuli A1 through A3 served as sample stimuli with stimuli C1 through C3 serving as comparisons. An incorrect response in the first three trials of the AC transitivity test with sets 1-3 led to training of such relations.

As indicated by dashed grey arrow 8 in Figure 3, a test for CA relations 1 through 3 was then conducted. Stimuli C1 through C3 served as samples and A1 through A3 as comparisons. As with previous tests, training was re-implemented if any of the first three trials were incorrect, and training continued until mastery criteria was met.

Finally, the dashed black arrow 9 in Figure 3 indicates CA equivalence tests for classes 4-6. Stimuli C4 through C6 served as sample stimuli to A4 through A6 comparison stimuli. This was the final phase, and with these last three classes the relations were not trained to criterion.

Results

A total of 63 sessions were carried out for Rico and 79 sessions for Isabelle across a period of 20 weeks for Rico, and 24 weeks for Isabelle. Between two and four sessions were run each week for both participants.

Rico

Each session averaged two minutes, with five to seven minutes of play pending completion of the programmed trials. Rico could choose any combination of items from the bin of toys, and often favored spin toys. Rico participated in every session to completion.

The results for Rico are displayed in Figure 4. The X axis indicates sessions, and the Y axis indicates independent correct responses. The data path throughout the graph is separated at points where a prompted session occurred. Data points for each
relation are indicated by a different symbol, solid symbols representing relations that were directly trained, and open symbols indicating relations that were tested (then trained if necessary). The legend of Figure 4 provides the corresponding symbol for each relation.

**AB and BC acquisition.** Rico met mastery criteria of AB relations for stimulus sets 1 through 3 in 11 sessions, as indicated by the solid squares in the first section of Figure 4. During sessions 2 and 7, this participant’s performance was prompted by the experimenter as described previously. Mastery of AB relations 4-6 was achieved in four sessions (solid diamonds in the second section of Figure 4). Session 16 consisted of trials prompted by the experimenter. Both relations were maintained as illustrated by the data displayed in the third section of Figure 4.

Mastery of BC relations for stimuli sets 1 through 3 was reached in four sessions, as indicated by the closed triangles in Figure 4. One session was prompted as indicated in session 32. Training of BC stimuli sets 4-6 (indicated by the closed circles in Figure 4) lasted four sessions, with one prompted session (38). Maintenance probes indicated that both relations were maintained (Figure 4).

**BA symmetry test for first AB relations.** The results of Rico’s first test, with stimuli B1 through B3 as samples and A1 through A3 as comparisons indicate failure to demonstrate symmetry. The first data point in the fourth section of Figure 4 shows two correct responses, indicated by open squares. After a prompted session by the experimenter at session 27, this relation was then trained to mastery in three sessions.

**CB symmetry test for first BC relations.** The open triangles in Figure 4 indicate Rico’s performance for CB relations, stimulus sets 1 through 3. Rico selected the
corresponding comparison B1 through B3 stimulus when presented with a C1 through C3 stimulus as sample stimuli for each relation. No prompted trials were necessary to establish criteria for mastery.

**AC transitivity test for first AB, BC relations.** The closed stars in Figure 4 indicate Rico’s performance during the initial AC transitivity test for stimulus sets 1-3. When presented with stimuli A1 through A3 as samples and C1 through C3 as comparisons, Rico indicated the correct comparison in one of three opportunities. After a prompted session (57), this relation was acquired in three sessions.

**CA symmetry test for first AB, BC, and AC relations.** Rico accurately responded to CA stimulus relations (sets 1-3), as indicated by the open stars in Figure 4. Mastery criteria were reached in three sessions, and it was not necessary for the experimenter introduce a session in which relations were prompted.

**CA equivalence test for remaining potential class.** In the final equivalence test, Rico was presented with stimuli C4 through C6 as samples and with stimuli A4 through A6 as comparisons. As indicated by the solid cross in Figure 4, Rico selected the correct comparison stimulus when presented with a corresponding sample in 9 of 9 trials.

**Isabelle**

Each session averaged 2.5 minutes, with five to seven minutes of play pending completion of the programmed trials. Isabelle could choose any combination of items from the bin of toys.

Despite slight modifications, Isabelle did not maintain baseline relations and failed to promptly demonstrate equivalence class formation with stimuli 4-6. There are
some identifiable reasons for this. First, the sessions extended longer than predicted for Isabelle, and certain observations were made during sessions. Lack of correct independent responses, requests to be finished before completion of the session, and a weak attending response are some examples. Consequently, an EO was added at session 53. In addition, the auditory and visual feedback provided by the computer as well as the praise by the experimenter wasn’t sufficient, so the value of getting a correct answer was increased with certain minor changes made to the reinforcement procedures. A reinforcement system was included, whereby the participant could earn a token for any session with at least eight of nine correct responses. When all tokens were received, a “menu” of items became available.

Results for Isabelle are shown in Figure 5. Similarly to Figure 4, sessions are numbered across the X axis and accuracy represented on the Y axis. Also, as in Figure 4, the data path throughout the graph is separated at points where a prompted session occurred and data points for each relation are indicated by a different symbol. The legend of Figure 5 provides a symbol for each relation.

**AB and BC acquisition.** Isabelle met mastery criteria of AB relations for stimulus sets 1 through 3 in 14 sessions, as indicated by the solid squares in the first section of Figure 5. During sessions 2, 6, and 10, this participant’s performance was prompted by the experimenter as described previously. Mastery of AB relations 4-6 was reached in 15 sessions (solid diamonds in the second section of Figure 5), with sessions 16, 19, and 24 prompted by the experimenter. Maintenance probes for both relations indicated that the relations were maintained, as illustrated by the data displayed in the third section of Figure 5.
Mastery of BC relations for stimuli sets 1 through 3 was reached in three sessions, as indicated by the closed triangles in Figure 5. One session was prompted at number 41. Training of BC stimuli sets 4-6 (indicated by the closed circles in Figure 5) required 10 sessions, with prompted sessions at number 47 and 51. Maintenance probes for both relations were conducted, and the results suggested that the relations were maintained, as displayed in the seventh section of Figure 5.

**BA symmetry test for first AB relations.** The results of Isabelle’s first test, with stimuli B1 through B3 as samples and A1 through A3 as comparisons show failure to demonstrate symmetry. The first data point in the fourth section of Figure 5 shows two correct responses, indicated by open squares. After a prompted session by the experimenter at session 36, this relation was then trained to mastery in three sessions.

**CB symmetry test for first BC relations.** The open triangles in Figure 5 indicate Isabelle’s performance on CB relations for stimulus sets 1 through 3. Isabelle did not select the corresponding comparison B1 through B3 stimuli when presented with a C1 through C3 stimuli as sample for each of the first three trials. After a session (63) prompted by the experimenter, mastery criteria was reached in three sessions.

**AC transitivity test for first AB, BC relations.** The closed stars in Figure 5 indicate Isabelle’s performance during the initial AC transitivity test for stimulus sets 1-3. When presented with stimuli A1 through A3 as samples and C1 through C3 as comparisons, Isabelle selected the correct comparison in two of three opportunities. After a prompted session (72), this relation was acquired in three sessions.

**CA symmetry test for first AB, BC, and AC relations.** Isabelle accurately responded to CA stimulus relations (sets 1-3), as indicated by the open stars in Figure
5. Mastery criteria were reached in three sessions, and it was not necessary for the experimenter to prompt a session.

**CA equivalence test for remaining potential class.** In the final equivalence test, Isabelle was presented with stimuli C4 through C6 as samples and with stimuli A4 through A6 as comparisons. As indicated by the solid cross in Figure 5, Isabelle selected the correct comparison stimulus when presented with a corresponding sample in 2 of 3 trials and failed to demonstrate equivalence with this relation.

**Discussion**

Although Shusterman and Kastak (1993) provided a convincing demonstration of equivalence in non-humans, one of the limitations of their study is the difficulty of replication due to time considerations and complex conditions. The original study took over four years for one subject and more than five years for the other. The current study provided a systematic replication of Shusterman and Kastak, and it lasted 63 sessions for Rico and 79 sessions for Isabelle. While the length and procedural complexity of the present study was significant, it was not unreasonable, and it opened the possibility of applying this type of methodology to both research and practice with humans. The main practical advantage of such methodology for research purposes is that it eliminates the confounding variable of carrying out equivalence probes under extinction. The same can be said in terms of application and technology development where the implementation of teaching procedures under extinction is, if not unethical, often ineffective.
In the context of basic research, future replications using non-verbal children would provide additional evidence in favor of Sidman’s (1994, 2000) position that equivalence is a basic process that does not depend on verbal performance.

It is important to notice that although both participants in the current study were verbal and displayed the ability to spontaneously name stimuli in their environment, neither one of them was able to promptly demonstrate equivalence or its defining properties with the stimuli used. Multiple exemplar training of properties of equivalence was effective for both participants with respect to the emergence of symmetry with untrained stimuli. For Rico, multiple exemplar training (i.e. training symmetry and transitivity for stimuli 1 though 3) was sufficient for the emergence of stimulus equivalence with untrained stimuli (e.g. sets 4 through 6). For Isabelle, multiple exemplar training was sufficient for the emergence of stimulus equivalence with trained stimuli (e.g. sets 1-3).

These findings raise important questions with respect to the role of multiple exemplars training in the formation of equivalence relations, and future research should further assess equivalence outcomes in the presence and absence of previous multiple exemplar training.

Finally, applied research could benefit from investigating the effectiveness of multiple exemplar training as a strategy. In other words, symmetry, transitivity, and equivalence describe performances that can be directly taught if not promptly demonstrated by individuals in a school setting. Such learning history may prove to be of central importance for the emergence of novel and complex stimulus relations in the future.
References


Hayes and Barnes (1997) Analyzing derived stimulus relations requires more than the concept of stimulus class. *Journal of the Experimental Analysis of Behavior, 68*, 235-270.


Figure 1. The figure on the top shows the apparatus, a Macintosh computer running OS9 software. The picture on the bottom presents an example of the stimulus orientation on the apparatus.
Figure 2. Eighteen visual stimuli divided into sets 1-6, with three stimuli in each. “A” stimuli included shapes of American states, “B” stimuli included the flag of that state and “C” stimuli included a landmark associated to it.

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Figure 3. Summary of the training and testing procedures for both participants.
Figure 4. Correct responses per session during each condition for Rico.
Figure 5. Correct responses per session during each condition for Isabelle.