

**BRIEF REPORT***THE EFFECT OF BASELINE TRAINING STRUCTURE ON EQUIVALENCE CLASS FORMATION IN CHILDREN*

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Stimulus equivalence refers to the observation that training a set of overlapping conditional relations (hereafter, baseline relations) results in many other conditional relations that are not directly trained but are nevertheless systematically related to or derived from the originally trained conditional relations (hereafter, derived relations). These derived conditional relations instantiate the reversal and recombination of directly trained stimulus functions which are described by the terms reflexivity, symmetry, and transitivity (cf. Sidman & Tailby, 1982). For example, reflexivity is defined as an increased likelihood of selecting comparison stimuli that are identical to the sample stimulus. Symmetry refers to the observation that the directly trained conditional and discriminative functions of stimuli have become reversible. Transitivity refers to the observation that the conditional stimuli from one trained conditional relation are effective in modulating the discriminative functions of stimuli from another conditional relation. In other words, the directly trained conditional and discriminative functions of stimuli are shown to recombine in untrained ways. The derived conditional discriminations define a relation of equivalence among the stimuli (cf. Sidman et al., 1982; Sidman & Tailby, 1982). The resulting equivalence classes can be structurally characterized in terms of the number of stimuli per class, the number of nodes, the distribution of single stimuli, and the training structure (Fields & Verhave, 1987). The present paper is concerned with the role of training

structures (defined below) on the likelihood of equivalence relations.

Most baseline training in stimulus equivalence research involves the establishment of conditional relations between members of various sets of stimuli (see Sidman, 1986; Sidman & Tailby, 1982 for a detailed discussion). For example, set 'A' may contain stimuli designated A1, A2, and A3 and set 'B' may contain stimuli designated B1, B2, and B3. Training conditions arrange for conditional relations among stimuli from different sets (i.e., given A1 pick B1 not B2 or B3 and given B1 pick C1 not C2 or C3) such that at least one stimulus is trained to be conditionally related to two other stimuli. Note that in the above example, stimulus B1 is related to both stimulus A1 and stimulus C1. Training structure here refers to the order and arrangement in which the baseline conditional discrimination trials are presented (described below; see also R. R. Saunders & Green, 1999).

The experimental literature on stimulus equivalence has primarily been characterized by three types of training structures – linear series, one-to-many or sample-as-node (hereafter, OTM), and many-to-one or comparison-as-node (hereafter, MTO). The linear-series training structure involves training participants to pick set B stimuli conditionally upon the presence of set A stimuli (hereafter, AB) and to pick set C stimuli conditionally upon the presence of set B stimuli (hereafter, BC). Tests for equivalence assay whether derived BA, CB, AC, and CA conditional discriminations characterize the participant's performance. The OTM training structure involving establishing AB and AC conditional discriminations and tests for equivalence assay whether derived BA, CA, BC, and CB conditional discriminations characterize the participant's performance. Finally, the MTO training structure

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Some of the results were presented as a paper at the ABA convention in Chicago 2005.

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involves establishing BA and CA conditional discriminations and tests for equivalence assay whether derived AB, AC, BC, and CB conditional discriminations characterize the participant's performance. All training structures are identical in terms of the number of baseline relations that are necessary to produce equivalence consistent responding. That is, all training structures involve training  $N$  conditional relations and have the potential to yield  $N^2 + N + 1$  derived conditional relations (including reflexivity, Fields & Verhave, 1987).

The necessity of training a minimum number of conditional relations in order to observe equivalence as traditionally defined may lead one to predict that all training structures would be identical in the ease with which they facilitate the development of equivalence consistent responding. Saunders and Green (1999), however, reviewed some empirical work in their lab (R. R. Saunders, Drake, & Spradlin, 1999; R. R. Saunders, Wachter, & Spradlin, 1988; Spradlin & Saunders, 1986) and noted that the MTO training structure has been more likely to lead to equivalence-consistent outcomes relative to the OTM or linear-series training structures. They offered an account of these observed differences in terms of a logical analysis of the task requirements for successful equivalence class formation. Their analysis suggests that the MTO training structure directly establishes more of the component discriminations necessary for successful outcomes on equivalence tests than either the OTM or the linear-series training structures. As a result, the authors argue that participants for whom the MTO baseline training structure is used should be more likely to show equivalence class formation relative to participants for whom the OTM or linear-series training structures are used.

The extant literature on the role of training structures, however, is inconclusive. The MTO training structure has consistently resulted in an increased likelihood of equivalence consistent responding when adolescents and adults with developmental delays have comprised the participant population (R.R. Saunders, et al., 1988, R.R. Saunders & McEntee, 2004; Spradlin & Saunders, 1986). The data with typically developing children and adults, however, have been inconsistent. For example, Barnes (1992; as cited in Barnes, 1994) and Hove (2003) have reported the superiority of the MTO training

structure with typically developing college students but Arntzen and Holth (1997, 2000) have found the OTM training structure to be more likely to produce equivalence-consistent responding. In addition, an unpublished study from the second author's laboratory (Rawls & Vaidya, 2005) compared the three training structures directly in a within-subject design with college students and found no difference in the likelihood of equivalence-consistent responding as a function of training structure. Finally, Saunders, et al. (1988) reported finding differences in the likelihood of equivalence class formation as a function of training structure in pre-school aged children but Smeets and Barnes-Holmes (2005) failed to find any differences between the OTM and MTO training structures with participants in the same age range.

One factor that may play a role in the discrepant results observed is the number of stimuli used in the study. The analysis offered by Saunders and Green (1999) suggests that an increase in the number of stimuli to be included in a class will result in an increase in the number of component discriminations necessary for successful outcomes on equivalence tests. The analysis would lead one to predict that the effects of training structure will be more pronounced when the prerequisites for larger classes are being trained than when the prerequisites for smaller classes are being trained (see K. J. Saunders, Saunders, Williams, & Spradlin, 1993 for a more elaborate discussion of this point).

The main purpose of the present study was to explore the effect of training structure on the likelihood of equivalence consistent outcomes. In an effort to precisely identify the role of training structure, the study was conducted as a within-subject design in which OTM and MTO training structures were directly compared. The size of the putative equivalence class (or number of class members) was also manipulated across conditions to better investigate the relation between relative influence of training structure and the number of class members.

## METHOD

### *Participants*

Four typically developing children served as participants in the experiment (see Table 1). All

Table 1  
Participant characteristics: age and training procedure assignment listed from youngest to oldest. The sequence of training structures was always OTM → MTO → OTM → MTO.

Participant	Age	Training Procedure
#1004	7 years 6 months	3 three-member classes → 2 three-member classes
#1003	8 years 5 months	3 three-member classes → 2 three-member classes
#1001	8 years 9 months	3 three-member classes → 2 three-member classes
#1002	13 years 3 months	3 three-member classes → 3 four-member classes

participants were naive with respect to stimulus equivalence research and had never participated in any experiments before. They were debriefed after the session.

#### *Apparatus*

A personal computer controlled stimulus presentation and data collection. A transparent touch screen was mounted in front of a 15" monitor. A radio controlled by the computer arranged automatic onset of music for 3 s following correct responses during training.

#### *Procedure*

*Stimulus material.* Visual stimuli were displayed on the monitor. The stimulus materials were Greek, Hebrew, Cyrillic, Arabic, and Japanese letters, as shown in Figures 1 and 2. The presentation of the sample stimulus was always in the left-hand key (7 X 7 cm). Six comparison stimulus keys (4 X 4 cm) were arranged in two columns and three rows on the right-hand side of the monitor.

*General information to the participants.* When participants were enlisted to the experiment they were told that the task was to touch stimuli presented on a computer with a touch screen. They were also told that duration of the experiment would be approximately 2 hours, depending on how rapidly and correctly they responded.

*Instruction.* The participants were given the following instruction when seated in front of the computer:

When you press this key, the first stimulus will appear on the key. When you touch the stimulus, one or more stimuli will appear on the right hand-side of the monitor. After a few seconds, a new stimulus will appear on the left-hand key etc. Touches on the correct stimulus will be followed by music from the radio/cassette player, while incorrect responses will be followed by the blanking of the screen for 5 s before a stimulus in the left-hand key is presented again. Each part of the training requires a certain number of correct responses before proceeding to the next part. The training will be followed by tests. During the tests, there will be no different consequences for correct and incorrect responses - no music and no blank screen.

An overview of the experimental structure is shown in Figure 3. A new set of stimuli was used in each condition.

In both sequences, in the first phase the participants were exposed to a three 3-member OTM training structure followed by a three 3-member MTO training structure. If the two training structures produced differences in

MTO training structure with three members and two classes.		
	1	2
A	ب	ج
B	ش	ظ
C	خ	گ

OTM training structure with three members and two classes.		
	1	2
A	η	σ
B	μ	ξ
C	φ	λ

MTO training structure with three members and three classes.			
	1	2	3
A	𐎧	𐎡	𐎠
B	カ	キ	𐎡
C	ラ	𐎡	𐎡

OTM training structure with three members and three classes.			
	1	2	3
A	𐎧	𐎡	𐎠
B	𐎡	𐎡	𐎡
C	𐎡	𐎡	𐎡

Figure 1

equivalence class formation the participants were exposed to a two 3-member OTM training structure followed by a two 3-member MTO training structure. On the other hand, if the training structures did not produce any differences the participants were exposed to a three 4-member OTM training structure followed by a three 4-member MTO training structure.

*Training and test.* Each trial started with the presentation of a sample stimulus. A touch on

MTO training structure with three members and three classes.			
	1	2	3
A	𐎧	𐎡	𐎠
B	カ	キ	𐎡
C	ラ	𐎡	𐎡

OTM training structure with three members and three classes.			
	1	2	3
A	𐎧	𐎡	𐎠
B	𐎡	𐎡	𐎡
C	𐎡	𐎡	𐎡

MTO training structure with four members and three classes.			
	1	2	3
A	δ	φ	λ
B	ش	ظ	𐎡
C	Ψ	ζ	θ
D	خ	گ	𐎡

OTM training structure with four members and three classes.			
	1	2	3
A	β	σ	η
B	ن	ث	ض
C	γ	μ	ξ
D	ب	ج	𐎡

Figure 2

the sample stimulus was followed by the presentation of comparison stimuli in the keys on the right-hand side of the monitor. The sample remained present until a comparison stimulus was touched. The intertrial-interval (ITI ) was 3 s. Initially during each training, a touch on the sample stimulus was followed by the presentation of the correct comparison stimulus only. Through nine successive correctly completed trials the number of comparison stimuli increased to three (or four or two,

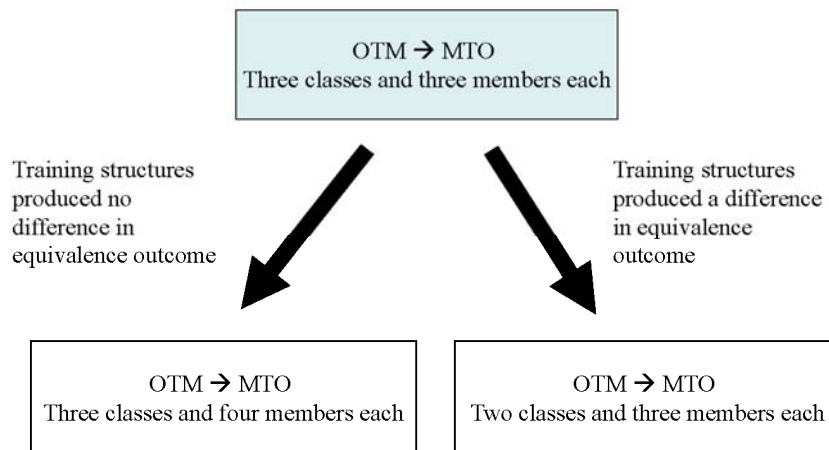


Figure 3

dependent on the conditions). The three comparison stimuli appeared in a random position from trial to trial, except that there was never more than one comparison in each row. The programmed reinforcers followed only preliminary training trials in each part, a minimum of 12 trials if performance was errorless.

In each training structure, the first conditional discrimination training (AB or BA) required 21 consecutive trials, as did the second (BC or CB) training. Finally, during the mixing of all previous trials, 24 consecutive correct trials were required. In all cases, the completion of each training structure was followed by a 24-trial CA equivalence test. The tests were divided into two identical test halves.

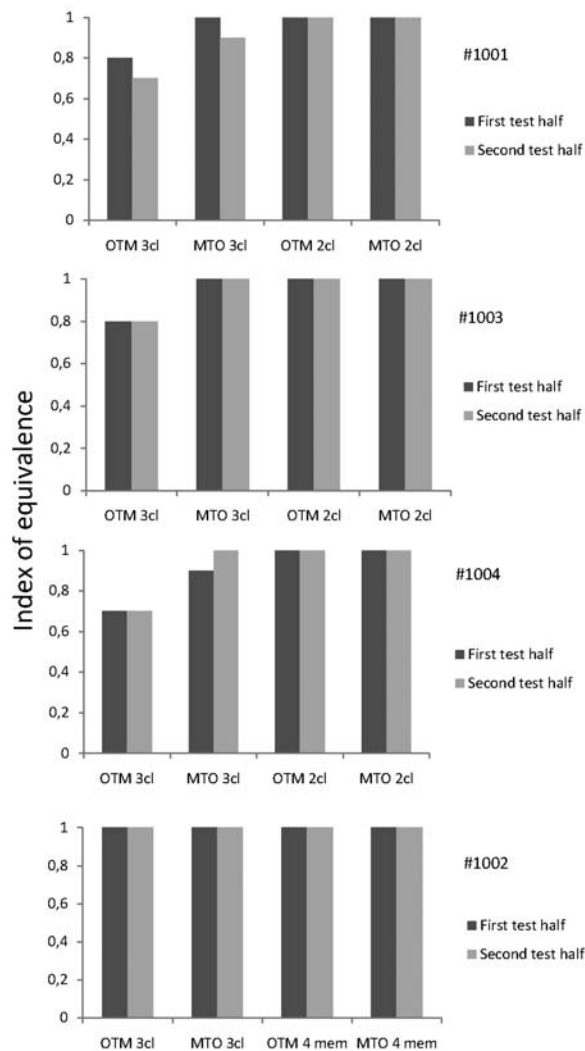
Following each training structure the equivalence test(s) was followed by a block of baseline probes (without presentation of any programmed reinforcers). The block consisted of two types of each trial.

*Dependent measures.* Key presses on the touch screen in front of the monitor, reaction times or latencies, and the number of trials to criterion were recorded. An index of equivalence was calculated for each participant by dividing number of "correct" responses by the total number of trials during the test. Equivalence was defined as an index of 0.9 or 1.0.

## RESULTS

Figure 4 shows that three of the four participants (#1001, #1003, and #1004) responded in accord with equivalence following the MTO structure, but not the OTM structure when three 3-member classes were established. The latencies to sample-observing did not differ for OTM or MTO, while the latencies to comparison-selection responses in this condition were slightly longer during training (last five training trials) for OTM relative to MTO and longer during the first part of testing (five first test trials) for MTO relative to OTM. Figure 4 further shows that the differences in the likelihood of equivalence were largely attenuated when the number of classes was reduced to two 3-member classes. The latencies to sample-observing and comparison-selection responses in this condition did not differ between MTO and OTM. For all three participants, probes conducted after the equivalence tests showed that the baseline relations were maintained.

The fourth participant was interesting in that equivalence-consistent responding was equally likely given both training structures when three 3-member classes were established. The latencies to sample-observing and comparison-selection responses for this participant in this condition were slightly longer during training (last five training trials) for OTM relative to MTO and higher during the first part of testing (five first test trials) for MTO relative to OTM. Furthermore, the training structure failed to produce an effect even when



**Figure 4**

the procedure was changed to establish four 3-member classes. The latencies to sample-observing and comparison-selection responses for this participant in this condition were replicated. As with the other participants, probes conducted after the equivalence tests confirmed that the baseline relations were maintained.

#### DISCUSSION

The findings from this study are in general accord with the predictions of Saunders and Green's (1999) analysis of the role of component discriminations in equivalence-consistent responding. Specifically, the results show that three of the four participants were more likely to

make equivalence-consistent choices following training in the MTO training structure than in the OTM training structure. Furthermore, consistent with Saunders and Green's (1999) predictions, the effects of training structure were more pronounced in training procedures involving three-choice conditional discrimination training as compared to two-choice conditional discrimination training procedures. These data, then, are consistent with results reported with adults with developmental disabilities (R. R. Saunders & Green, 1999; Spradlin & Saunders, 1986) and elderly adults (R. R. Saunders, Chaney, & Marquis, 2005). The data collected with college-age adults serving as participants, however, are inconsistent. With typically developing adults, the findings have included the superiority of the OTM procedure (Arntzen & Holth, 1997, 2000); superiority of the MTO procedure (Barnes, 1992; as cited in Barnes, 1994; Hove, 2003) or no difference among any of the procedures (Rawls & Vaidya, 2005).

The discrepant findings described immediately above could be a function of different prerequisites for equivalence class formation in children, typically developing adults and senior citizens and populations with developmental disabilities. Specifically, according to R.R. Saunders and Green's (1999) analysis, the superiority of MTO training structure is based on the fact that MTO procedures teach successive discrimination of stimuli that are to be discriminated simultaneously during the test whereas OTM which teaches simultaneous discrimination of stimuli that need to be discriminated successively during the test. R.R. Saunders and Green's analysis (1999) assumes that 1) successive discriminations are more difficult than simultaneous discriminations and that 2) stimuli that are discriminated simultaneously are not necessarily discriminated successively but that stimuli discriminated successively can be discriminated simultaneously without further training. The MTO procedure is expected to produce a greater likelihood of equivalence (relative to OTM) because the MTO procedure establishes successive discriminations during training among stimuli that need to be discriminated simultaneously during tests

(easier transfer) whereas the OTM procedure establishes simultaneous discriminations during training among stimuli that need to be discriminated successively during tests (more difficult transfer). This analysis also implies that response latencies should be shorter on test trials following MTO training relative to OTM training. The data from this study are not consistent with this implied prediction, however. Comparison-selection latencies were longer on test trials following MTO training relative to OTM training. It is possible that these differences between successive and simultaneous discriminations are most pronounced during early childhood and are attenuated in increasingly sophisticated behavioral repertoires leading to the inconsistent results observed with adult participants. It is interesting to note in that regard that Participant #1002, whose was equally likely to show the development of equivalence relations following both training structures for 3 and 4-class procedures, was considerably older than the other three participants for whom a clear effect of training structure was observed.

An important element in such comparisons is the ability to ensure that a participant's performance in various conditions are independent of one another - to ensure that experience in an earlier experimental condition does not influence performance in a later experimental condition. An arrangement in which participant performances cannot be verified as being independent of one another introduces difficulties in interpretation. For example, it is not possible to rule out something like a learning set effect. It is for this reason that most studies to investigate such phenomena have relied on large-N between group comparison designs. The present study differs in its attempt to study the same phenomena within a single-subject design. An unfortunate by-product of the within-subject design is our inability to rule out the possibility that participants simply improved with extended exposure to test trials (because each participant was exposed to multiple conditions, requirements of independence could not be strictly identified). Future studies will need to identify procedural arrangements that allow for the rigor of within-subject analyses with the

important requirement that participants' performances in various conditions remain independent. Perhaps a hybrid mix of within-subject analyses embedded within large-N between group comparisons may provide a solution. For example, individual participants could be exposed to the different training structures in different order while groups of participants with similar ordering could be compared against each other.

In conclusion, R.R. Saunders and Green (1999) offer an interesting account of the role of simple discriminations in the development of equivalence relations. There is some empirical support for their proposition but the data are not always consistent - especially with typically developing adult participants. Future research should continue attempting to isolate and pinpoint the source of these discrepancies as they may prove to be valuable not only for understanding the role of training structures in the likelihood of equivalence but also for understanding the behavioral pre-requisites of equivalence more broadly.

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