# ON THE ROLE OF COMMON STIMULUS FUNCTIONS IN THE DEVELOPMENT OF EQUIVALENCE CLASSES

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College students were exposed to training designed to teach nine simple discriminations, such that sets of three arbitrary visual stimuli acquired common functions. For seven of eight participants, three 3-member contingency classes resulted. When the same stimuli were presented in a match-to-sample procedure under test conditions, four participants demonstrated equivalence-consistent responding, matching all stimuli from the same contingency class. Test performance for two participants was systematically controlled by other variables, and for a final participant was unsystematic. Exposure to a yes/no test yielded equivalence-consistent performance for one participant where the match-to-sample test had not. Implications for the treatment of equivalence as a unified, integrated phenomenon are discussed.

ACKNOWLEDGEMENTS

I would like to express my gratitude to all the professors in the Department of Behavior Analysis for filling the last three years with a myriad of rich and inspiring learning experiences, and for being immensely supportive of my ongoing academic and professional development. I would especially like to thank Manish Vaidya for instilling in me the passion to tackle basic behavioral research questions, and for agreeing to work to my required timeframe over the last couple of months. This has been a life changing experience in so many ways, and I look forward to knowing you all for the rest of my professional and academic career. I would also like to thank Anthony DeFulio for his continuous support, advice and encouragement throughout this year.

TABLE OF CONTENTS

## LIST OF TABLES AND FIGURES

Tables Page



Figures

# CHAPTER 1

## INTRODUCTION

Stimulus equivalence refers to the development of systematic yet untrained conditional relations following the establishment of a few overlapping conditional relations. The emergent conditional relations instantiate the reversal (symmetry) and recombination (transitivity) of directly trained stimulus functions (Sidman, 1989; Sidman,1994; cf. Hayes, 1989). Specifically, tests for symmetry assay whether sample and comparison stimuli are (or have become) reversible relative to training, and tests for transitivity  assay whether stimuli that were not presented together during training can now function as effective samples and comparisons within the same test trial. Tests for reflexivity assess the likelihood of generalized identity matching. These reversals and re-combinations of stimulus functions define the properties of an equivalence relation among the stimuli. The participating stimuli are considered to be members of a stimulus equivalence class (Sidman and Tailby, 1982).

An interesting feature of equivalence classes is that stimulus functions, other than those that define equivalence relations, established for one member of an equivalence class are observed to extend to other members without direct training (Hayes, Brownstein, Devany, Kohlenberg & Shelby, 1987; Hayes, Kohlenberg, & Hayes, 1991; Dougher, Auguston, Markham, Greenway & Wulfert, 1994; Dymond & Barnes, 1994). Hayes and colleagues suggest that the extension of function across class members is a defining feature of arbitrarily applicable relational responding, of which equivalence is an instance (Hayes, 1991; Hayes, Barnes-Holmes & Roche, 2001). Over the last 30 years, many kinds of stimulus functions have been shown to extend across equivalence classes.

Despite the inclusion of extension of function in the definition of stimulus equivalence, researchers have drawn a distinction between functional classes and equivalence classes (see Vaughan, 1988 and commentary by Hayes, 1989; McIntire, Cleary and Thompson, 1987; and commentaries by Hayes, 1989 and Saunders, 1989). Functional classes are defined as a set of stimuli that share a common behavioral function and by the observation that changing the function for one member is sufficient to produce a similar change for all other members (cf. Dougher & Markham, 1994). The distinction is based on the difference between extension of function across derived stimulus relations (e.g., Hayes, Kohlenberg, & Hayes, 1991), and the reversibility of directly trained stimulus functions (e.g., Vaughan, 1988). The consensus appears to be that equivalence classes may be functional (i.e., functions assigned to one member may extend to other members) but that functional classes are not equivalence classes (McIlvane and Dube, 1990; Hayes, 1989; cf. Vaughan, 1988).

One by-product of this distinction between equivalence and functional classes is the suggestion that extension of function with human subjects is mediated by equivalence (see, for example, Hayes, Barnes-Holmes and Roche, 2001). However, the literature suggesting that equivalence relations mediate extension of function is inconsistent. For example, some studies have reported the development of equivalence relations but no extension of stimulus function (de Rose, McIlvane, Dube & Stoddard, 1988; Green, Sigurdardottir & Saunders, 1991) and extension of stimulus functions prior to the observation of equivalence relations (e.g., Barnes and Keenan, 1993; Catania, Horne and Lowe, 1989; Wulfert and Hayes, 1988). In addition, data from several recent studies have suggested that simple mediation may not be an accurate description of the relation between equivalence and extension of function (Markham and Markham, 2002; Tonneau & Gonzalez, 2004; Vaidya and Hackenberg, 2004). For example, in an attempt to track the development of equivalence classes and the extension of stimulus functions together over time, Vaidya and Hackenberg (2004) trained the interrelated conditional discriminations, tested for the emergence of equivalence-consistent performance, established discriminative functions for a subset of the stimuli and tested for the extension of those functions to other stimuli via interlaced trials from the beginning of the experiment. Results showed a close temporal relation between the development of equivalence-consistent performance and extension of function for two participants, though in one case extension of function lagged behind demonstration of equivalence. More interestingly, a third participant demonstrated extension of function prior to the development of equivalence relations. Vaidya and Hackenberg propose that the conditional relations training between sample and comparison stimuli may have been sufficient to give rise to both the development of equivalence relations and the extension of directly trained discriminative functions.

Similarly, Dougher and Markham (1994) argue that published studies concerned with stimulus equivalence and transfer of function have investigated only whether interrelated conditional discrimination training will result in both stimulus equivalence and functional equivalence, and that it may not be possible to show that function transfer occurs as a result of equivalence. In summary, there is an implication that, across all the studies cited, the results point to the degree of correlation between two phenomena resulting from the same training and testing procedures. In addition, several authors have noted the similarity between these phenomena by pointing out that stimuli in both class types share functions with other class members (Dougher & Markham,1994; Rosales-Ruiz & Baer 2001).

Sidman, Wynne, Maguire and Barnes (1989) empirically investigated whether conditional relations among members of a functional class would meet the reflexivity, symmetry and transitivity criteria that define equivalence relations. Participants included a college student and two verbally skilled teenagers diagnosed with autism. Figure 1 outlines the experimental procedures. In the first phase of the experiment (TR1) participants were taught to select any of a set of three positive stimuli in the context of a two-choice simple discrimination task, and to ignore any of three negative stimuli. When these discriminations were learned, the contingencies were reversed, and re-reversed until errors only occurred after exposure to the first trial following a contingency reversal (cf. Vaughan, 1988). As changing the function of one member was sufficient to produce a change for all other members, two functional classes (A1, B1, C1 and A2, B2, C2[1]) had successfully been created for all three participants. In the second phase of the experiment (frame T1), tests for emergent conditional relations between the A and B class members were conducted (A1-B1, B1-A1, A2-B2, B2-A2). Two of the participants passed these tests immediately. A third participant took several exposures to the test before performance became highly accurate. In Phase 3 (TR2) novel stimuli (set D) served as sample and original members of the functional classes (set A) served as comparison stimuli, respectively, in conditional discrimination training (D1-A1, D2-A2). In Phase 4 (T2), only two participants demonstrated emergent conditional relations

[1] Note that the letter designations for the classes have been changed to fit with common convention.

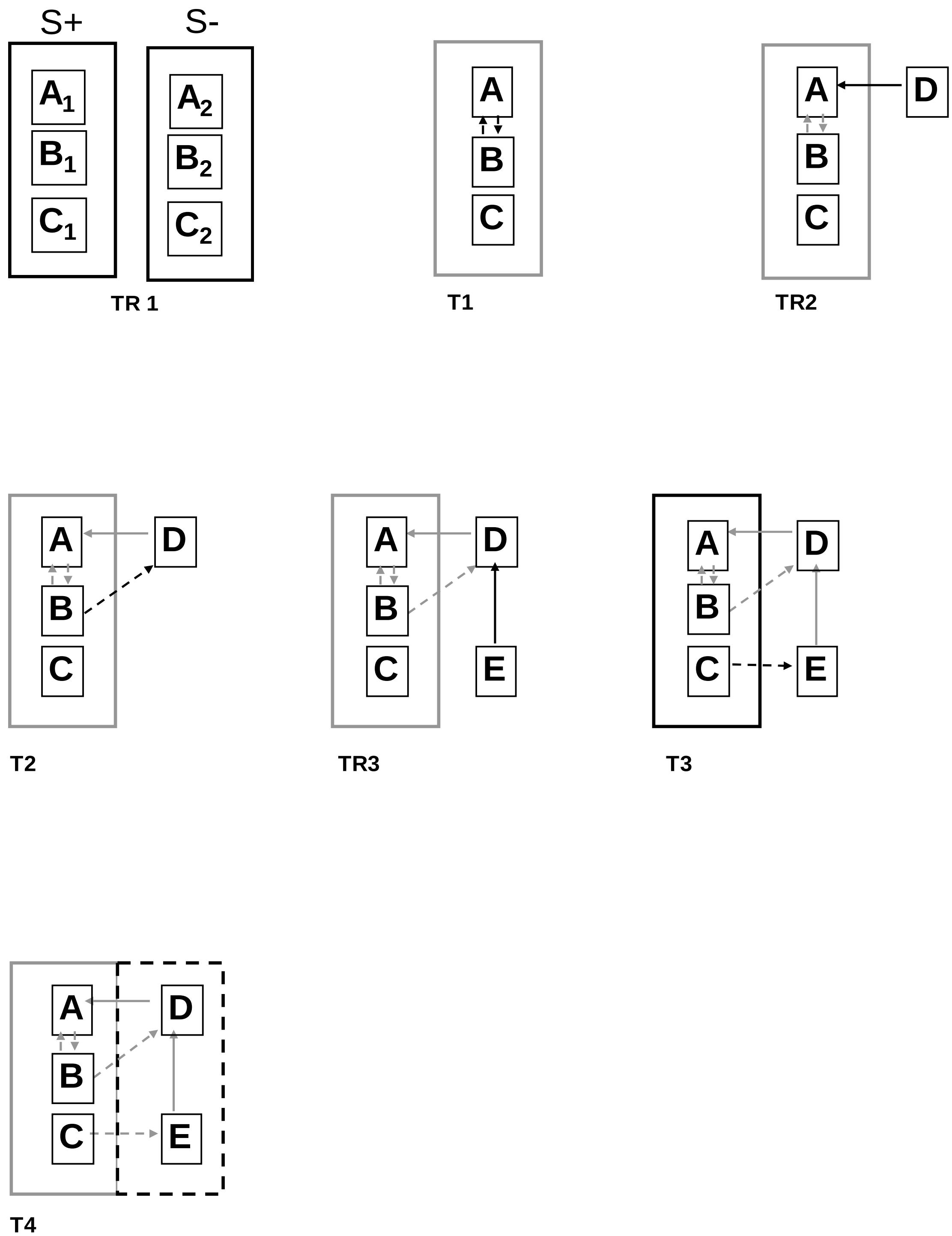



Figure 1. The seven phases of the Sidman et al. (1989) study are depicted. Solid lines show the trained relations. Dotted lines show the tested relations. Training and testing relevant to each phase are depicted in black. Shared simple discriminative functions are drawn as rectangles. Conditional relations are drawn as arrows.

between B and D stimuli (B1-D1, B2-D2). Despite maintenance of the functional classes, the third participant's performance on the trained D-A relations deteriorated. This participant also failed the equivalence tests as well as the A-B relations derived in Phase 2. The first two participants performed accurately on C-E equivalence tests (T3), after having learned two additional conditional discriminations in which novel E stimuli served as sample and D stimuli served as comparison stimuli respectively (TR3). Finally, tests to determine whether D and E stimuli had become functional class members (T4) were positive. Data for the first two participants strongly suggest that once functional classes are established they can become organized in ways that suggest properties of equivalence classes, but the performance of the third participant was not equivalence-consistent during tests for emergent conditional discriminations, despite continued accuracy on functional class tests. Sidman and colleagues concluded that functional classes and stimulus equivalence are a result of different underlying behavioral processes and need not coexist. This conclusion is generally consistent with other opinion in the field (Hayes, 1989; Saunders, 1989).

The goal of the current experiment was to attempt a systematic replication of Sidman et al.'s (1989) study. There are, however, several important differences. First, rather than being conducted in sequential phases, training and testing blocks were interlaced throughout the experiment to allow for a temporally detailed analysis of the simultaneous development of multiple performances. Second, in the current experiment, a procedure to teach shared conditional position functions replaced the simple discrimination reversal procedure used in the previous study. Third, in order to avoid the problems associated with S- control in two choice match-to-sample preparations

(Carrigan and Sidman, 1992; Sidman, 1987), comparison arrays in training and testing included three response options. Finally, all participants were college students. In summary, we asked, will stimuli that share a function in the context of a simple discrimination procedure be substitutable for each other in the context of a 3-choice, conditional discrimination procedure?

# CHAPTER 2

# METHOD

## Participants

Participants were recruited through an advertisement in a student newspaper. Eight students, 3 male and five female, aged between 19 and 27, enrolled at the University of North Texas, were selected from a pool of applicants based on schedule compatibility and naïveté with respect to behavioral research and principles. Participants were told they would earn $10 for their involvement in the experiment. After the second session, some participants were offered a further $10 for continued participation. Hourly pay rates ranged from $6.59 to $18.75, averaging $11.19 across participants. Because this payment was not contingent on performance, an additional payment contingency was added to encourage accuracy. Participants were told, “At the end of the study, the person with the highest point total will earn an additional $20.00 as a bonus.” Each correct response during the session earned the participant 3 points. These points were totaled at the end of each session and written on a slip of paper that was immediately handed to the participant.

## Setting and Apparatus

The apparatus consisted of an Apple G3® notebook computer (©Apple Computer Inc., www.apple.com) fitted with a Troll Touch® TouchSTAR™ touch screen adapter (©Troll Touch/T2D Inc., www.trolltouch.com). When participants touched the screen, the computer recorded the location and the timing of the touch. Using a program (MTS v 11.6.7) written by William Dube and Eric Hirris, the computer screen was divided into 9 (136 by 136 pixel) invisible keys, arranged in rows of three, upon which individual stimuli could be presented. Participants sat in front of the computer at a table in a small experimental room. Each experimental session was pre-programmed and run entirely by the computer.

## Stimuli

Nine black computer-generated visual forms from the MTS v 11.6.7 stimulus bank served as experimental stimuli for each participant (see Figure 2). The stimuli were judged by the experimenter to be both abstract and physically dissimilar. These properties were important in order to reduce the probability that extra-experimental histories could affect task performances. In addition, three black squares marked three discrete positions on the screen during the conditional position training trials. The stimuli were always presented on a blank white screen. Sample stimuli always appeared on the center key and comparison stimuli were displayed on six of the remaining eight keys. The exact positioning of comparison stimuli varied across training and testing formats (see Figure 3).

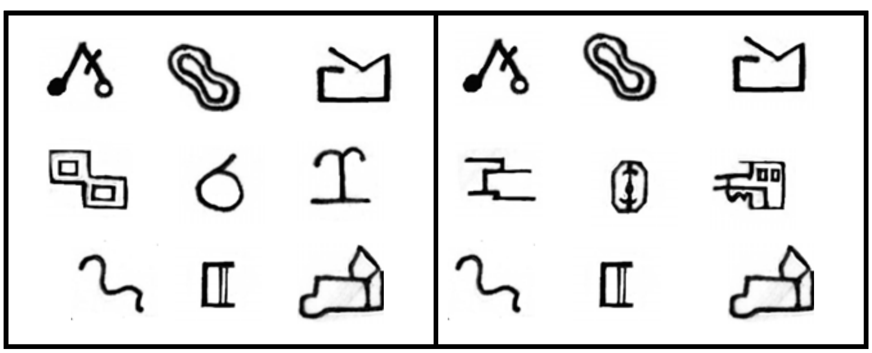


Figure 2. The right section of the figure shows the stimuli used with participants 6 and 11. The left section shows the stimuli used with all other participants.

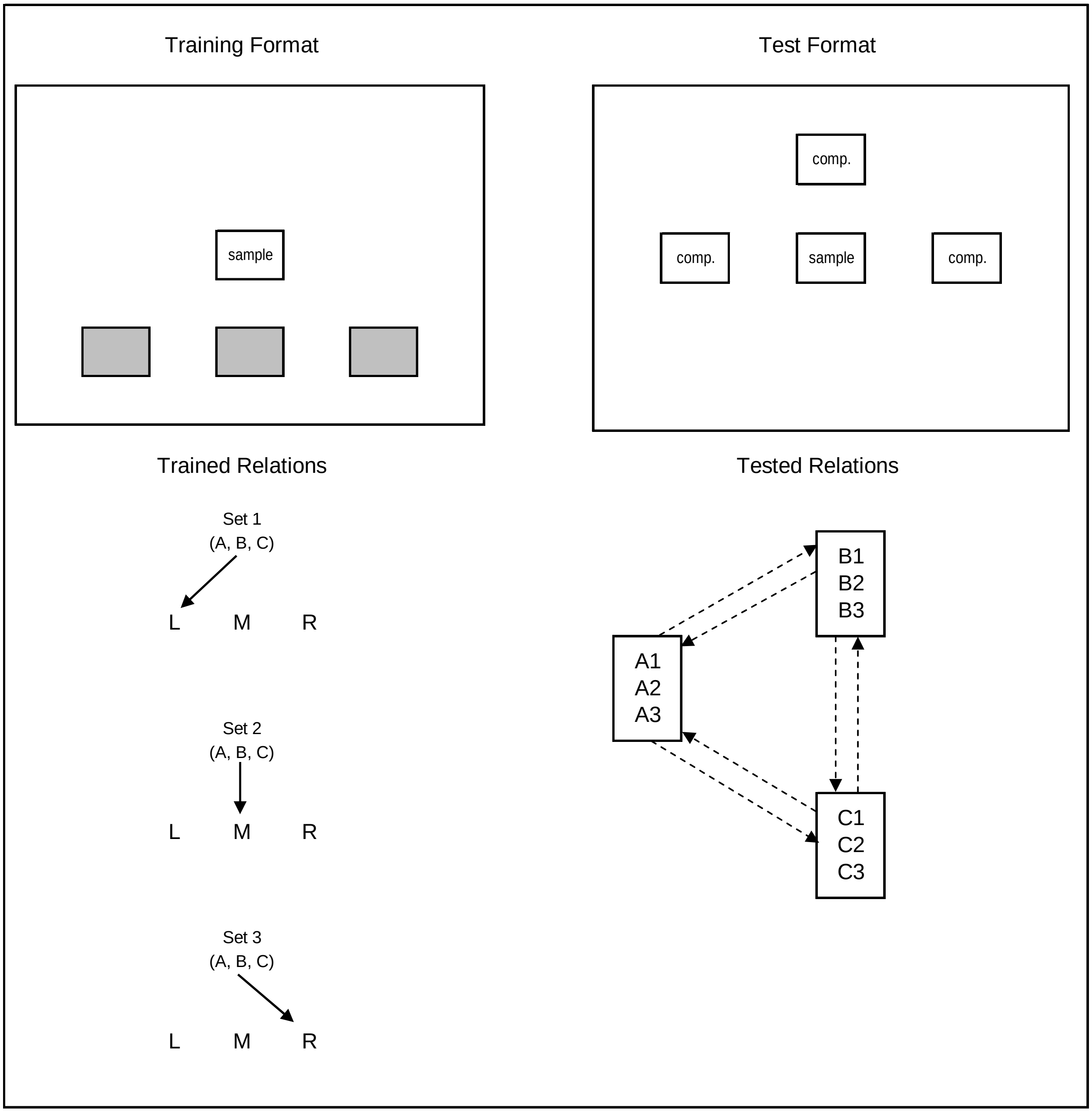



Figure 3. The top of the figure shows screen shots respectively for training and test trial presentations. In the training task, three identical grey boxes served as response keys. The nine pictures shown in figure 1 served as all sample stimuli and additionally as comparison stimuli during the test task. The bottom part of the figure illustrates the 9 trained relations (solid arrows) and the 18 tested relations (dotted arrows) during each component. (L)eft, (M)iddle and (R)ight refer to box positions on screen.

General Procedure

Each session comprised 324 trials, organized into alternating blocks of 9 training and 18 testing trials (see Figure 4). Trials within and across all blocks were separated by a 1.5s inter-trial interval. Participation in the study continued until stable test performance had been demonstrated across at least six blocks. All participants were free to terminate their involvement at any time, but none chose to do so.

The following instructions were given orally by the experimenter immediately before initiation of the first trial of each session, "Stimuli will appear on the screen in front of you. It is your job to decide how to respond to them. Respond by touching the computer screen. Sometimes the computer will give you feedback for your responding

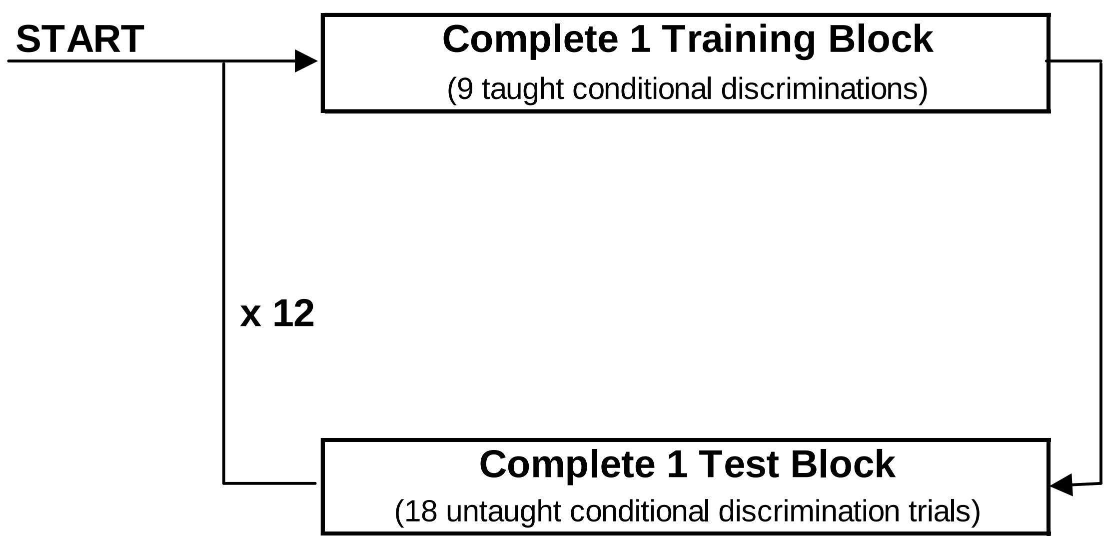



Figure 4. A schematic of the procedure for a single session. 12 training blocks alternated with 12 test blocks, such that each block designed to train conditional position discriminations was immediately followed by a block designed to test for untrained conditional discriminations.

and sometimes it will not." No other instructions were given until the end of the experiment when participants were asked to complete a feedback form (Appendix).

Discrimination training: A schematic representation for the conditional-position discrimination training task (hereafter referred to as 'training') is presented on the left hand side of Figure 3. A trial began with the appearance of three black squares at the bottom of the screen. After a 1-s waiting period, one of the nine stimuli (see Figure 2) appeared in the vertical and horizontal center of the screen, with no further response requirement. The stimulus remained in place until the participant touched one of the three black squares. Responses prior to appearance of this stimulus reset the waiting period. A two-tone high-pitch beep sequence, accompanied by the printed word "correct," immediately followed experimenter designated correct responses. Incorrect responses initiated the ITI with no additional consequences. Responses during the ITI caused it to reset. During training, three stimuli were correlated with reinforcement for touching the left square (set 1), three for touching the middle square (set 2), and three for touching the right square (set 3). This procedure was designed to establish a discriminative function (go left, go middle, or go right) for each of the nine stimuli, so that each function would be shared by 3 stimuli, putatively creating three contingency classes. Although stimuli for each participant were taken from the same stimulus pool (see Figure 2), composition of the stimulus sets varied across participants. There were four different stimulus set arrangements, and two participants were exposed to each arrangement.

Testing for untrained conditional discriminations: The 9 computer generated forms used as stimuli in discrimination training also served as experimental stimuli during arbitrary match-to-sample testing blocks (from now on referred to as ‘test blocks’). For explication purposes, the stimuli were assigned a set designating number (1, 2 or 3) and a letter name (A, B, or C) to allow for assessment of emerging equivalence-like relations (see bottom right of  Figure 3). Within each test block, each stimulus served twice as a sample and six times as a comparison, such that each sample appeared with two different comparison arrays. In any given trial, comparison arrays comprised stimuli of only one letter designation. For example, sample A1 was presented with the B comparison array (B1, B2 and B3) and separately with the C comparison array (C1, C2 and C3). A1 also appeared as part of a comparison array in the presence of the B and C sample stimuli. Each of these 18 arrangements will be referred to as a trial type. Across each session and within each trial type, the designated correct key was distributed equally across the three active comparison keys. No key position was designated correct more than three times in a row. A trial began with the appearance of the sample in the center of the screen. An observing response to the sample produced the comparison array. The sample remained on screen as the comparison selection was made. During testing, responses did not produce any programmed consequences except the ITI, regardless of accuracy of the response.

In summary, discrimination training blocks were designed to create three 3-member contingency classes. During testing blocks, stimuli were presented in a context that allowed for the emergence of untrained conditional relations that define equivalence relations.

# CHAPTER 3

# RESULTS

Participants' involvement in the experiment lasted from 2 to 4 sessions. Average session length per participant ranged from 20 to 46 minutes. The median time between consecutive sessions was 6 days, ranging from 1 to 13 days. The involvement of two participants (S7 and S9) continued after their test performance had reached stability so that interesting patterns observed in their data could be further analyzed.

The purpose of this experiment was to determine whether establishing shared discriminative functions for a set of stimuli would result in those stimuli being treated as equivalent, as defined above, in a three-choice, simultaneous MTS preparation. The data analyses were designed to evaluate i) acquisition and maintenance of nine trained conditional position relations during discrimination training, ii) emergent performance during conditional discrimination probes, and iii) possible relations between responding in these two conditions.

## Common Discriminative Functions

The left cluster of graphs on Figures 5 to 12 shows each subject's choices on every trial of the trained discriminations. Trials with set 1, set 2 and set 3 stimuli appear at the top, center and bottom of the figure respectively. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial, and each shaded box represents one response. The graphs show the distribution of responses across left, middle and right key positions. For seven of the eight participants, performance on the conditional position discriminations was 100% accurate within a few sessions. Accurate performance was reached after two sessions for S5, S10, S12, S6 and S9 (Figures 5, 6, 7, 8, 9 respectively), and three sessions for S7 and S11 (Figures 10 and 11 respectively). The training performance of a final participant (S8, figure 12) was only 50% accurate after exposure to 48 training blocks or 4 sessions. As the main interest here was to evaluate the effects of acquisition of trained relations on the emergence of untrained relations, this data set will not be discussed further.

The specified stability criterion required that every trained relation was mastered but acquisition was typically a gradual process. For some participants, individual relations reached stability between 8 (S10, Figure 6) and 27 (S11, Figure 11) blocks prior to satisfaction of the stability criterion for the trained relations as a whole. For the majority of the participants, performance on the trained relations remained stable until completion of the experiment, with the exception of minimal disruption at the start of some sessions. Two of the participants (S9 and S11) demonstrated a loss of some of the trained relations following satisfaction of the stability criterion (S9, Figure 12, set 2 and S11, Figure 11, set 3). Individual differences in the rate and pattern of acquisition of the trained relations did not appear to be related to stimulus features in any obvious or systematic manner.

## Development of Derived Conditional Relations

Of the seven participants who learned the trained relations, four showed the development of conditional relations that define equivalence. The right cluster of graphs in Figures 5 to 12 represents the trial-by-trial performances of individual participants. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figures respectively. Labels at the top of each group of columns specify the trial type represented. Light grey shading shows response distribution across left, middle and

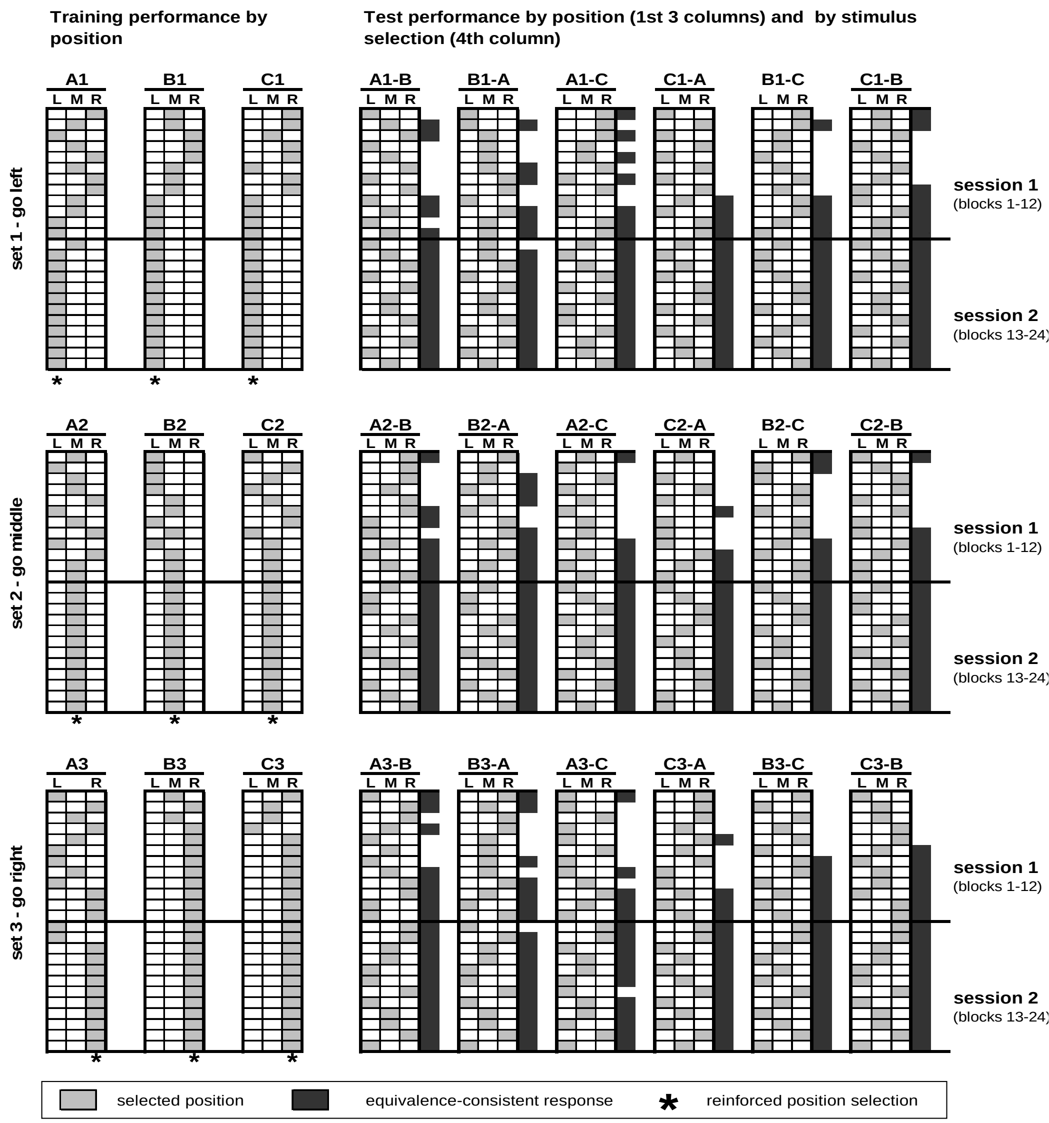



Figure 5. Trial by trial development of trained and tested performances are shown for S5, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.

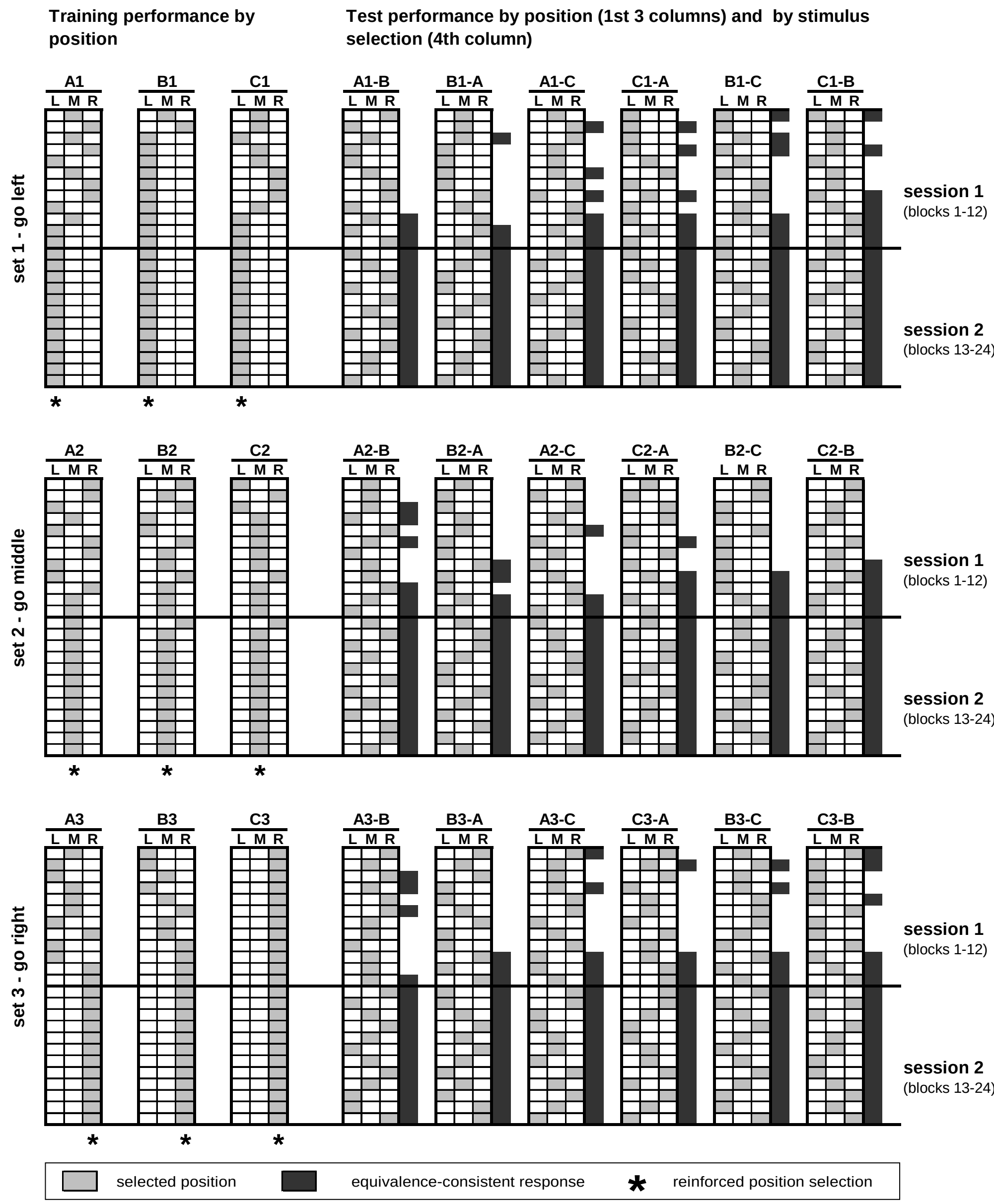



Figure 6. Trial by trial development of trained and tested performances are shown for S10, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.

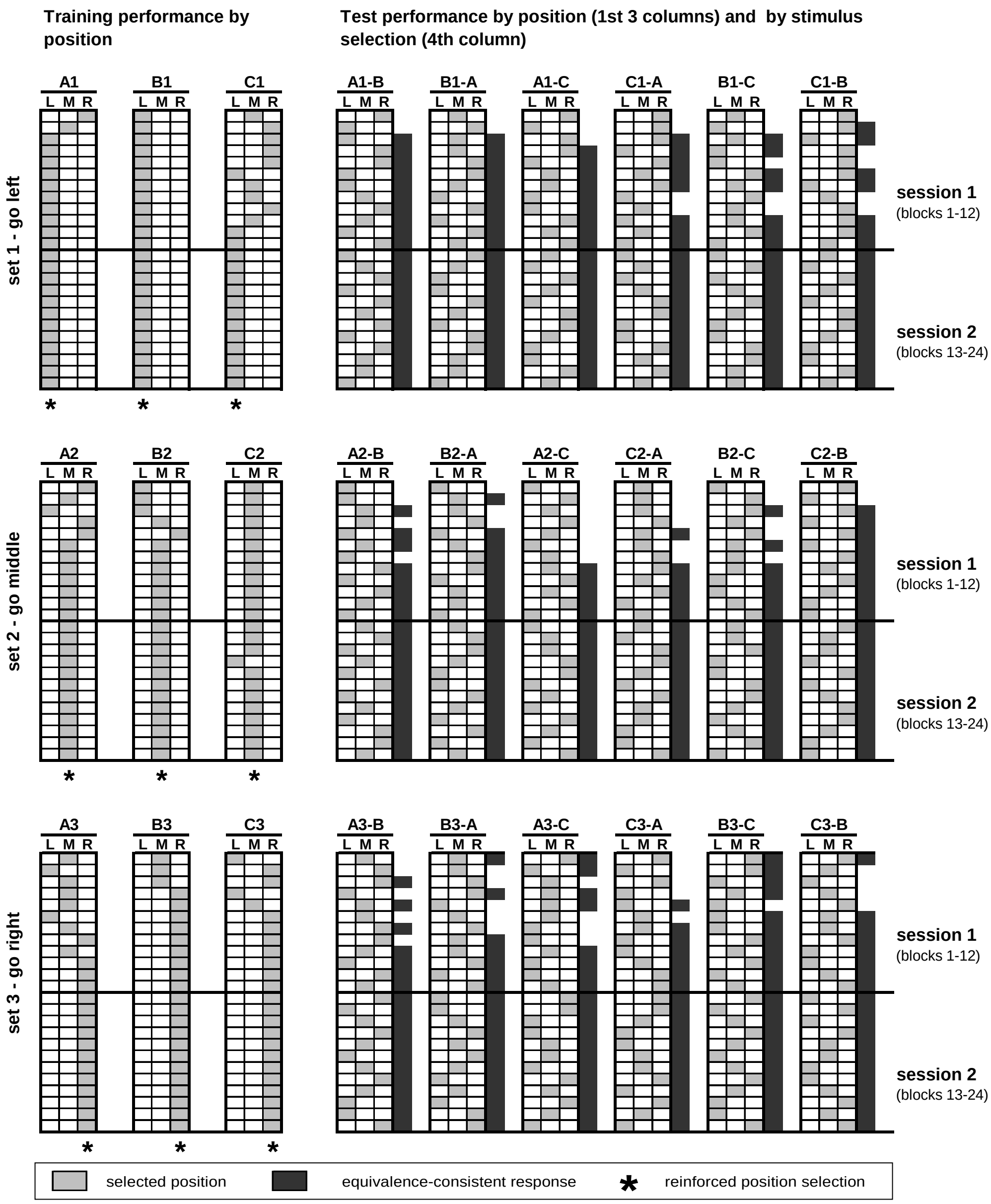



Figure 7. Trial by trial development of trained and tested performances are shown for S12, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.

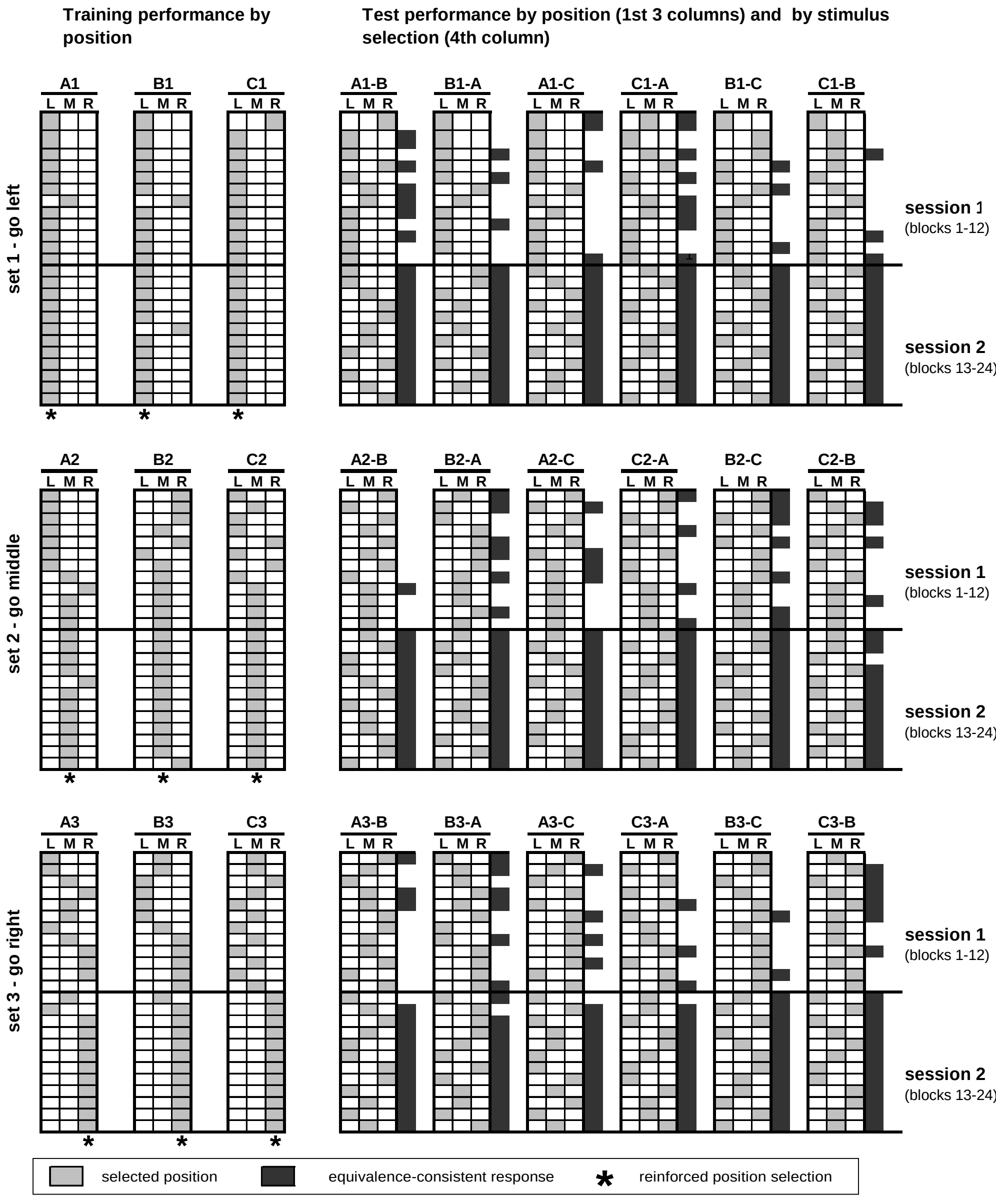
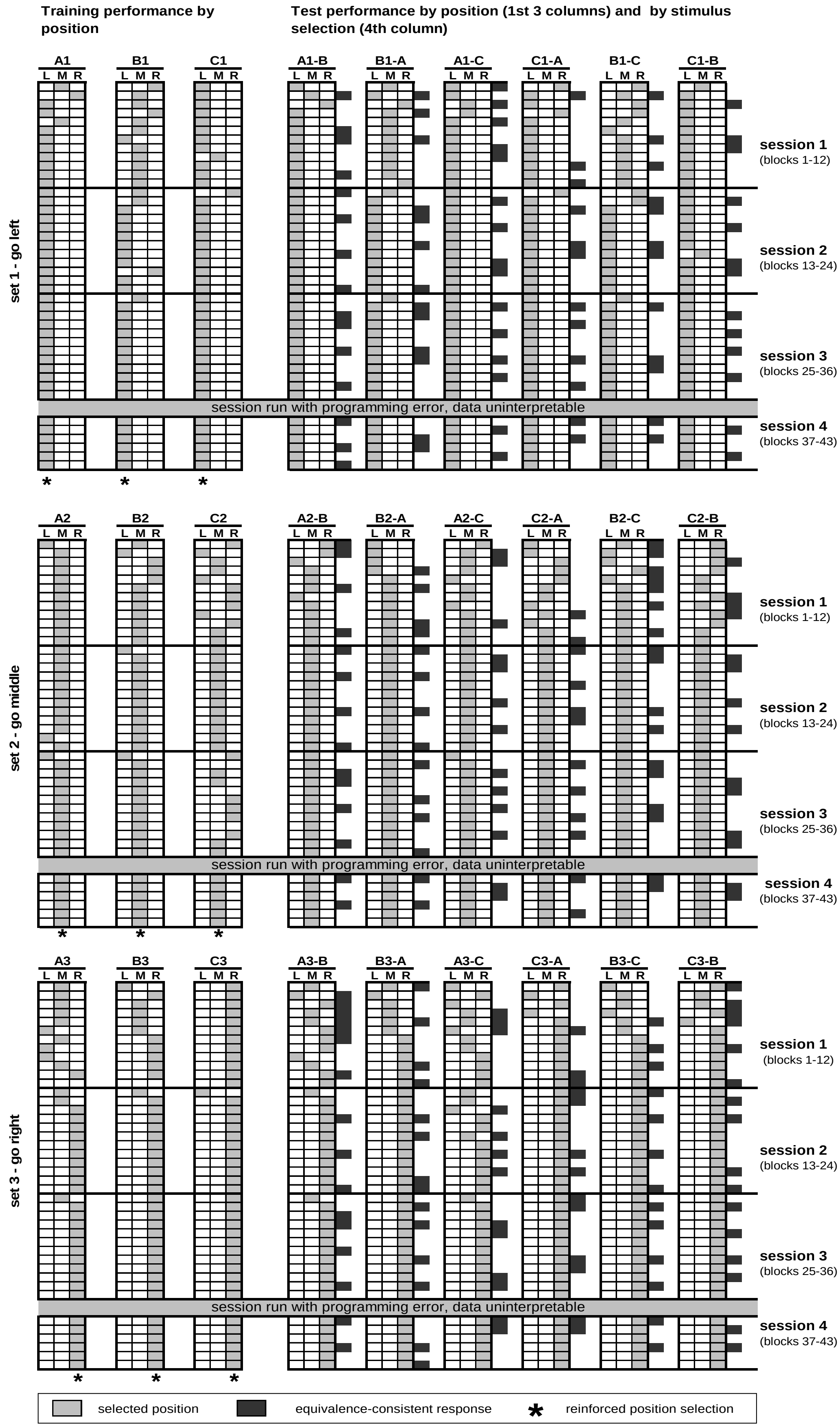



Figure 8. Trial by trial development of trained and tested performances are shown for S6, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.



Training performance by position
Test performance by position (1st 3 columns) and by stimulus selection (4th column)
A1 B1 C1
A1-B B1-A A1-C C1-A B1-C C1-B
L M R
session 1 (blocks 1-12)
session 2 (blocks 13-24)
session 3 (blocks 25-36)
session run with programming error, data uninterpretable
session 4 (blocks 37-43)
set 1 - go left
A2 B2 C2
A2-B B2-A A2-C C2-A B2-C C2-B
set 2 - go middle
A3 B3 C3
A3-B B3-A A3-C C3-A B3-C C3-B
set 3 - go right
selected position
equivalence-consistent response
reinforced position selection

Figure 9. Trial by trial development of trained and tested performances are shown for S9, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.

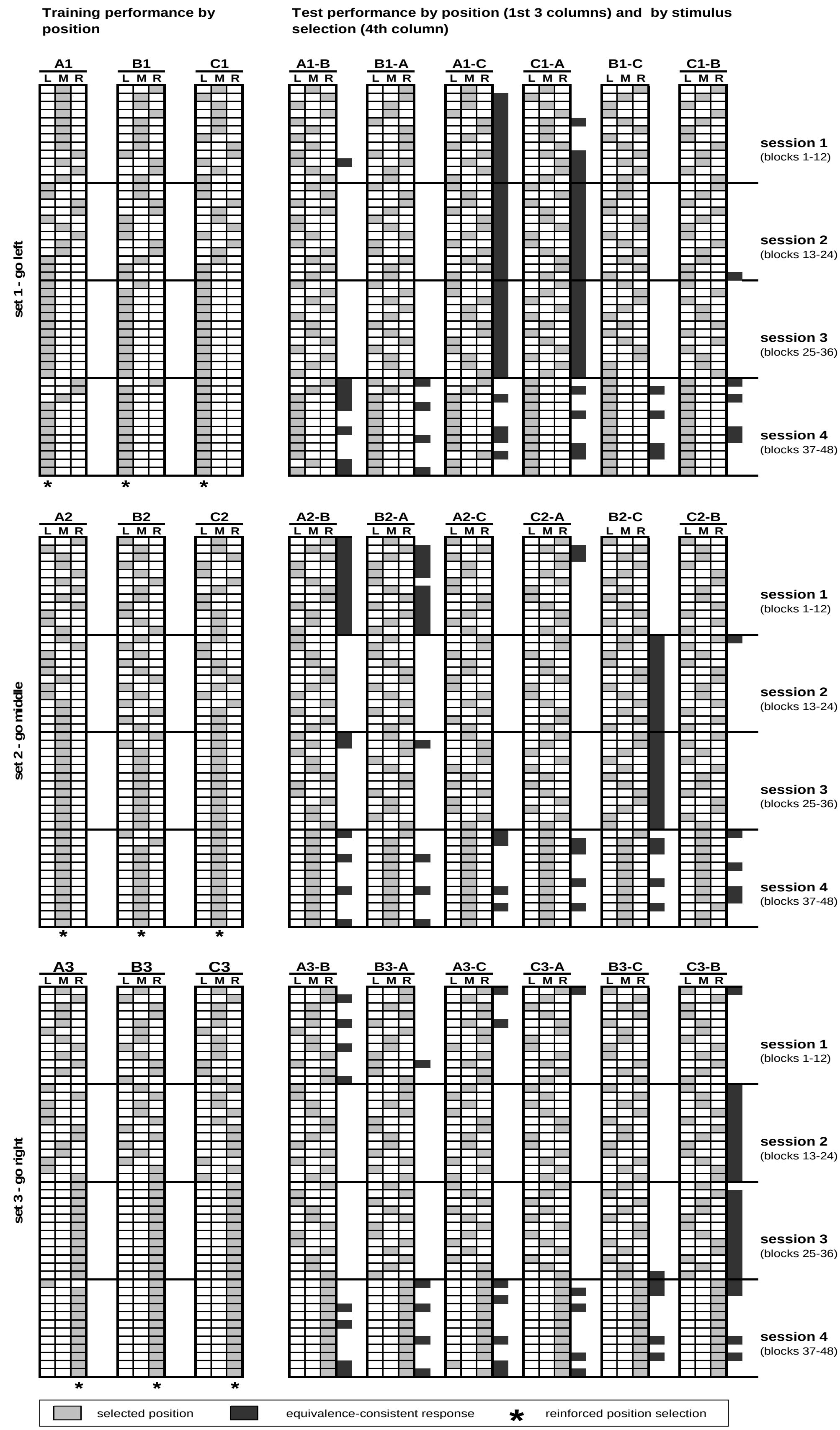
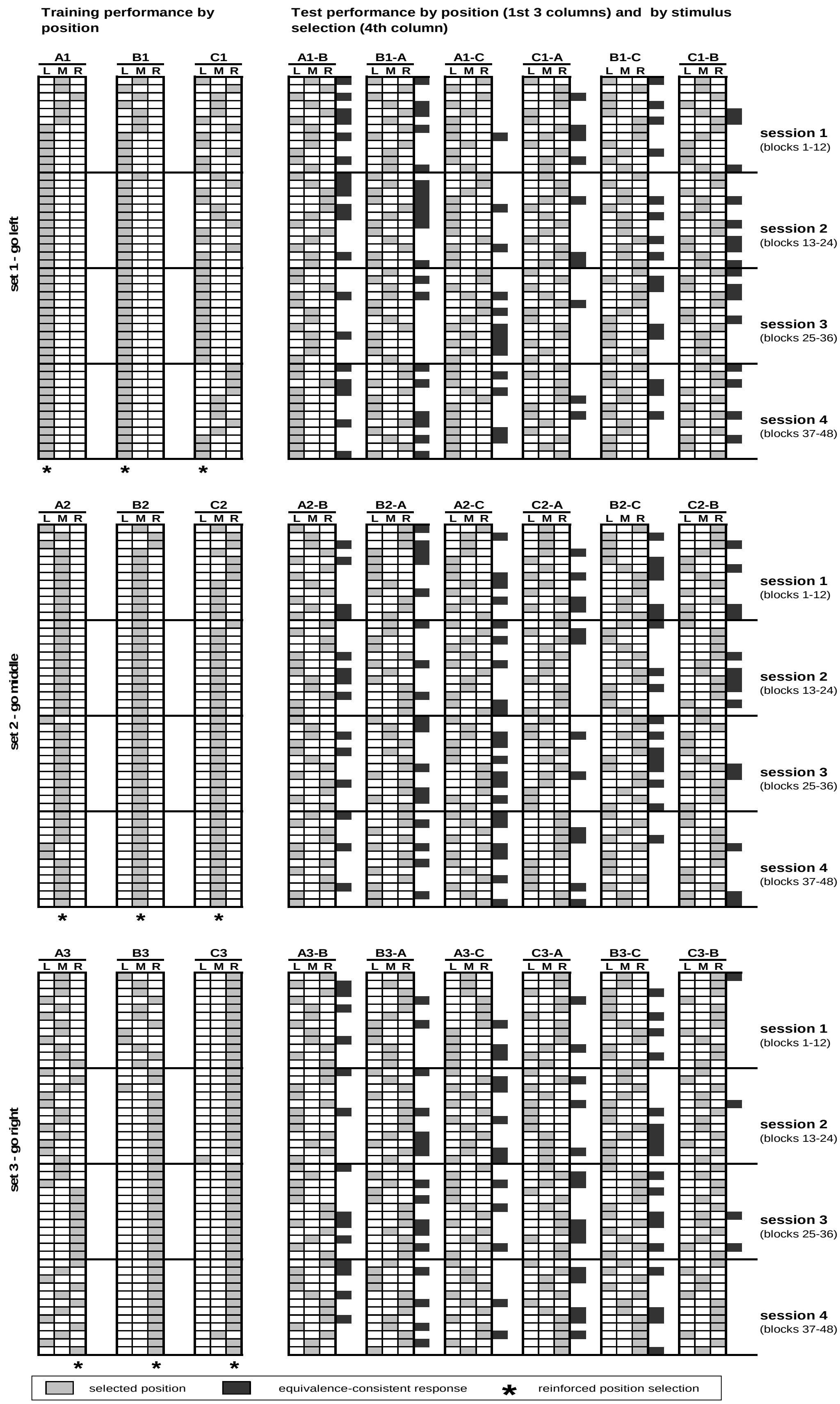
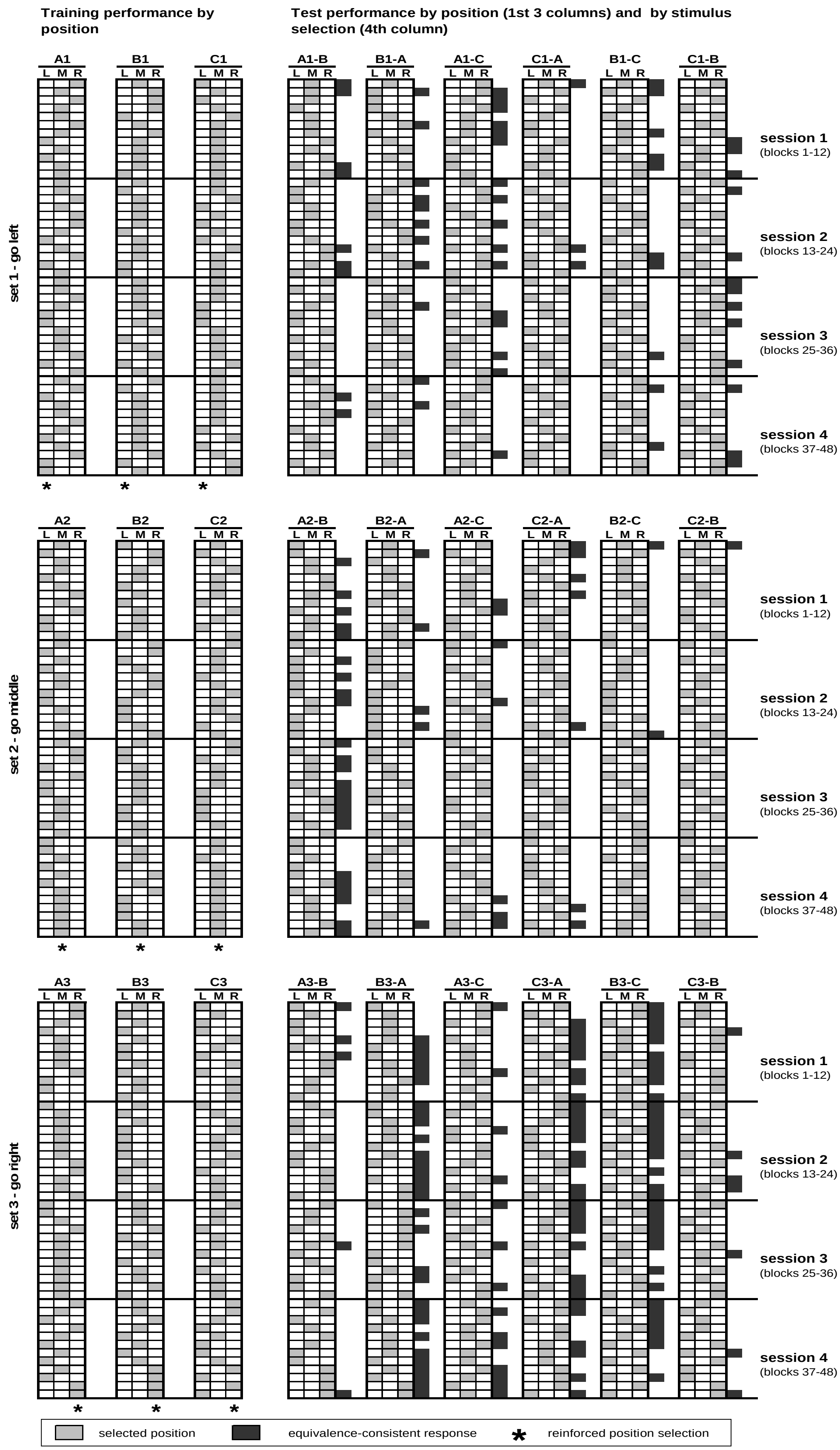

Training performance by position
Test performance by position (1st 3 columns) and by stimulus selection (4th column)
A1 B1 C1 A1-B B1-A A1-C C1-A B1-C C1-B
A2 B2 C2 A2-B B2-A A2-C C2-A B2-C C2-B
A3 B3 C3 A3-B B3-A A3-C C3-A B3-C C3-B
L M R
set 1 - go left
set 2 - go middle
set 3 - go right
session 1 (blocks 1-12)
session 2 (blocks 13-24)
session 3 (blocks 25-36)
session 4 (blocks 37-48)
selected position
equivalence-consistent response
reinforced position selection

Figure 10. Trial by trial development of trained and tested performances are shown for S7, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.



Training performance by position
Test performance by position (1st 3 columns) and by stimulus selection (4th column)
set 1 - go left
A1 B1 C1
A1-B B1-A A1-C C1-A B1-C C1-B
set 2 - go middle
A2 B2 C2
A2-B B2-A A2-C C2-A B2-C C2-B
set 3 - go right
A3 B3 C3
A3-B B3-A A3-C C3-A B3-C C3-B
L M R
session 1 (blocks 1-12)
session 2 (blocks 13-24)
session 3 (blocks 25-36)
session 4 (blocks 37-48)
selected position
equivalence-consistent response
reinforced position selection

Figure 11. Trial by trial development of trained and tested performances are shown for S11, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.



Training performance by position
Test performance by position (1st 3 columns) and by stimulus selection (4th column)
A1 B1 C1
A1-B B1-A A1-C C1-A B1-C C1-B
A2 B2 C2
A2-B B2-A A2-C C2-A B2-C C2-B
A3 B3 C3
A3-B B3-A A3-C C3-A B3-C C3-B
L M R
set 1 - go left
set 2 - go middle
set 3 - go right
session 1
(blocks 1-12)
session 2
(blocks 13-24)
session 3
(blocks 25-36)
session 4
(blocks 37-48)
selected position
equivalence-consistent response
reinforced position selection

Figure 12. Trial by trial development of trained and tested performances are shown for S8, arranged by trial type. Trials with set 1, set 2 and set 3 sample stimuli appear at the top, center and bottom of the figure respectively. The three columns to the left show the development of the trained relations. The six columns to the right show the development of relations during the test component. Labels at the top of each group of columns specify the trial type represented. Each row represents one trial. Each shaded box represents a response. Response distribution across left (L) middle (M) and right (R) keys is shown for trained and tested trials. For each test trial type, dark grey shading in the fourth column represents equivalence-consistent selection.

right positions. Dark grey shading in the fourth column represents equivalence-consistent selection.

As a result of the arrangement of comparison stimuli during test trials, there were two ways for systematic test responding to be related to the trained performance. Participants could either match stimuli that shared a common discriminative function (e.g., matching set 1 to set 1 stimuli and set 2 stimuli to set 2 stimuli, etc.) such that stimuli within a set functioned as an equivalence class; or the stimulus in sample position could continue to control selection of a particular position regardless of the particular comparison stimulus appearing in that position (see Figure 3). Response patterns from four of the seven participants showed the development of equivalence classes. For three of these participants, the development of equivalence-consistent responding was highly correlated with acquisition of the trained relations. Two of the remaining participants showed systematic test performance, though patterns were inconsistent with experimenter-defined equivalence classes. A final participant's test performance (S11) was unsystematic throughout the experiment. Figure 13 summarizes the experimental outcomes for all eight participants. Each of these data sets will be discussed in detail below.

Figure 14 presents summary data for the four participants whose performance was consistent with the definitional requirements for stimulus equivalence (S5, S6, S10 and S12). S12's final test performance in both tasks is representative of the other subjects and will be described in some detail. As for S10 and S5, equivalence-consistent performance emerged as the simple discriminations were learned, with no time lag. In the presence of set 1, 2 and 3 samples, choice of set 1, 2 and 3 comparison

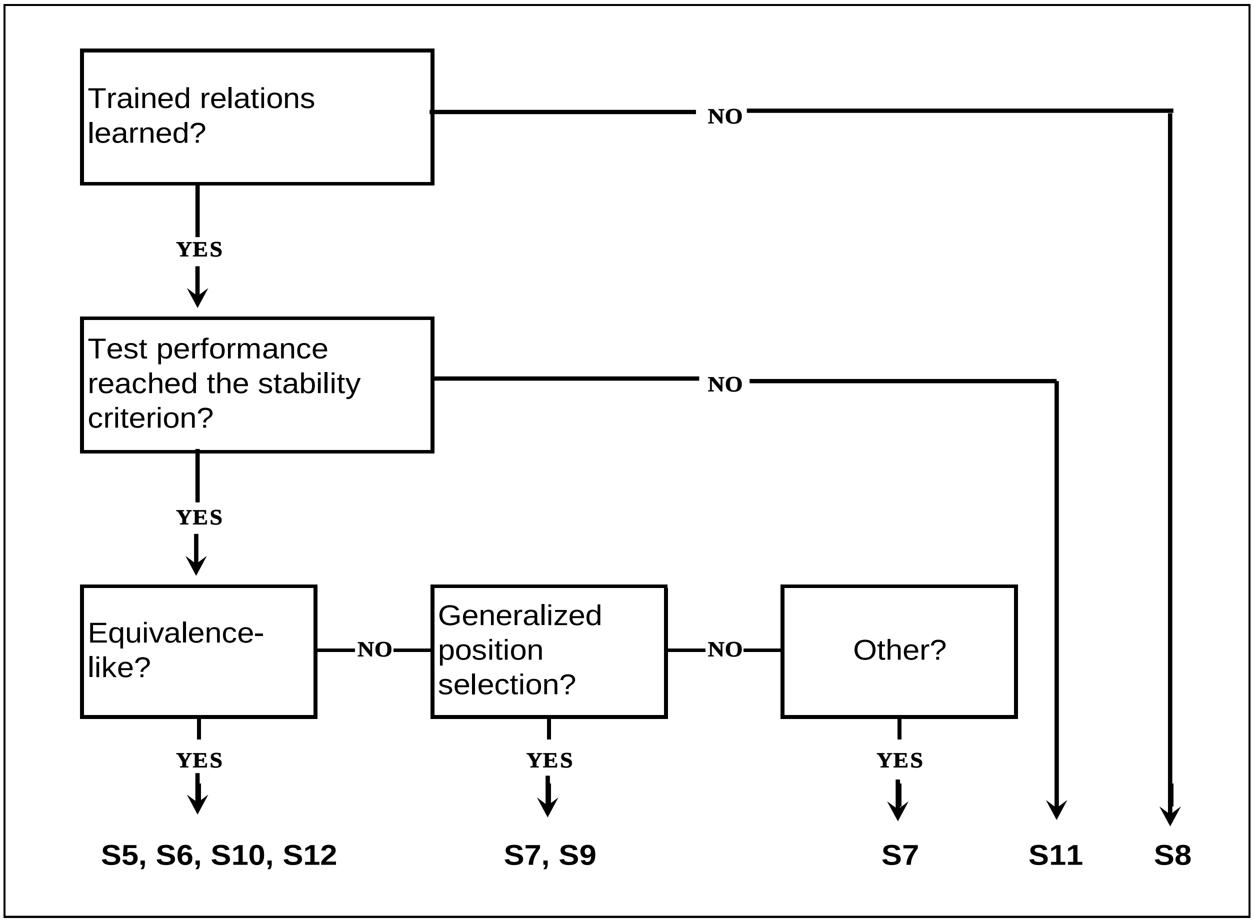



Figure 13. A summary of the experimental outcomes for all eight participants. Participants are grouped by common outcome. S7's test performance met the stability criteria twice. This will be described in more detail in the text.

stimuli, respectively, increased. After these trained and untrained relations developed, they remained stable until the end to the experiment.

Figure 7 shows that S12's acquisition of some trained relations began during the first block of Session 1 (B1-L, C2-M). Mastery of some relations took longer (C1-L, A3-R) but the stability criterion for all trained relations was met during block 16. Two test relations (A1-B1 and B1-A1) reached stability during block 8. By block 15, performance on all test relations had satisfied the six-block stability criterion. In some instances, consistent performance on tested relations appeared before that on the putatively necessary trained relations. Specifically, stable responding on A1-C1 and C1-A1 test trial types began at block 4, but stable responding to the baseline trial type C1-L did not begin for another six blocks. Stable responding on C2-B2 test trials began at block 3, though stable responding on the baseline trial type B2-M did not begin for another three blocks. Stable responding on C3-A3 test trials began at block 6, though stable responding on the baseline trial type A3-R again did not begin for an additional 3 blocks. Prior emergence of the symmetrical relations for these test trial types did not occur and therefore cannot explain these observations, but in some cases acquisition of trained relations that would allow accurate test performance through S- control may be causative. For example learning the relations A1-L, C2-M, C3-R may lead to the rejection of C2 and C3 comparisons in the presence of the A1 sample because the sample and negative comparisons presented during testing would have been established as members of separate classes during training. Similar patterns are evident in the data sets for S5 and S10.

Despite showing equivalence-consistent performance during session 2, the data for S6 differ from those of the other equivalence-consistent participants. Rather than developing simultaneously with the simple discriminations, equivalence-consistent performance appeared for the first time at the beginning of session 2 (see Figure 8). Figure 14 clearly shows that prior test responding was controlled by position. Between the final three blocks of session 1 and the first three blocks of session 2, control by position was replaced by equivalence-consistent responding. This effect is particularly clear for sets 1 and 2.

## Correlations between Training and Test Performances

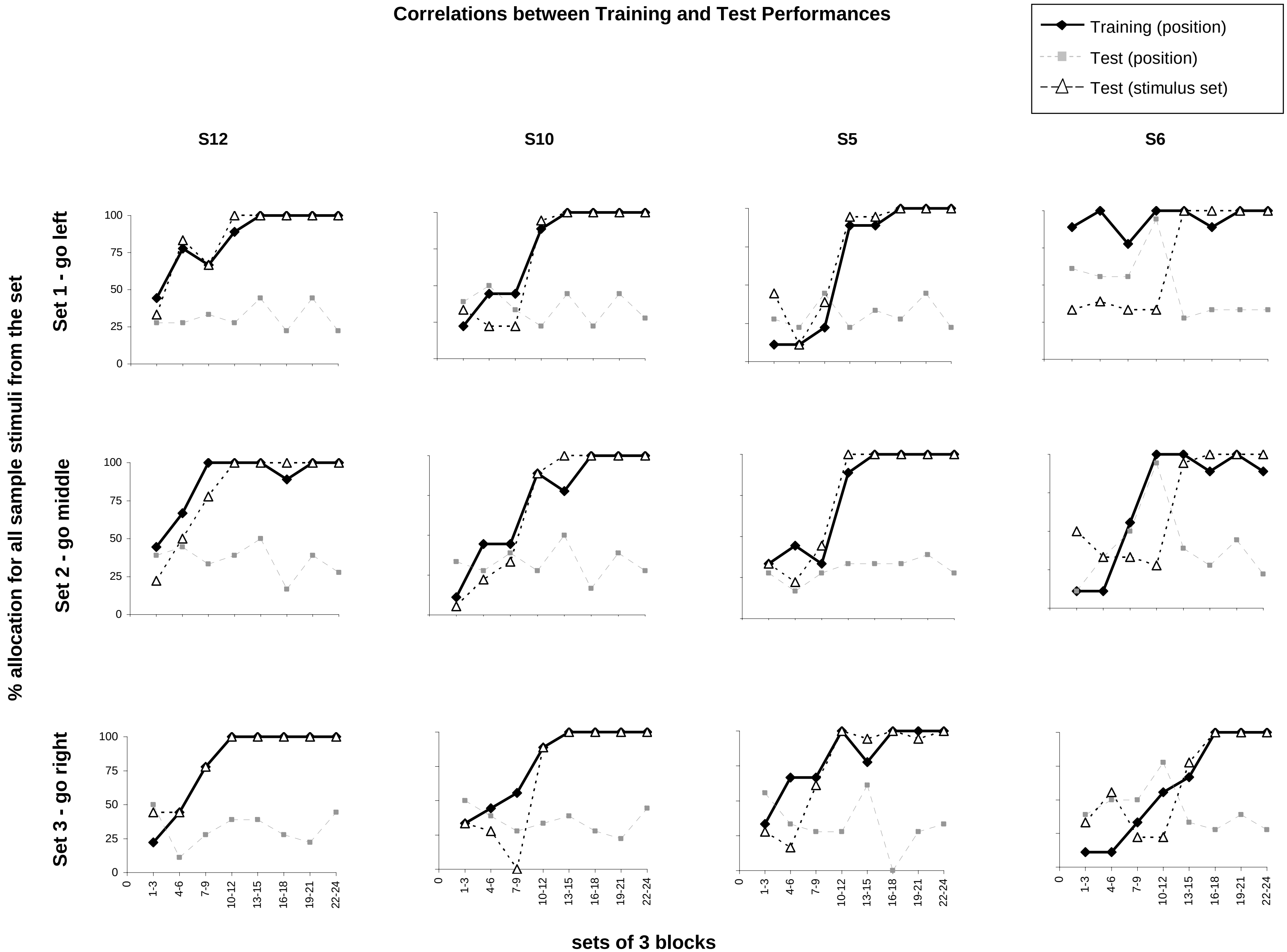


Figure 14. The development and maintenance of trained (bold) and tested relations are shown for each set of stimuli, for the equivalence-consistent group, across all sessions completed. Grey squares show response allocation to specified key positions, and white triangles to stimuli from the same experimenter-defined set during the testing. Graphs on the top row show percentage response allocation to the left key or to set 1 comparison stimuli. Graphs on the middle row show percentage response allocation to the middle key or to set 2 comparison stimuli. Graphs on the bottom row show percentage response allocation to the right key or to set 3 comparison stimuli. Each data point represents one quarter session (or 3 blocks).

In summary, acquisition of the trained stimulus functions and emergence of novel stimulus functions were almost perfectly synchronized for three participants. For a fourth participant there was a time lag before equivalence-consistent performance was shown.

Figure 15 presents data for the three remaining participants. For two of these participants (S9 and S7) final test performance was systematic albeit different from predictions. Each of the three participant's data will be described in turn.

For S7, acquisition of the trained relations was not apparent until blocks 22-24 but then preceded rapidly, meeting the stability criterion between blocks 31 and 33 (see Figure 10). Initially, test performance appeared neither equivalence-consistent nor illustrative of generalized conditional position functions. Test response allocation to the specified key position, or to the stimulus from the same designated set, remained at chance levels until the start of session 4 (blocks 37-39). From the beginning of session 4, in the presence of set 1, 2, and 3 samples, selection of left, middle and right positions predominated. Response allocation to comparisons from the same set as sample stimuli remained at near chance levels throughout. These relations remained stable until the end of the experiment.

A closer examination of S7's data revealed that test performance was systematic, though unrelated to the training contingencies; met the stability criterion 2 blocks before acquisition of the trained relations began; and was initially unaffected by the acquisition of the trained relations. Though the black bars and consistent white spaces in the equivalence columns of Figure 10 are indicative of the initial systematic performance, Figure 16 more clearly shows the stable choices of individual comparison stimuli by S7.

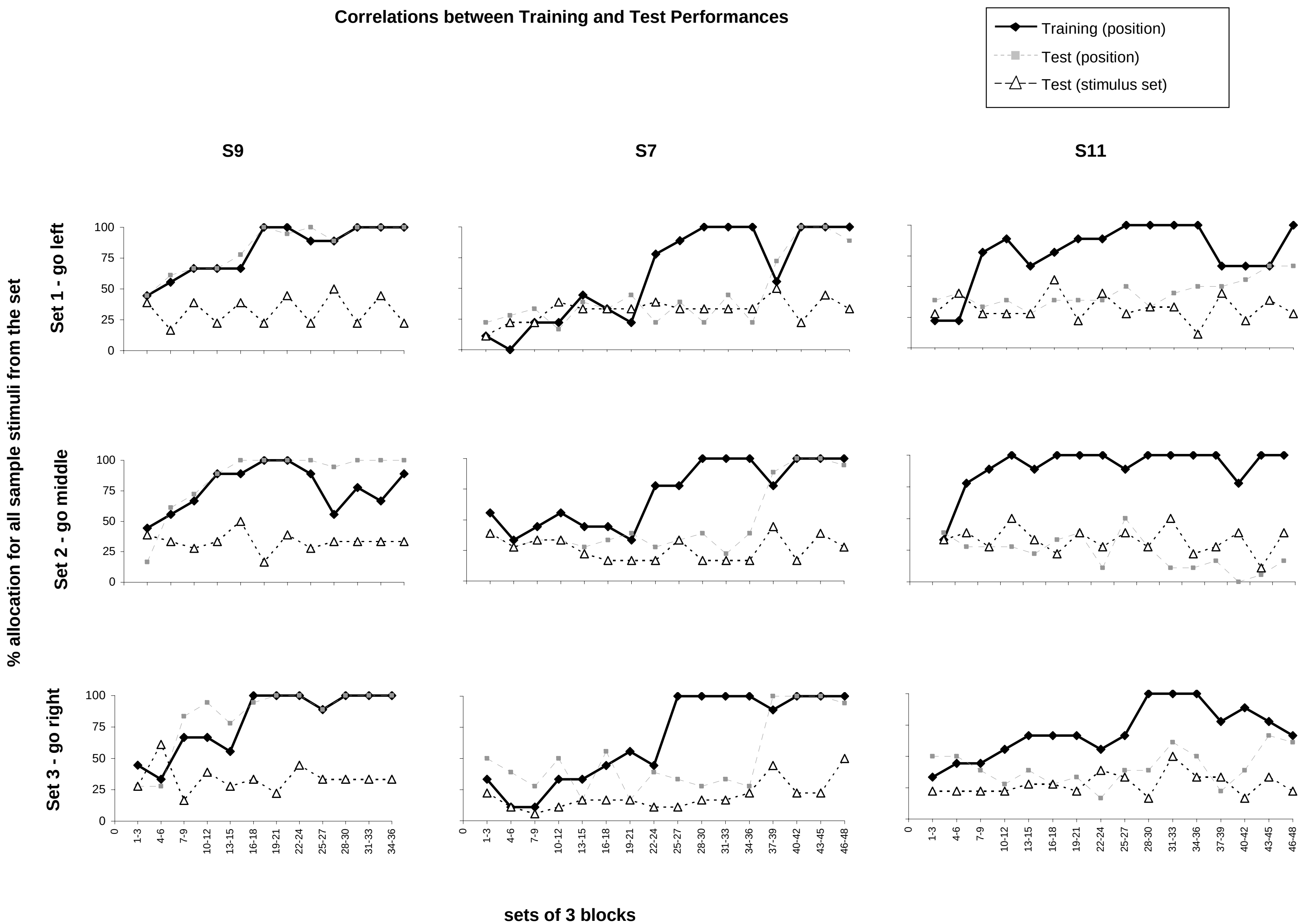

Correlations between Training and Test Performances
Training (position)
Test (position)
Test (stimulus set)
S9
S7
S11
% allocation for all sample stimuli from the set
Set 1 - go left
Set 2 - go middle
Set 3 - go right
sets of 3 blocks

Figure 15. The development and maintenance of trained (bold) and tested relations are shown for each set of stimuli, for the non-equivalence group, across all sessions completed. Grey squares show response allocation to specified key positions, and white triangles to stimuli from the same experimenter-defined set during the testing. Graphs on the top row show percentage response allocation to the left key or to set 1 comparison stimuli. Graphs on the middle row show percentage response allocation to the middle key or to set 2 comparison stimuli. Graphs on the bottom row show percentage response allocation to the right key or to set 3 comparison stimuli. Each data point represents one quarter session (or 3 blocks).

Sample stimuli are listed vertically to the left of each grid, comparison stimuli are listed horizontally across the top. For the given sample, black shaded cells represent selection of the comparison in excess of 75%. Grey cells represent selection in excess of 50%. Hatch cells show missing symmetrical relations. The grid for session 1 shows several untrained relations that were highly consistent and symmetrical. Although some shifting of response allocation occurred at the beginning of session two (e.g., A2-B3 and A3-C2), responding to most trial types remained consistent across the first three sessions. Of the untrained relations demonstrated by S7, only four did not show symmetry. This presentation method also allows for consistent stimulus relations to be grouped together to reveal equivalence classes as 3 by 3 black boxes (cf. Saunders and Green, 1992). If the three experimenter-defined stimulus sets functioned as stimulus equivalence classes, shaded cells would form three, 3 by 3 black boxes diagonally from the top left to the bottom right of the grid (see the grid for S12). Rearranging the stimuli along the vertical and horizontal axis to capture consistency in the subject's performance revealed two equivalence classes unrelated to the training contingencies (class X: A1, C1, B3; class Y: B1, A3, C2). Two additional stimuli (A2 and C3) are shown to be related symmetrically and to share a conditional function with class X (evoking B3 comparison selection). Finally, B2 shared some conditional functions with class Y (evoking A3 and C2 comparison selection), but did not enter into any equivalence relations with these class members. The source of these equivalence classes is unclear. They are unrelated to the training contingencies and were unrelated to the participant's responding during training blocks. In post-experiment debriefing, the participant indicated that he did not consistently name any of the stimuli. Figure 17 shows the computer generated

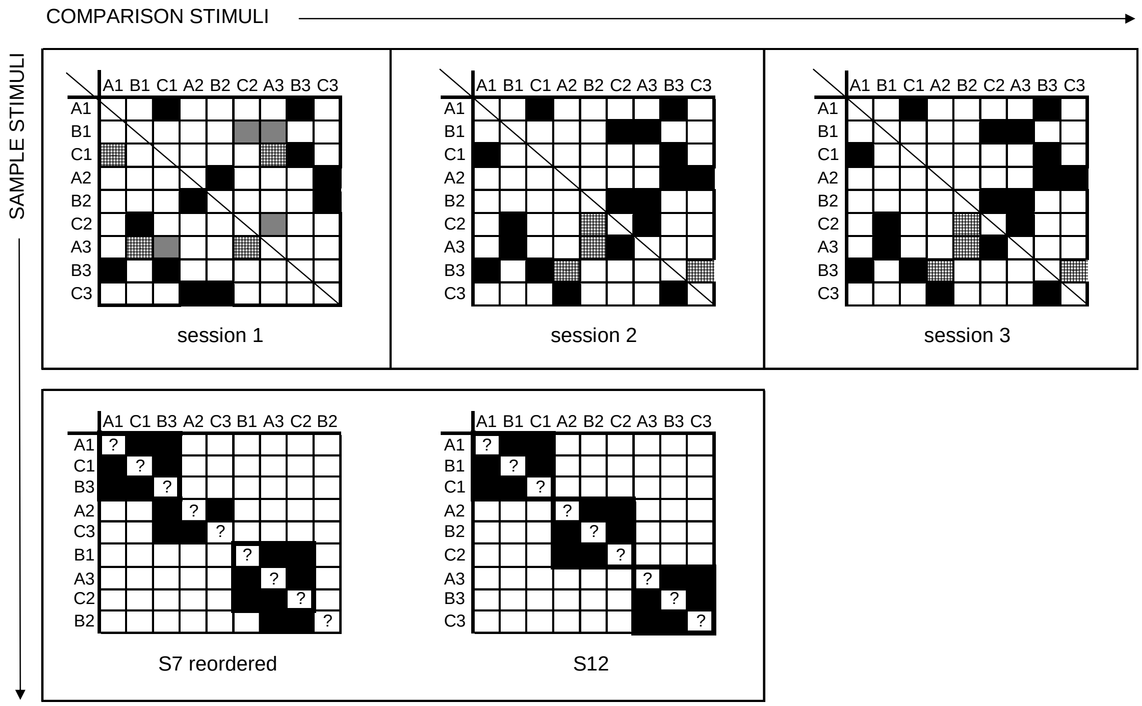



Figure 16. The top of the figure shows development of test performance for each trial type, across sessions 1 to 3 for S7. Sample stimuli are listed vertically to the left of each grid. Comparison stimuli are listed horizontally across the top of the grids. For each trial type, black cells represent response allocation to the comparison stimulus in excess of 75%, grey cells represent response allocation in excess of 50%. The diagonal line through the middle of each grid highlights the symmetry of these untaught stimulus relations. Hash filled boxes highlight the missing relations required for all performance to be symmetrical. At the bottom of the figure S7, data are re-presented after rearrangement of the sample and comparison labels. The grid is a summary of blocks 19-36 (the blocks following initial satisfaction of the test stability criterion). For comparison purposes, a summary grid of S12's post-stability test performance is also presented. Question marks depict the untested reflexive relations.

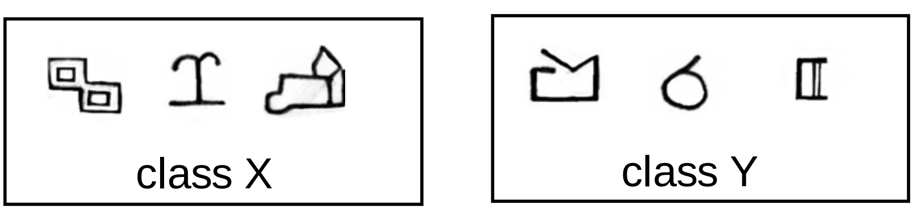



Figure 17. The computer generated forms making up classes X and Y for S7

visual forms that made up classes X and Y. The stimuli across the two classes do not appear to be distinguishable in terms of stimulus dimensions. Highly consistent test performance, inconsistent with the training contingencies, may have hindered acquisition of the trained relations. Note that training trial performance was highly inconsistent until session 3 (Fig 10). At the beginning of Session 4, this consistent selection of stimuli ceased for all trial types and was entirely replaced by generalized conditional position performance. The trained discriminative functions had generalized to the test condition. Stimuli in sample position controlled selection of position regardless of the computer generated visual form appearing in that position.

Figure 9 shows that for S9, acquisition of some trained relations began during the first block of session 1(C1-L, C3-R). Mastery of some relations took longer (B1-L, C2-M and A3-R) but the stability criterion for all trained relations was met during block 20. S9's final test performance was not equivalence-consistent but rather was illustrative of generalized conditional position functions (see figure 15). In the presence of set 1, 2 and 3 samples, selections of left, middle and right positions, respectively, were observed. Response allocation to comparisons from the same set as sample stimuli remained at chance level throughout. After the untrained relations developed, they remained stable until the end of the experiment, despite minor disruption of the trained relations during Session 3 (blocks 25-36). Performance on one derived conditional relation (C1-B1) reached stability during block 7. Performance on 10 further test relations reached stability by the end of session 1. By block 36, performance on all test relations satisfied the six-block stability criterion. Interestingly, initial stable performance on trained relation B1-L was not in line with the arranged reinforcement contingency.

The effect of this ‘incorrect’ training performance was selection of the middle position on all probe trials where B1 served as a sample stimulus.

The immediate and highly consistent generalized conditional position responding shown by S9 in testing warranted further analysis. Control over position selection seemed to predominate over equivalence. In order to impede responding by position in test trials, a series of procedural modifications was carried out for this participant.

The original testing format will now be referred to as Condition I. The first procedural modification will be referred to as Condition II. Condition II was identical to Condition I, except in the arrangement of comparison stimuli during test trials. During Condition II, the location of comparison stimuli changed from trial to trial, such that the three comparison stimuli could appear in any of four available positions (see top left of Figure 18). Within the session and across trial types the designated correct key position was distributed equally across the four positions. It was expected that precluding control by position would allow equivalence-consistent choices to emerge.

Table 1 shows response allocation across available keys for trials with set 1, set 2 and set 3 sample stimuli respectively. The left of Figure 18 shows the screen position of each numbered key. The top section of Table 1 shows that in the presence of set 1 sample stimuli, responses were allocated to the stimulus on the left, regardless of the specific key position. For example, when the available keys were 4, 5 and 8 (see Figure 18), responding was allocated entirely to key 4. When the available keys were (4, 5, 7), (4, 7, 8) or (5, 7, 8), responding was allocated entirely to key 7. Summary data for this procedural modification are presented in the first phases of the graphs in Figure 19. Each graph displays the data for one experimenter-designated set. In sum, performance following this first procedure change continued to be almost perfectly controlled by the position of the comparison key. The procedural modification failed to disrupt this participant's conditional position performance.

Condition III was designed to eliminate the possibility of responding to position completely by removing the three concurrent response options that had typically been available. Instead, S9 was exposed to a "yes"/"no" task (cf. Spence, 1937) in which the

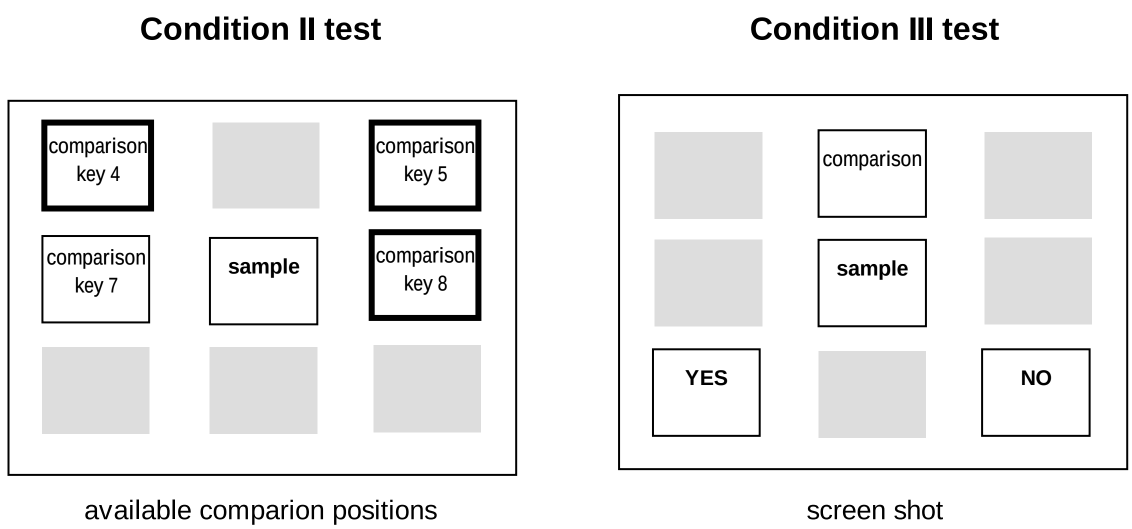



Figure 18. To the left of the figure, on-screen positions of samples and comparisons are shown for Condition II. Any three of the four comparison keys were active during a single trial. The highlighted boxes show one of four possible comparison key combinations. Response key numbers are given as a reference for table 1. To the right, on-screen positions of sample, comparison, and response keys are given for the "yes"/"no" test in Condition III. In all cases, grey boxes indicate positions of inactive keys.

**Set 1- go left**

| Unavailable Key | Comparison Position | | | |
|---|---|---|---|---|
| | 4 | 5 | 7 | 8 |
| **7** | 1.00 (L) | 0.00 (M) | -- | 0.00 (R) |
| **8** | 0.00 (M) | 0.00 (R) | 1.00 (L) | -- |
| **5** | 0.00 (M) | -- | 1.00 (L) | 0.00 (R) |
| **4** | -- | 0.00 (M) | 1.00 (L) | 0.00 (R) |
| **response allocation:** | **0.25** | **0.00** | **0.75** | **0.00** |

**Set 2 - go middle**

| Unavailable Key | Comparison Position | | | |
|---|---|---|---|---|
| | 4 | 5 | 7 | 8 |
| **7** | 0.00 (L) | 1.00 (M) | -- | 0.00 (R) |
| **8** | 0.94 (M) | 0.00 (R) | 0.06 (L) | -- |
| **5** | 1.00 (M) | -- | 0.00 (L) | 0.00 (R) |
| **4** | -- | 0.94 (M) | 0.00 (L) | 0.00 (R) |
| **response allocation:** | **0.49** | **0.49** | **0.01** | **0.00** |

**Set 3 - go right**

| Unavailable Key | Comparison Position | | | |
|---|---|---|---|---|
| | 4 | 5 | 7 | 8 |
| **7** | 0.00 (L) | 0.00 (M) | -- | 1.00 (R) |
| **8** | 0.00 (M) | 1.00 (R) | 0.00 (L) | -- |
| **5** | 0.00 (M) | -- | 0.00 (L) | 1.00 (R) |
| **4** | -- | 0.00 (M) | 0.00 (L) | 1.00 (R) |
| **response allocation:** | **0.00** | **0.25** | **0.00** | **0.75** |

Table 1. Results of condition II procedural manipulation for S9. Response allocation to each of the three comparison keys is shown for the 72 test trials in which set 1, set 2 and set 3 stimuli served as samples (respectively top, middle and bottom ). For any given trial, one of the four response keys was unavailable. Four different comparison key arrangements appeared 18 times for each sample set. Letter symbols (L, M, R) indicate the left, middle or right position of each key in each comparison array.

participant is required to select “yes” if the stimuli go together and “no” if they do not. A screen shot of the “yes”/“no” procedure used here, is presented in Figure 18. A trial began with the appearance of the sample in the center of the screen. An observing response to the sample produced the comparison stimulus and the two response keys (“yes” and “no”). The sample and comparison remained on screen until the evaluation response was made. There was no programmed feedback.

Because only one, rather than three, comparison stimuli could be presented at a time, each test condition included 3 times as the number of trials than previously to allow presentation of all previously presented combinations of sample and comparison stimuli (i.e., each test block now comprised 54, rather than 18 trials) . Three training blocks and three test blocks were presented, yielding a session of 189 trials. As before, training and test blocks alternated such that each training block was followed by a test block.

In this preparation, test responding is equivalence-consistent when “yes” responses follow stimulus pairs in which both stimuli belong to the same experimenter-defined class, and “no” responses follow stimulus pairs in which the stimuli belong to different experimenter-defined classes. The second phase of each graph in Figure 19 shows the total percentage of equivalence-consistent responses, for all trials with samples from the same set, across all three test blocks presented. Each data point includes the designated correct “no” responses for each sample as well as the designated correct “yes” responses. For the first time, S9’s responding to stimuli in all sets was

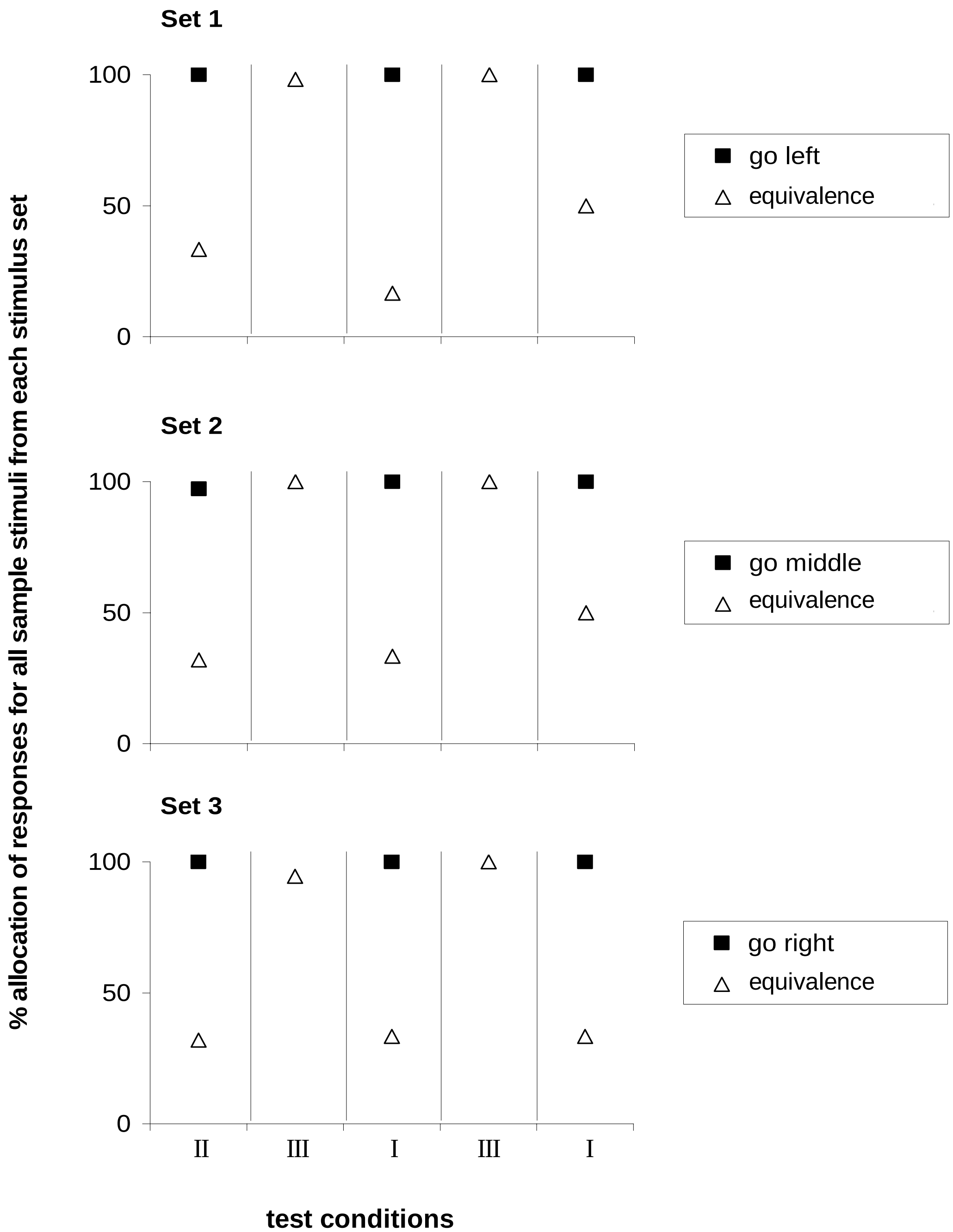



Figure 19. Responding consistent with stimulus equivalence (open triangles) and with generalized conditional position (filled squares) is shown for each of the modified test conditions to which S9 was exposed. Data points in the first two phases of the graph show average performance across entire sessions. Data points in the final three phases of the graph, show average performance within individual test blocks of the final session.

equivalence-consistent. Within blocks, the lowest percentage of equivalence-consistent responding was 83% (block 3, set 3).

Finally, test conditions I and III were presented within the same session in order to see whether the class organization demonstrated in Condition III would be observed during Condition I testing. The session sequence began with a training block, followed by a Condition I test block and then a second block of training. A Condition III test block was then presented followed by a final training block and an additional exposure to the Condition I test. Data points in the final three phases of the graphs in Figure 19 show average performance across each stimulus set, for the three test blocks of the final session. Re-exposure to the Condition I test format revealed highly persistent conditional control over position selection. The class organization demonstrated during exposure to the Condition III test format had not influenced responding to the original test format. The extreme contrast in equivalence-consistent performance across these two test formats was replicated in two further reversals. Unfortunately, a programming error discovered after the completion of the experiment limits the interpretation of the results from the final session. The composition of the comparison arrays in the condition I tests had been inadvertently changed such that stimuli from all three letter designations were mixed. This resulted in i) arrangements of comparisons not previously encountered, and ii) stimuli never previously presented as a comparison in the presence of the given sample; for example, the presentation of a B1, A2, and C3 comparison array in the presence of an A1 sample. However, a comparison was never identical to the current sample and the comparison array always consisted of one stimulus from each of the experimenter-designated sets.

In sum, S9 showed equivalence-consistent responding in the context of the "yes"/"no" task, but not in the context of the traditional match-to-sample task.

# CHAPTER 4

# DISCUSSION

The goal of this experiment was to investigate whether stimuli that shared a function in the context of a conditional position discrimination task would also be equivalent in the context of a 3-choice match to sample task. The results were affirmative for four of seven participants (S5, S6, S10 and S12), and for three participants (S5, S10 and S12) the effect was immediate. As soon as responding came under control of the arranged contingencies during training, response allocation to comparison stimuli from the same set as the sample began to increase during testing. Thus, acquisition of the trained stimulus functions and emergence of novel stimulus functions were almost perfectly synchronized for these participants. For S6, the relation between training and test performance was more complicated. Percentage of equivalence-consistent performance showed a sudden increase after the majority of the shared functions had been acquired in training blocks, rather than emerging gradually as the shared functions developed.

Results show that, for three participants (S7, S9 and S11), stimuli that shared a function in the context of a conditional position discrimination were not equivalent in the context a 3-choice match-to-sample task. For two of the three (S7 and S9) the “problem” was the generalization of conditional position functions. The degree of relatedness between training and test performances varied considerably across these participants. For S9, performances were highly correlated from the beginning of the experiment, indicating immediate generalization of the directly trained conditional position functions to the match-to-sample test context. S7’s performances across the two tasks remained unrelated until session 4, at which point the trained conditional stimulus functions generalized to the match-to-sample context. Finally, across four sessions of exposure to the contingencies, there was no clear relationship between performances in the training and test blocks for S11.

A closer analysis of S7's data was presented in Figure 16, revealing highly consistent performance during test blocks, from the beginning of the experiment. Responding was in accordance with idiosyncratic equivalence classes that were unrelated to the contingencies arranged during the training component. Interestingly, this participant reported of the test blocks, “I never felt like I nailed down a specific course of action.” Performance during training blocks showed no evidence of this idiosyncratic equivalence class organization, suggesting that performances across the two tasks were independent. The two-session delay in the acquisition of the conditional position discriminations, however, may have been a reflection of the existing competing class organization shown under test conditions. However, performance during the match-to-sample task remained unaffected for almost an entire session following this acquisition. It is unclear what led  to the immediate performance change during the match-to-sample task at the beginning of session 4 for this participant, but clearly, the previously persistent stimulus control in the this context was overridden by generalized conditional control that developed and been maintained during the training task.

Because S11's involvement in the experiment was terminated after session 4 due to time constraints, it cannot be determined if training and test performances would have become related for this participant after additional exposure to the experimental contingencies.

In summary, both the nature and the timing of the relationship between conditional position training and match-to-sample test performances varied across participants. Thus, the role of shared stimulus functions in the emergence of equivalence relations appears to differ across the data sets examined. These differences are examined more closely below.

A commonality between the training and the test tasks in this experiment was the inclusion of three response keys positioned horizontally across the screen. As a result, it was possible for the shared ‘go-left’, ‘go-middle’ and ‘go-right’ functions developed during simple discrimination training to generalize to the equivalence test. From this perspective, the immediate development of equivalence-consistent performances for S5, S10 and S12, and, the replacement of initial generalized conditional position functions with equivalence-consistent responding at the beginning of session 2, for S6, is particularly interesting. Equivalence-consistent responding occurred even though a competing response pattern with an immediate history of reinforcement was possible in this context. These four data sets strongly support an assertion that shared stimulus functions can lead to equivalence.

For S7 it is unclear what the role of shared function might have been in the emergence of equivalence-consistent performance seen in the test context prior to acquisition of the trained conditional position functions, as there is no way of knowing upon what basis the stimuli were matched. Some feature of the test context may have occasioned matching behavior at the outset, independently of any arranged contingency or instruction. This feature or set of features may have functioned as an instruction for S7 to match. Idiosyncratic grouping of the stimuli may have facilitated this process.

Results showed that after the stimuli had acquired shared conditional position functions, these functions eventually overrode any pre-existing stimulus control present during the match-to-sample test. The participant may have learned, “when you see this picture, don’t match it, go left.” Here, the role of trained shared functions on the emergence of equivalence relations may have been an inhibitory one because directly trained responding interfered with preexisting equivalence-consistent responding.

For S9 the original test context did not occasion matching behavior at any point during the course of the experiment. It is unclear whether the necessary stimulus control topographies were absent, or whether they were overridden by competing stimulus control developed during training blocks. Again, the role of trained shared functions on the emergence of equivalence relations may have been an inhibitory one. Results following the first procedural manipulation (condition II) revealed the robust nature of the trained stimulus functions. Contingencies designed to teach selection of one of three boxes along the bottom of the computer screen conditional upon the sample presented, had in fact taught selection of left, middle or right key positions, wherever they appeared on the screen (see Table 1). Thus, the shared stimulus functions acquired during training blocks dominated performance as they had in condition I during presentation of the original match-to-sample test format. Results following the second procedural modification (condition III) revealed the possible effect of task on the emergence of untrained stimulus functions. The two-response-key “yes”/“no” task immediately yielded equivalence-consistent performance. The immediacy of this effect was surprising following four sessions of equivalence failure in the context of the match-to-sample test. When the original test was re-presented, there was no evidence of the newly demonstrated class organization, but a re-presentation of the “yes”/“no” task replicated the initial results. Clearly, in the context of the “yes”/“no” task, untrained stimulus functions did result from the development of shared conditional position functions. The current procedures however did not allow the analysis of the temporal relationship between these performances that would have been possible if the “yes”/“no” task had been presented from the beginning of the experiment. It seems that the role of shared function in the emergence of equivalence-consistent performance was an inhibitory one in the context of the match-to-sample tests, but that these same, shared functions led to equivalence-consistent responding in the context of the “yes”/“no” test. Heretofore, it makes sense to talk about functional equivalence within the context of a particular task or tasks, rather than independently of task specification.

For S9, the three equivalence tests presented differed in terms of whether directly trained stimulus functions could compete with the stimulus functions necessary for the emergence of equivalence. However, the emergent functions required for equivalence-consistent performance in the “yes”/“no” test were different from those required in both match-to-sample tests (conditions I and II). It is possible that this difference was enough to produce differential outcomes across match-to-sample and “yes”/“no” tests for S9. In addition, the discrepancies in comparison array content between the match-to-sample blocks in the original condition I and those that followed presentation of the “yes”/“no” test, resulting from a programming error, may have affected the outcome of the reversals. After completion of the experiment however, this participant claimed to have paid no attention to the items in the match-to-sample stimulus arrays. If this is true, it seems unlikely that familiar stimuli appearing in atypical combinations would have affected performance.

The data sets for S7 and S9 demonstrate the importance of task choice for experiments investigating functional equivalence across contexts. Results demonstrating the relationship between shared function in one context, and emergence of different shared functions in a second context, were clouded when directly reinforced functions dominated in the context of the equivalence test. Unusually in equivalence research, we are able to point to the source of the failure to demonstrate equivalence. It has been suggested (Iversen, Sidman, & Carrigan,1986; Iversen, 1997) that control by position is a major impediment in the demonstration of emergent conditional discriminations for other animals; data from conditions I and II with S9 appear to model this impediment in humans. S9's data suggest that testing for emergent-shared-functions in the context of a task in which recently reinforced responding cannot occur, may be a useful method for revealing the development of equivalence relations in such cases. However, because S9 was the only participant exposed to the “yes”/“no” test, and because this exposure occurred long after mastery of the conditional position discriminations, it is clear neither how other participants would have responded to this task, nor if equivalence classes may have developed simultaneously with the taught discriminations. Further research is necessary to investigate these questions.

Examination of S11's data revealed an ongoing independence between training and test performances, suggesting that shared stimulus functions had no role in the emergence of equivalence-consistent performance in this context. This data set would be consistent with an assertion that shared stimulus functions are not always sufficient to produce equivalence.

All eight participants experienced the same conditions during the current experiment. Of the seven that demonstrated mastery of the conditional position task, there were three general outcomes in the match-to-sample task: equivalence-consistent responding, generalized conditional position responding, and undifferentiated, chance level responding. The following section will address some of the possible underlying causes of these differences.

Whether or not common stimulus functions in one context will lead to equivalence in a second context may depend upon the performance, or performances, occasioned by features of this second context. It is reasonable to assume that these performances will depend upon histories of reinforcement and/or histories of instruction with respect to these task features. From this perspective, the participant must learn not only that the stimuli from each stimulus set are functionally the same in the context of the conditional position task, but they must also have learned how to treat such stimuli in the context of the match-to-sample equivalence test. If either of these learning histories is incomplete, it seems unlikely that equivalence-consistent responding will emerge. The dangers of teaching-procedures that allow the development of stimulus control topographies or SCTs (McIlvane & Dube, 1996; 2003) other than those intended by the experimenter, are well known. For example, failure to randomize the position of comparison stimuli in a match-to-sample preparation may inadvertently lead to the development of conditional position responding, and participants may fail to learn the arranged discriminations. Researchers take great care to ensure that irrelevant stimulus features do not vary in accordance with the arranged contingencies. When there are no contingencies in effect for an untaught task, it is possible that features of the task display have previously been associated with a number of different response topographies, with different histories of instruction or reinforcement. If the dominant SCTs are not those tested, it may be impossible to ascertain the existence of the desired SCTs without conducting additional experimental manipulations that isolate the relevant controlling variables. Researchers use various strategies to prevent these problems from occurring. Experimental stimuli are usually arbitrary, difficult to name and cannot easily be grouped based upon physical appearance. Prior to the experiment, it is common to teach the matching procedure with identity matching (e.g., Sidman et al., 1989), or to instruct participants explicitly to find the stimulus that 'goes with' the sample (e.g., Cullinan, Barnes-Holmes, & Smeets, 2000). Such practices likely increase the probability that the match-to-sample task will occasion matching behavior and decrease the probability that competing SCTs will control responding. The current procedure involved neither training nor instructions with respect to the matching task. In addition, there was initially no attempt to eliminate the possibility that SCTs developed during the conditional position training task could generalize to the match-to-sample test. The dominance of these SCTs seen for participants S7 and S9 may have precluded those that otherwise would have occasioned matching behavior. It would be necessary to demonstrate that the MTS task occasioned matching of stimuli that had not previously participated in a conditional-position-discrimination in order to make a firm statement to this effect. This experiment did not include an analysis of this kind. Results of the additional procedural manipulations conducted with S9 suggest that removal of the opportunity to respond to left, middle and right keys allowed the yes/no task to control responding. By changing the nature of the task presented, it was possible to produce and replicate equivalence-consistent responding several times. From the current analysis, it would follow that other procedural manipulations may have similar effects, by strengthening or weakening the control of the test task over equivalence-consistent responding. For example, displaying “This is a matching task,” at the top of the screen during the match-to-sample test may have strengthened any SCTs that in the past had occasioned matching behavior. Similarly, for equivalence-consistent performers, displaying “This is not a matching task” at the top of the screen during the test may have weakened any SCTs that had occasioned matching and strengthened alternative SCTs. Until we understand the potential role(s) of preexisting stimulus control in untrained tasks, it will not be possible to isolate the role played by shared stimulus functions in the development of equivalence-consistent performances.

Up to this point, I have attempted to conduct the analysis of this data outside the paradigm of mainstream equivalence research in the hope of encouraging the reader to focus on the correlation between performances across different tasks, rather than to consider one task as the baseline for the other. In the following paragraphs, I will discuss two ways in which the current experiment could fit into the traditional stimulus equivalence paradigm.

Several conditional discrimination training structures have been shown to lead to equivalence-consistent performances (R. Saunders & Green 1999; K. J. Saunders, Williams & Spradlin, 1996). A commonly reported structure in the stimulus equivalence literature is the many-to-one structure. In this structure, all but one of the stimuli from each experimenter-designated set serve as samples in conditional discrimination training. When performances are consistent with the arranged contingencies, the presence of each of these stimuli occasions the selection of a common comparison stimulus (e.g., given sample B1 or C1, participants pick A1, not A2 or A3). If we consider the horizontally positioned boxes in the current preparation stimuli from the experimenter-designated set, the conditional position task can be considered a many-to-one training structure, and the match-to-sample task a test for three, four member equivalence classes. From this perspective, there were no tests for symmetry, as the squares did not appear in the equivalence test context, but it is not uncommon to use a subset of the tests as evidence for equivalence classes (e.g., Devany, Hayes, & Nelson, 1986; Sidman & Tailby, 1982). In this light, an emergent conditional relation between stimuli sharing a function in the training task would be considered a demonstration of stimulus equivalence. Emergent stimulus functions demonstrated in the "yes"/"no" test are less likely to be considered so, as such functions cannot result from reversals or re-combinations of the trained conditional relations. Although other researchers have used variations of the "yes"/"no" task to test for equivalence (Cullinan et al., 2000; Fields & Verhave, 1987) the training in these experiments has typically been conducted in the same format as the tests.

A group of studies within the equivalence literature can be categorized as using atypical training or testing procedures. Using traditional match-to-sample tests, researchers have reported equivalence-consistent performance following training that did not involve interrelated conditional discriminations of the form required in the test context (Cullinan et al., 2000; Leader, Barnes, & Smeets, 1996; Leader & Barnes-

Holmes, 2001; Sidman et al., 1989). Leader and colleagues sequentially presented pairs of stimuli from experimenter-defined classes to young children and college students, on a computer screen, with no response requirement. Specifically, in A1-B1 trial types, A1 was presented for 1s, B1 was presented 0.5s later for 1s. An inter-trial interval of 3s preceded presentation of the next stimulus pair. A-B and B-C stimulus pairing for each of three experimenter-defined sets were presented in training for a total of 60 trials (10 trials per stimulus pair). Subsequent tests for symmetry and transitivity in a 3-choice match-to-sample preparation yielded equivalence-consistent performance for all participants. In most of these studies, reversals and re-combinations of baseline conditional discriminations were not required to pass the equivalence tests (cf. Sidman et al., 1989). As a result, these studies break away from an interpretation of equivalence based on conditional discriminations. It is possible to place the current experiment in this category. Treating selection of the left, middle and right positions as simple discriminations, rather than treating the three boxes as members of the experimenter-defined classes, equates this work with the Sidman et al. (1989) study in which members of a functional class were shown to demonstrate properties of equivalence classes.

Researchers have also demonstrated emergence of a range of new stimulus functions that are clearly different from those that emerge in the context of a match-to-sample task. Sometimes these have been conditional functions (e.g., Cullinan et al., 2000; Fields & Verhave, 1987; Sidman et al., 1989) and sometimes, as in the case of studies investigating extension of function, they have not (e.g., Barnes and Keenan, 1993; Hayes, Browstein, Devany, Kohlenberg and Shelby, 1987). Interrelated conditional discrimination training was used in some, but not all of these studies. The results of these experiments do not seem to fit comfortably in the traditional equivalence paradigm in terms of the 4 term contingency account offered by Sidman (1994). They. In addition, studies that have used more than one equivalence test task (e.g., Cullinan et al., 2000; the current study) have shown that equivalence-consistent outcomes across these tasks can vary, suggesting that the “yes”/“no” equivalence test and the match-to-sample equivalence tests should not be regarded as different methods for measuring the same thing. With the breaking away of equivalence from traditional conditional discrimination procedures, and the confusion resulting from the extension of function research, a different way of talking about these phenomena seems warranted.

The strategy used here is to avoid viewing the components of the experiment as training the relations that underlie equivalence and testing for the existence of an equivalence class. Instead, the current arrangements are characterized as a task in which feedback is programmed to teach a relationship between stimuli, and an additional task in which the same stimuli are presented with no available feedback. From this perspective, the specific nature of the taught and emergent functions is not constrained by a priori assumptions about those functions. Thus, procedural distinctions between functional classes, extension of function, and stimulus equivalence need not be relevant. The broad question becomes as follows. When a teaching procedure relates a set of stimuli in some way within the context of a given task, will the same stimuli also be related in the context of different tasks, whether these tasks require the reversal and recombination of the original conditional discriminations, the extension of a function trained to only a subset of stimuli, or the sharing of untrained functions?

Specifically, we can ask questions about the roles of different types of conditionality and different types of shared function in the emergence of shared functions across a broad range of tasks. Conditionality may take the form of any of the training structures identified by Saunders, Williams and Spradlin (1996) as well as other, as yet unidentified, training structures. Shared functions could result from operant or respondent procedures. Controlled responses could involve conditional discriminations, schedule-specific performances (e.g., go fast, go slowly, no go), sequencing tasks (e.g., touch first, second, and third) and others. Under what conditions is emergence most likely/least likely? Can we manipulate the tasks such that equivalence-consistent responding is more or less likely to be seen? When we are looking for emergent control, it is important that we restrict extraneous sources of competing stimulus control but at the same time, recognize that the resultant performance is a function of the task presented.

In summary, it may be important to qualify the context when evaluating the equivalence of stimuli. The results of studies in which researchers have placed equivalence-consistent responding under contextual control further support this caution (Bush, Sidman & de Rose, 1989; Gatch & Osborn, 1989; Hayes, 1991; Wulfert & Hayes, 1988). If we wish to avoid inferring the existence of stimulus classes outside the context of behavior that defines them, it does not make sense to speak of an equivalence class in terms of anything more than observed behavior in context. Common reports of correlations between emergences of untrained stimulus functions in multiple contexts as well as the current results that the development of common stimulus functions was highly correlated with the emergence of untrained shared functions in a second context, show that stimuli equivalent in one context are frequently equivalent in additional contexts. However, frequent reports of the dissociation between these performances should caution us from seeing equivalence as a unified, integrated given rather than as a correlation of discriminated operants requiring explanation in their own right (Pilgrim and Galizio, 1996). Although particular reinforcement histories with given sets of stimuli, appropriate test context, and the absence of interfering stimulus control topographies, may set the stage for the demonstration of equivalence, until we have identified, manipulated and isolated the contributions of these (and, perhaps, other) important variables, we cannot safely say more.

APPENDIX

Participant:___________
Date:__________

1) Did you use strategies to approach the task? If you did, describe them.

2) Did you create names for the symbols? If you did, describe them.

3) How did you think you were supposed to respond?

4) What do you think the experiment was about?

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