CONDITIONAL DISCRIMINATION AND STIMULUS EQUIVALENCE: EFFECTS OF SUPPRESSING DERIVED SYMMETRICAL RESPONSES ON THE EMERGENCE OF TRANSITIVITY

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Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

May 2007

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Jones, Aaron A. *Conditional discrimination and stimulus equivalence: Effects of suppressing derived symmetrical responses on the emergence of transitivity*. Master of Science (Behavior Analysis), May 2007, 65 pp., 5 tables, 11 figures, references, 21 titles.

Symmetry suppression was conducted for five subjects who demonstrated a tendency to derive equivalence relations based on conditional discrimination training in a match-to-sample procedure. Symmetry suppression was applied in three consecutive sessions in which symmetrical responses were suppressed for one stimulus class in the first condition, two stimulus classes in the second condition, and all three stimulus classes in the final condition. Symmetry suppression slowed the emergence of transitivity for two subjects and prevented it for the other three. Results indicated that unplanned features of stimulus configurations emerged as discriminative variables that controlled selection responses and altered the function of consequent stimuli. Disruption of cognitive development by conflicting contingencies in natural learning environments is discussed.

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CHAPTER 1

INTRODUCTION

Purpose

In a typical stimulus equivalence preparation, conditional discriminations are trained between sample stimuli (A1, A2, or A3 designated as Set A) and two sets of comparison stimuli (B1, B2, and B3 as well as C1, C2, and C3 designated as sets B and C). Subjects learn to select B1 or C1 when A1 is the sample, to select B2 or C2 when A2 is the sample and to select B3 or C3 when A3 is the sample. Following training, untrained (derived) stimulus relations typically emerge. One derived relation, symmetry, is shown when stimuli from set B or C are presented as samples and A stimuli as comparisons. When subjects reliably select (in the absence of programmed consequences) comparison A1 when B1 is the sample, A2 when B2 is the sample, and so forth, the relations between A and B stimuli are called *symmetrical*. *Transitivity* is demonstrated when B stimuli are presented as samples and subjects select the designated comparisons from an array of C stimuli, and when C stimuli are presented as samples and subjects select the designated comparisons from an array of B stimuli. When both symmetry and transitivity among the stimuli of the 3 sets are demonstrated, *equivalence* is said to exist among the associated stimuli from the different sets, and those associated stimuli are said to be members of an *equivalence class* (Sidman & Tailby, 1982).

This phenomenon has implications for understanding the behavioral processes involved in human language and cognition (Hayes, 1991; Sidman, 1994; Hayes, Barnes-Holmes & Roche, 2001). According to Hayes et al. (2001), humans learn to relate stimuli in specific ways, resulting in “relational frames” of coordination, opposition, and comparison. In typical language training scenarios, humans learn frames of coordination first. When parents teach infants language, they train a series of relations in which the same or similar stimuli are related to one another in different ways. A typical scenario might go as follows: The parent holds a doll up to the child and says "*doll*." The child repeats the word *doll* and the parent reinforces the imitation. In this situation, the child learns to emit the word *doll* in the presence of the object. Concurrently, her parent teaches her to look at, touch, or retrieve her doll when they ask *Where is your doll?* At this point the child has been directly taught the A to B relation as well as the B to A relation between the two stimuli. According to Hayes et al. (2001) this type of training occurs naturally in the social environment, producing multiple stimulus classes. Procedurally, this arrangement amounts to a kind of distributed conditional discrimination training. This may be as close as unplanned, real-world training gets to the "match to sample" experimental procedure in which children are taught multiple A to B relations as well as B to A relations. Eventually a generalized operant unit emerges (i.e., a "frame of coordination") so that when a new relation is trained ("given A, select B"), the subject derives *without training* "given B, select A."

Note that the training described above is accomplished in two parts. The first part was when the parent taught the child to say "doll" (thus producing the auditory stimulus *doll*) when showing the child a doll. The second part was when the parent reinforced the selection of the doll when the parent said "doll." Now, imagine that the child's French-speaking mother teaches her to point to, look at or retrieve her doll when she asks the child "*Où est votre poupée?*" [Where is your doll?] and teaches her also to say "*poupée*" when she holds up her doll and says "*Qu'est-ce que c'est*?" [What's this?] At this point, the child has been taught two separate sets of relations that can be called "symmetrical" but has not yet demonstrated symmetry as an emergent relation evidencing that a generalized "frame of coordination" has been acquired. That will be demonstrated when the child is taught to say the name of an object (in either French or English) and then later (without teaching) points to, looks at, or retrieves that object when the parent says its name in the trained language. Does this indicate that the child knows that *poupée* means *doll*?

Sidman's (1971) original work that started this line of research came from efforts to teach reading comprehension to an individual with mental retardation. In that study, a developmentally disabled subject was taught to match spoken words (A) to pictures (B) and spoken words (A) to printed words (C). Without direct training, the subject was also then able to match printed words (C) to pictures (B) and printed words (C) to spoken words (A). Thus it is predicted that when asked "What is another word for doll?" the child would say "*poupée*," and vice versa, thus demonstrating that the verbal stimuli *poupée* and *doll* are equivalent, even though this relation has never been taught.

Because of this automatic proliferation of untrained stimulus relations, equivalence has been considered to be involved in a variety of examples of complex human behavior including induction, intellectual development and functioning, symbolic representation, creativity, and meaning (Sidman, 1994). As a key concept within the broader topic of Relational Frame Theory, equivalence has also been applied to theoretical analyses of rule-governance, social and group behavior, psychopathology, religion, spirituality, concepts of self, and more (Hayes et al., 2001). It is perhaps because of the hope of devising an experimental analysis of complex psychological process, such as those involved in human cognition, that behavior analysts have devoted decades of research to stimulus equivalence and to exploring the functional nature of derived stimulus relations. The considerable amount of research on stimulus equivalence has led to some general conclusions about the phenomenon, but a definitive understanding is still lacking.

Questions still linger, for example, regarding the emergence of equivalence relations. Do stimulus relations emerge prior to the presentation of trials to test for equivalence? Responses indicative of equivalence have been shown to emerge based on the conditional discriminations originally taught, even when the differential reinforcement contingencies applied to the original conditional discriminations are reversed prior to testing (Saunders, Saunders, Kirby, and Spradlin, 1988). Other researchers (McIlvane & Dube, 1990; Vaidya, 1994) have pointed out that the presumption that stimulus relations exist prior to testing cannot be demonstrated empirically since the tests are required to confirm that the relations have emerged. However, following conditional discrimination training, subjects often engage in responses indicative of equivalence with few or no errors immediately upon the introduction of test trials. A closer analysis of the development of untrained conditional control is warranted. Although the operant response of selecting a comparison stimulus is necessary to demonstrate how stimuli in an array control the selection response, it is feasible to consider that subjects do a considerable amount of covert weighing, considering, deciding and final selecting before they finally emit the observable operant response. The often considerable length of time subjects spend prior to making their selection (Touchette, 1971; Vaidya, 1994) suggests that a great deal of (covert) discriminated behavior occurs prior to the overt response.

The study of cognition as a phenomenon of stimulus equivalence has typically focused on demonstrating operant characteristics of cognition by establishing and expanding stimulus classes. For example, Sidman (1994) described a study in which he and his colleagues demonstrated that by training 15 conditional discriminations, 60 additional untrained relations emerged. Sidman termed this “a veritable explosion in the size of a subject’s repertoire of conditional discrimination” (p. 230), and went on to describe how the original enthusiasm over stimulus equivalence came from the success with teaching individuals who were previously considered unteachable to reliably demonstrate mastery with a task as complex as reading.

Some subsequent research, however, has investigated variables that might alter the typical development of emergent stimulus relations. Healy, Barnes-Holmes, and Smeets (2000) delivered accurate and inaccurate feedback for symmetrical and transitive responses. When inaccurate feedback (feedback that was inconsistent with the predicted emergent relation) was delivered, subjects' responses followed the feedback (reinforcement) for those responses in opposition to the direction of the predicted emergent relations. These outcomes support Sidman's (1994) assertion that testing for emergent relations must be conducted under extinction (no programmed consequences on test trials). The method used in Healy et al. (2000) functionally converted test trials into conditional discrimination trials when feedback was applied.

Pilgrim and Galizio (1990; 1995) altered the predicted derivation of stimulus relations by reversing the originally trained relations (i.e., A1 to C1 was originally trained and then A1 to C2 was trained). Similar to Saunders et al. (1988), the originally trained relations and the symmetrical relations proved sensitive to changes in direct contingencies. Transitive relations, however, tended to remain consistent with the original conditional discrimination training.

Another clever alteration of the predicted emergence of relations was conducted by Peuster (1995) in which subjects lost points for making the correct symmetrical response in two of three contexts. Subjects received conditional discrimination training with stimulus classes containing figures composed of thick lines, figures composed of thin lines, and figures composed of lines and shaded polygons. The three different types of figures constituted the three different contexts. Following conditional discrimination training, subjects lost points for making the correct symmetrical response in the thick line and shaded polygon contexts. Under these conditions, symmetrical and transitive responses occurred less frequently in all three contexts.

These studies, while tampering with the emergence of equivalence classes in the typical manner, have maintained the integrity of the generalized class of responding. That is, after the following relations are trained: A1→B1, A2→B2, A1→C1, and A2→C2, contingencies are then reversed such that the subject must respond according to A1→B2, A2→B1, A1→C2, and A2→C1. The same original relations on all stimulus classes are reversed and performances simply follow the new contingencies. What if, then, after learning the same original conditional discriminations listed above, the new contingencies retrain relations on just one stimulus class? In this case, the contingencies would be arranged to train A1→B1, A2→B2, A1→C1, and A2→C2, as well as B1 to NOT A1, and C1 to NOT A1, and the relations between stimuli in Class 2 are left alone. With only two-member stimulus sets, "B1 to NOT A1" is equivalent to "B1 to A2," so a third stimulus must be added to each set (Sidman, 1987). If the disruption is only applied to the emergent symmetrical relations between stimuli in Class 1, what would be the effect on emergent relations between stimuli in Classes 2 and 3?

The experiment reported here was designed to determine the effect of disrupting the emergence of symmetry—first in one stimulus class, then in two stimulus classes, and finally in all three stimulus classes—on transitive relations for participants who have demonstrated generalized frames of coordination (equivalence) in the experimental setting. The main dependent variable in this study was the formation of transitive relations among stimulus classes. The independent variable was the extent to which symmetrical responding was followed by a putative aversive stimulus. It was expected that at some point, the proposed generalized frame of coordination would break down, evidenced by failure of transitivity to emerge.

CHAPTER 2

METHOD

Subjects

Five subjects were recruited from undergraduate classes at the University of North Texas. Students were compensated with extra credit points for participation in the study. Students were required to complete the study to receive extra credit. Each subject completed four experimental sessions of approximately one to two hours in length depending on each individual's rate of acquisition. Subjects normally completed one session per day.

Setting and Apparatus

Sessions were conducted in a small observation room in the Department of Behavior Analysis at the University of North Texas on an Apple computer running Pascal-based match-to-sample software (MTS v11.6.7). Experimental stimuli were presented on the computer screen and subjects used a one-button mouse to interact with the stimuli. A different set of 9 abstract, black and white, computer-generated line drawings, designated by the experimenter as A1, A2, A3, B1, B2, B3, C1, C2, and C3 were used in four separate conditions as described below. A sample of these stimuli is included in Appendix A.

Procedure

Subjects participated in four experimental session of a maximum of 2 hours each. In those sessions, subjects were exposed to 4 conditions of training and testing, one condition for each session. This is a departure from typical equivalence research in which the same condition continues for several sessions until the subject reaches some predetermined criterion. In this study, sessions continued for a predetermined number of trials (to be described below) or until 2 hours had elapsed. Thus, the words *condition* and *session* can be used interchangeably when describing these procedures.

A match-to-sample (MTS) format was used to train conditional discriminations (e.g., A1-B1, A2-B2, A3-C3, etc.) among novel stimulus sets for each separate condition. Four different trial types were used to present experimental stimuli and consequences. Whereas training trials with original relations typically are presented until subjects demonstrate the conditional demonstrations, and are then followed by probe trials (with or without original relations trials interspersed). All four trial types were presented throughout each condition in the current study (with the exception of Condition 1 in which symmetry suppression trials were not presented, and Condition 4 in which symmetry probe trials were not presented). Trial types were presented quasi-randomly to minimize consecutive presentations of any particular stimulus or trial type. The trial types presented in this study were as follows:

Original relations trials: On each trial, a sample stimulus (e.g., A1) appeared in the middle of the screen. Subjects emitted an observing response by clicking on the sample stimulus which caused three comparison stimuli (e.g., B1, B2, B3) to appear, randomly positioned, in a row across the bottom of the screen. Subjects selected a comparison stimulus by clicking on one of them. Following correct responses (e.g., selecting B1 in the presence of A1), all experimental stimuli disappeared, the word CORRECT was displayed in the middle of the screen for 1 s, and two short tones played from the computer's speakers. Following an incorrect response (e.g., selecting B2 or B3 in the presence of A1), all experimental stimuli disappeared, the word WRONG was displayed in the middle of the screen for 1 s, and a brief buzz sound played. The next trial began after a 1.5 s inter-trial interval which reset if the subject clicked the mouse before the next sample stimulus appeared.

Symmetry probe trials: Symmetry probe trials were included to test the extent to which symmetrical relations emerged based on original relations training. Probe trials were similar to original relations trials except for the configuration of the stimuli and the programmed consequences. On each trial, a B or C stimulus appeared in the middle of the screen as the sample stimulus. Following the observing response, all 3 A stimuli appeared in a row across the bottom of the screen. Subjects clicked on one of the A comparison stimuli. All stimuli then disappeared and a new trial started after an inter-trial interval of 1.5 s. No programmed consequences were delivered for responses on symmetry probe trials.

Transitivity probe trials: Transitivity probe trials were included to test the extent to which transitive relations emerged based on original relations training. Transitivity probe trials operated identically to symmetry probe trials. On each trial, either a B or C stimulus was displayed in the middle of the screen. If the sample stimulus was a B stimulus, clicking on it caused the C comparisons to appear in a row across the bottom of the screen. If the sample stimulus was a C stimulus, clicking on it caused the B stimuli comparisons to appear in a row across the bottom of the screen. Subjects responded by clicking on one of the comparison stimuli. All stimuli then disappeared and a new trial started after an inter-trial interval of 1.5 s. No programmed consequences were delivered for responses on transitivity probe trials.

Symmetry suppression trials: Symmetry suppression trials were designed to interfere with the typical derivation of symmetry following match-to-sample training. Symmetry suppression trials also provided a measure of the extent to which subjects derived symmetrical relations. Symmetry suppression trials were identical to symmetry probe trials except that a symmetry suppression procedure (SSP) was applied to the stimulus classes scheduled for suppression. SSP trials operated as follows: if subjects selected the correct symmetrical stimulus (e.g., selecting A1 comparison in the presence of B1 sample), all stimuli disappeared and the same buzz sound delivered for incorrect responses on the original relations trials was played from the computer's speakers. If the subject selected an incorrect symmetrical stimulus (e.g., selecting A2 or A3 in the presence of B1), no programmed consequence was delivered and the trial appeared no different to the subject than a symmetry probe trial.

Condition 1. Condition 1 served as a qualifying condition. Subjects who learned the conditional discriminations and demonstrated equivalence in this session were invited to continue through the rest of the experiment. When the session began, the following instructions appeared on the screen:

> In this experiment, you will learn to match shapes to each other. When you see a shape in the middle of the screen, click it. Three shapes will appear at the bottom of the screen. Choose one by clicking on it and the computer will give you feedback on your choice. Click the button when you are ready to begin.

Subjects were exposed to conditional discrimination training on 6 MTS original relations trial types to train the following stimulus relations: A1→B1, A2→B2, A3→B3, A1→C1, A2→C2, and A3→C3. Stimuli were presented in blocks of 18 trials. Each sample stimulus was presented in three different trials to equalize and randomize the positions of the correct comparison stimuli on the screen. These trial blocks, each differently randomized to prevent order or placement bias, were repeated until subjects made at least 15 correct responses in a trial block. When subjects completed 15 correct responses in a trial block, the following instructions were displayed and the session continued:

> Great job! Let's keep going. Next, you will continue matching the same shapes, but in this section, sometimes the computer will give you feedback and sometimes

> it will not. When this happens, the computer is just testing what you've learned. Click the button when you are ready to continue.

In this section of Condition 1, trial blocks also included 18 transitivity probe trials quasi-randomized and interspersed with the original relations trials. These 36 trials were presented in 6 trial blocks, again differently randomized to prevent order or placement bias. When subjects completed 9 of 18 correct responses on transitivity probe trials, the program delivered the following instructions and continued to the next section of Condition 1:

> You're doing great! One section to go. Just keep doing what you've been doing. Click the button when you're ready to continue.

In this final section, trial blocks included 18 symmetry probe trials in addition to the original relations trials and transitivity probe trials presented in the previous section. After subjects completed a trial block in which they selected the correct response on all 18 original relations trials, the program ended and the first session was complete. Subjects who did not reach this point in Condition 1 within 2 hours were dismissed because subsequent conditions could not be implemented unless subjects' response patterns demonstrated some degree of equivalence following conditional discrimination training. Note that the criterion of 50 % correct responses on transitivity probe trials was used only to advance the session to the final section. The 50 % criterion was not intended to serve as evidence that subjects demonstrated equivalence. This was determined by examining their performance on transitivity probe trials, symmetry probe trials, original relations trials at the end of the session

Conditions 2 through 4. Symmetry suppression trials were introduced in Conditions 2 through 4. In Condition 2, symmetry probe trials for Stimulus Class 1 (Stimuli A1, B1, and C1) were replaced with symmetry suppression trials. This left 12 stimulus probe trials for Stimulus Classes 2 and 3. Because simply replacing probe trials with suppression trials would result in 6 symmetry suppression trials out of a total of 54 trials (11.1%) in each block, the number of symmetry suppression trials was doubled resulting in a trial block of 60 trials, of which 18 (30%) were original relations trials, 18 (30%) were transitivity probe trials, 12 (20%) were symmetry probe trials, and 12 (20%) were symmetry suppression trials. Thus, symmetry probe trials constituted a significant proportion of the trial block.

In Condition 3, symmetry probe trials for Stimulus Classes 1 and 2 (Stimuli A1, B1, C1, A2, B2, and C2) were replaced with symmetry suppression trials. This left 6 stimulus probe trials for Stimulus Class 3. Each trial block consisted of 66 trials, of which 18 (27.3%) were original relations trials, 18 (27.3%) were transitivity probe trials, 6 (11.1%) were symmetry probe trials, and 24 (36.4%) were symmetry suppression trials.

In Condition 4, symmetry probe trials for all three stimulus classes (Stimuli A1, B1, C1, A2, B2, C2, A3, B3, and C3) were replaced with symmetry suppression trials. Each trial block consisted of 72 trials, of which 18 (25%) were original relations trials, 18 (25%) were transitivity probe trials, and 36 (50%) were symmetry suppression trials. Table 2.1 summarizes the experimental changes in symmetry trials in each condition. See Appendix B through D for a complete list of nonrandomized trial configurations for each condition.

Table 2.1

Schedule of Symmetry Probe and Suppression Trials

Symmetry Relations	Cond 1	Cond 2	Cond 3	Cond 4
B1 → A1	P	W	W	W
B2 → A2	P	P	W	W
B3 → A3	P	P	P	W
C1 → A1	P	W	W	W
C2 → A2	P	P	W	W
C3 → A3	P	P	P	W

Note: P = Symmetry probed; W = Symmetrical response produced BUZZ sound

Each trial block, with quasi-randomized order of configurations, was presented twice in each session. Thus, Condition 2 was conducted in a single session that included 720 trials, Condition 3 was conducted in a single session that included 792 trials, and Condition 4 was conducted in a single session that included 864 trials. No completion criteria were defined for Conditions 2 through 4. The goal of these conditions was to observe the emergence of stimulus relations. Different results may be obtained by extended exposure to these contingencies, but this was not the focus of the present study. Therefore, the same amount of time (2 hours) available in Condition 1 was provided in subsequent conditions, and enough trials were included in each condition to approximately fill this amount of time. Sessions for Conditions 2 though 4 each began with the following instructions:

> In this session, you will learn to match shapes to each other, but they will be new shapes that you haven't seen before. When you see a shape in the middle of the screen, click it. Three shapes will appear at the bottom of the screen. Choose one by clicking on it and the computer will give you feedback on your choice. Sometimes the computer will not give you feedback. When this happens, the computer is just finding out what you've learned so far.

Due to limitations of the MTS software, the buzz sound, but not the word WRONG, could be delivered as a consequence for correct responses on symmetry suppression trials. Therefore, the instructions presented at the beginning of each session also included the following statement:

> You may notice sometimes that you hear the BUZZ sound but the word “WRONG” does not appear. When this happens, keep in mind that the BUZZ sound still means "WRONG" even if the word doesn't appear. Press the continue button when you are ready to begin.

The experimenter remained in the room while the subject read the instructions to reread portions of the instructions if necessary. When subjects clicked continue, the experimenter left the room and the session began.

CHAPTER 3

RESULTS

Two sets of data are presented for each subject. Each set of data includes 12 graphs laid out in 4 rows and 3 columns. Each row corresponds to one of the conditions in the experiment ordered from Condition 1 in the first row through Condition 4 in the fourth row. The first set of 12 graphs presents percentage of correct responses per trial block on all trials for each trial type. The data are separated into two categories: experimenter-designated stimulus classes for which SSP trials were presented, represented by the black bars; and experimenter-designated stimulus classes for which SSP trials were not presented, represented by the white bars. Note that SSP trials were not included for any stimulus class in Condition 1, and the SSP was applied to all three stimulus classes in Condition 4. The column on the left shows percentage of correct responses per trial block on original relations trials for each condition. The middle column of the first set of 12 graphs for each subject shows percentage of correct responses per trial block on symmetry suppression trials and symmetry probe trials for each condition. Recall that a “correct” response on a symmetry suppression trial resulted in a buzz sound indicating to the subject that the response was incorrect. The column on the right of the first set of 12 graphs shows percentage of correct responses per trial block on transitivity probe trials for each condition.

The second set of data for each subject presents the latency to select one of the 3 comparison stimuli after the subject clicked on the sample stimulus on each trial. As with the data on percentage of correct responses per trial block, these data are arrayed across 4 rows, one for each condition. The left column includes original relations trials, the middle column includes symmetry suppression and probe trials, and the right column includes transitivity probe trials. The colors used for data points follow the same convention as for data paths representing percentage of correct responses per trial block (described above). The y-axis uses a logarithmic scale to reveal small variances in latencies in data sets that include extreme outliers. For ease of comparison, the y-axis scale on all latency graphs is set to a maximum of 100 seconds and a minimum of .1 second.

The first row of graphs in Figures 1, 3, 5, 8, and 10 presents percentage of correct responses per trial block for each subject in Condition 1. Performances in Condition 1 were similar for all subjects. Selection of the experimenter-designated correct response occurred on original relations trials at a steadily increasing frequency throughout the session. Correct responses on symmetry probe trials began to occur as soon as those trials were introduced in the session, and continued throughout the remainder of the session. A delayed emergence of correct responses on transitivity probe trials was observed for all subjects. Subjects 1, 2, and 3 completed Condition 1 with correct transitive responses on over 90 % of transitivity probe trials. Subjects 4 and 5 completed condition 1 with correct transitive responses on over 80 % of transitivity probe trials.

Latencies on original relations trials (Figures 2, 4, 6, 9, and 10) tended to decrease over the course of Condition 1 for all subjects, and the introduction of transitivity probe trials noticeably enhanced this shortening of latencies on original relations trials for Subjects 1, 3, 4 and 5. In addition, less variability in original relations latencies was observed for Subject 5 after transitivity probes were introduced. The changes in latencies to select comparison stimuli on original relations trials as a function of the introduction of transitivity probe trials suggests that the transitivity probe trials did not serve merely as test trials to assess derived relations, but that they contributed to learning of original relations as well.

S1. The expected effect of SSP trials was an interference in the derivation of transitive relations. It is apparent from this subject's performance (Figure 1), however, that the SSP also affected acquisition of the original conditional discriminations. Acquisition of the original relations for this subject appeared unaffected for stimulus classes without SSP trials; however, acquisition of the original relations for the stimulus class to which SSP was applied failed to occur for the first half of the session. Acquisition of the original relations on the suppressed stimulus class appeared to occur around the 6^{th} trial block, although less consistently than the same performance on the stimulus classes without SSP trials. Transitive relations failed to emerge for S1 in Condition 2 on the stimulus class for which SSP trials were presented. Although transitive relations appeared to be forming within the remaining two stimulus classes during the first half of the session, transitive responding ceased on those classes at the same point at which acquisition of the original relations on the stimulus class to which SSP was applied began to occur. Another unexpected feature of the subject's performance was the selection of the experimenter-designated correct response on symmetry suppression trials prior to demonstration of the original relations. S1 continued to frequently select the correct response on these trials throughout the session. Correct responses on symmetry probe trials followed the same pattern, and then ceased at around the 6^{th} trial block, the same point at which acquisition of the original relations on the stimulus class to which SSP was delivered began to occur. S1 demonstrated almost the same pattern of acquisition and derivation in Condition 3 with the following differences: acquisition of the original relations occurred at near identical frequencies on stimulus classes with and without SSP trials; correct responses on symmetry probe trials

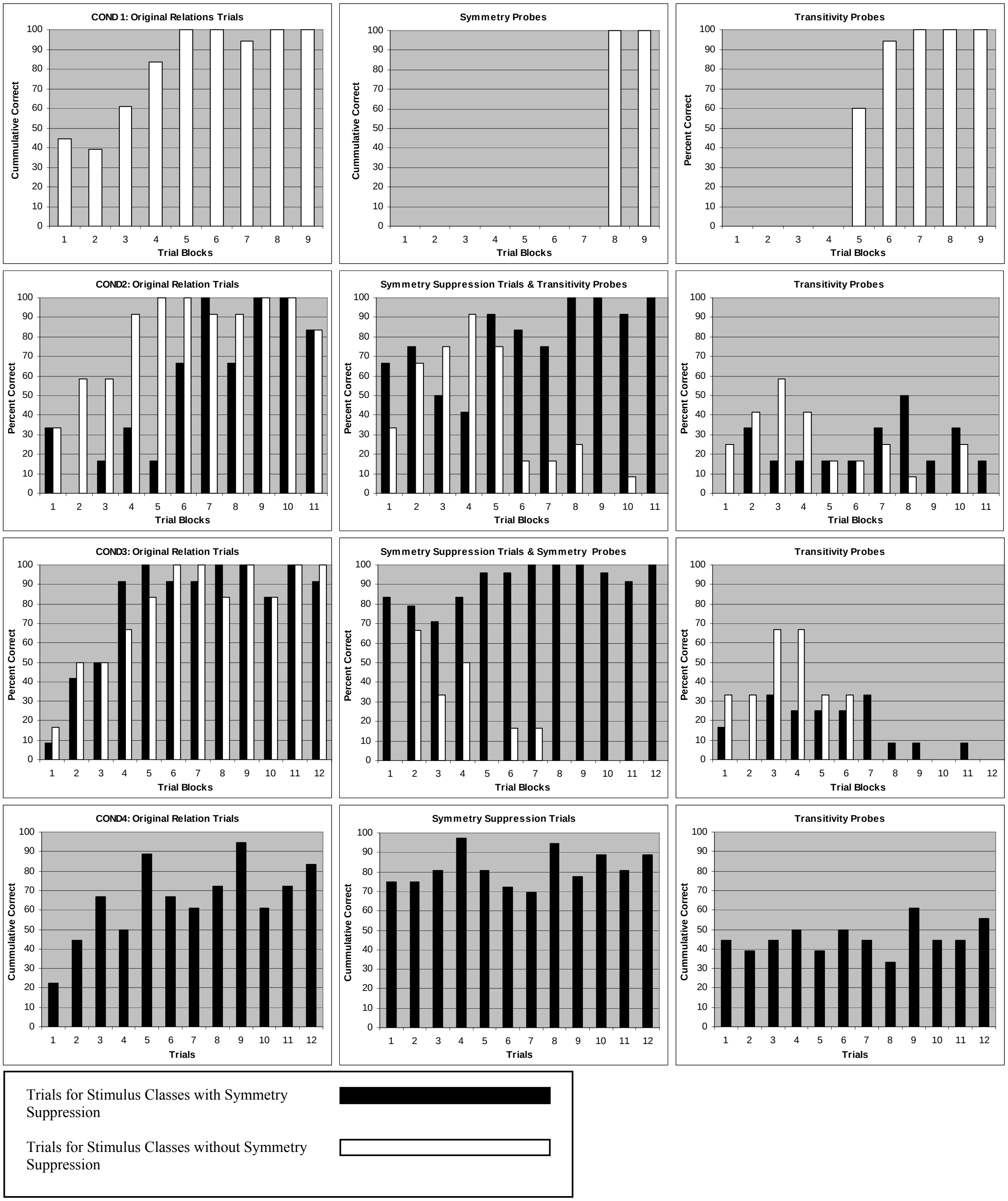


Figure 1. S1: Percentage of correct responses per trial block on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

ceased much earlier in the session although a few correct responses occurred sporadically until about the midpoint of the session; and correct responses on symmetry suppression trials occurred at a higher and more consistent frequency than in Condition 2.

In Condition 4, SSP was applied to all stimulus classes and performances were relatively smooth and consistent for all trial types. This pattern was seen for all subjects in Condition 4 and was perhaps due to the consistency of application of the suppression procedure. Following a positively accelerating period of acquisition, S1 continued to select the experimenter-designated correct response on original relations in Condition 4 at a high frequency. Correct responses on symmetry suppression trials occurred prior to acquisition of the original relations. Significantly more correct responses occurred on transitivity probe trials in Condition 4, but still not at a high enough frequency to conclude that transitivity emerged within the designated stimulus classes. Selection responses on transitivity probe trials were allocated equally across comparison stimuli.

Latency data for S1 (Figure 2) on original relations trials shows generally shorter latencies on stimulus classes without SSP trials. There was no trend in these data for S1, revealing that across Conditions 2, 3, and 4, S1 spent more time than in Condition 1 acquiring the original relations, probably due to interference by the suppression procedure. Further evidence that the suppression procedure was responsible for this effect is suggested by the increasing trends in latency data for both symmetry and transitivity trials in Condition 2. This trend reversed in Conditions 3 and 4 where latencies of all trial types decreased, which is consistent with the general trend for all subjects in the study.

S2. This subject's data do not show strong evidence of derived relations based on conditional discrimination training in any experimental condition after Condition 1. First, the

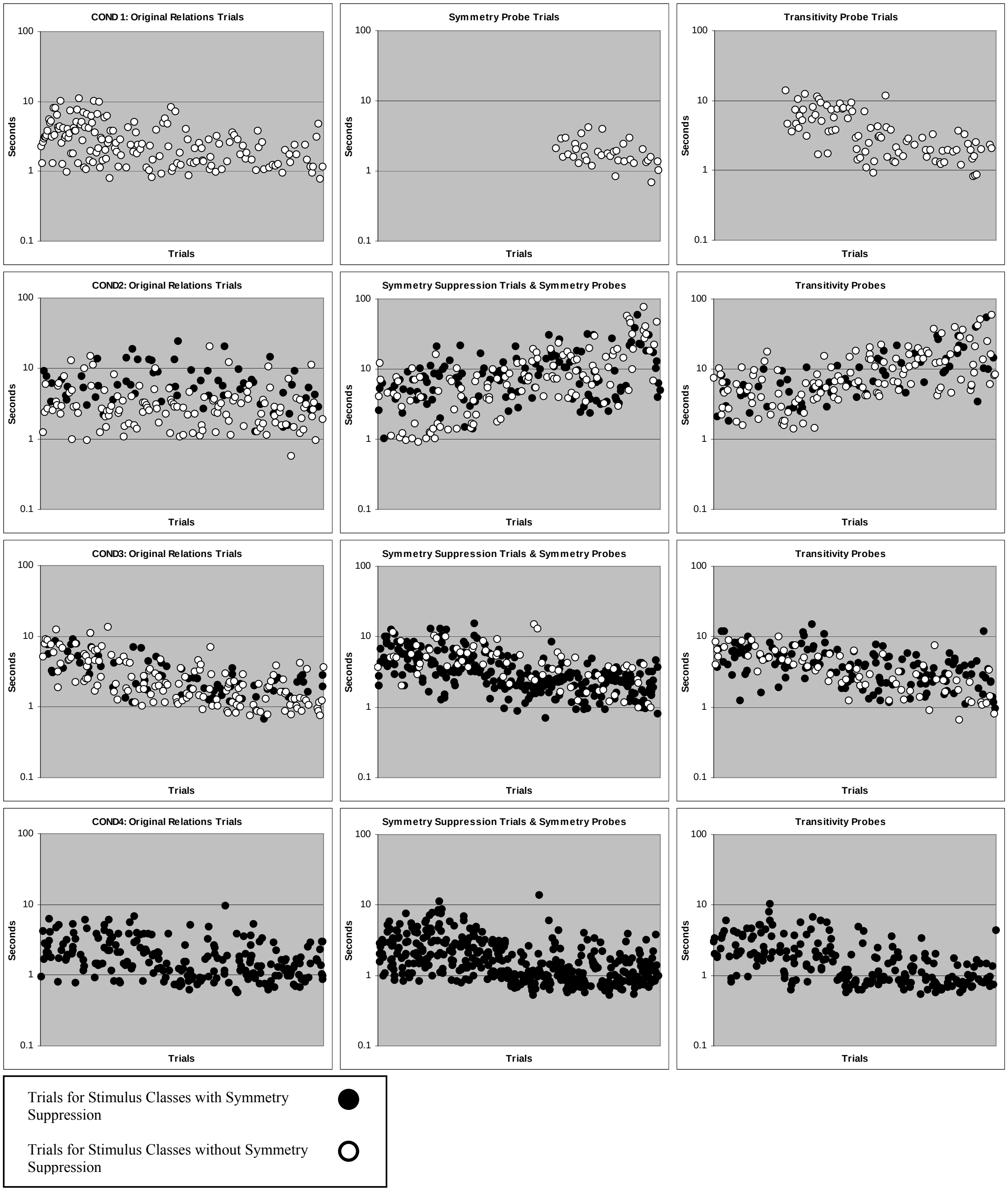


Figure 2. S1: Latency to respond on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

data do not show similar patterns of acquisition of original conditional relations in comparison to the acquisition demonstrated during Condition 1 (Figure 3). Inspection of the raw data revealed that the subject allocated responses equally across the three comparison stimuli on original relations trials, resulting in correct responses occurring on approximately a third of the trials.

Transitive relations also failed to emerge in comparison to the subject's performance in Condition 1. Responses were allocated roughly equally across all three comparison stimuli on these trials types as well. S2 selected the experimenter-designated correct response on symmetry suppression trials at a relatively high frequency. Correct responses on these trials occurred before correct responses on original relations trials, providing a third rationale for the conclusion that derived relations based on original relations were not demonstrated by this subject. Most latencies (Figure 4) were less than 2 s for all trial types, following some variability at the beginning of Condition 2. This was significantly shorter than the 1 to 6 s range that was common in Condition 1 where original relations were acquired and derived symmetrical and transitive relations were observed.

S3. The symmetry suppression procedure did not appear to substantially affect acquisition of the original relations for Subject 3 (Figure 5). Some interference is evident in Condition 2, but Subject 3 clearly learned the original relations in Conditions 2, 3, and 4 regardless of symmetry suppression. Correct responses on symmetry trials began to occur prior to the acquisition of original relations with a slightly higher frequency of correct responses on symmetry suppression trials. Finally, some evidence of transitivity is available in conditions 2 and 3, but transitivity failed to emerge in Condition 4 even though both original relations and symmetrical responses occurred at extremely high frequencies.

S4. Performances were sporadic and inconsistent for S4 in Condition 2 on all trial types

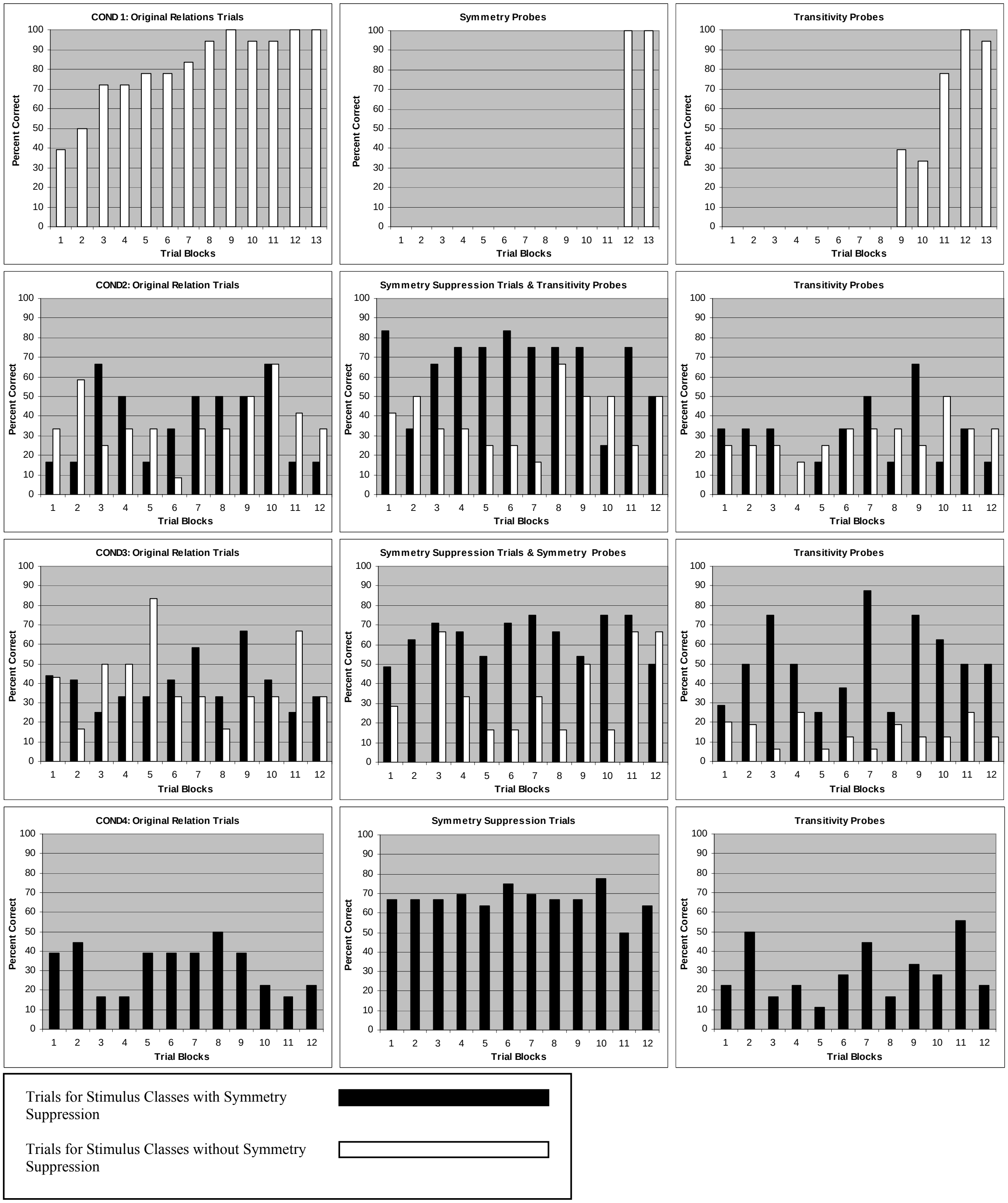


Figure 3. S2: Percentage of correct responses per trial block on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

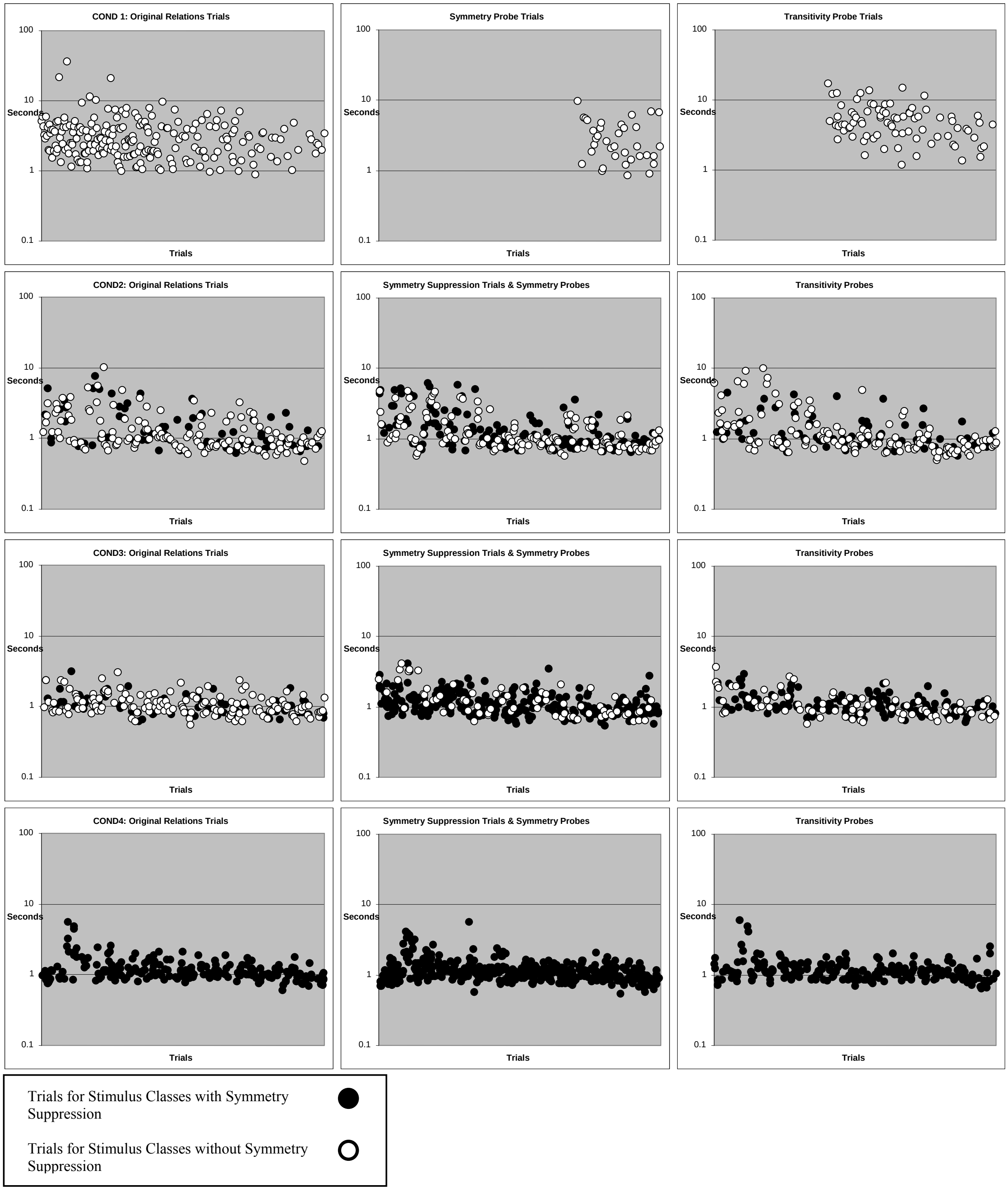


Figure 4. S2: Latency to respond on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

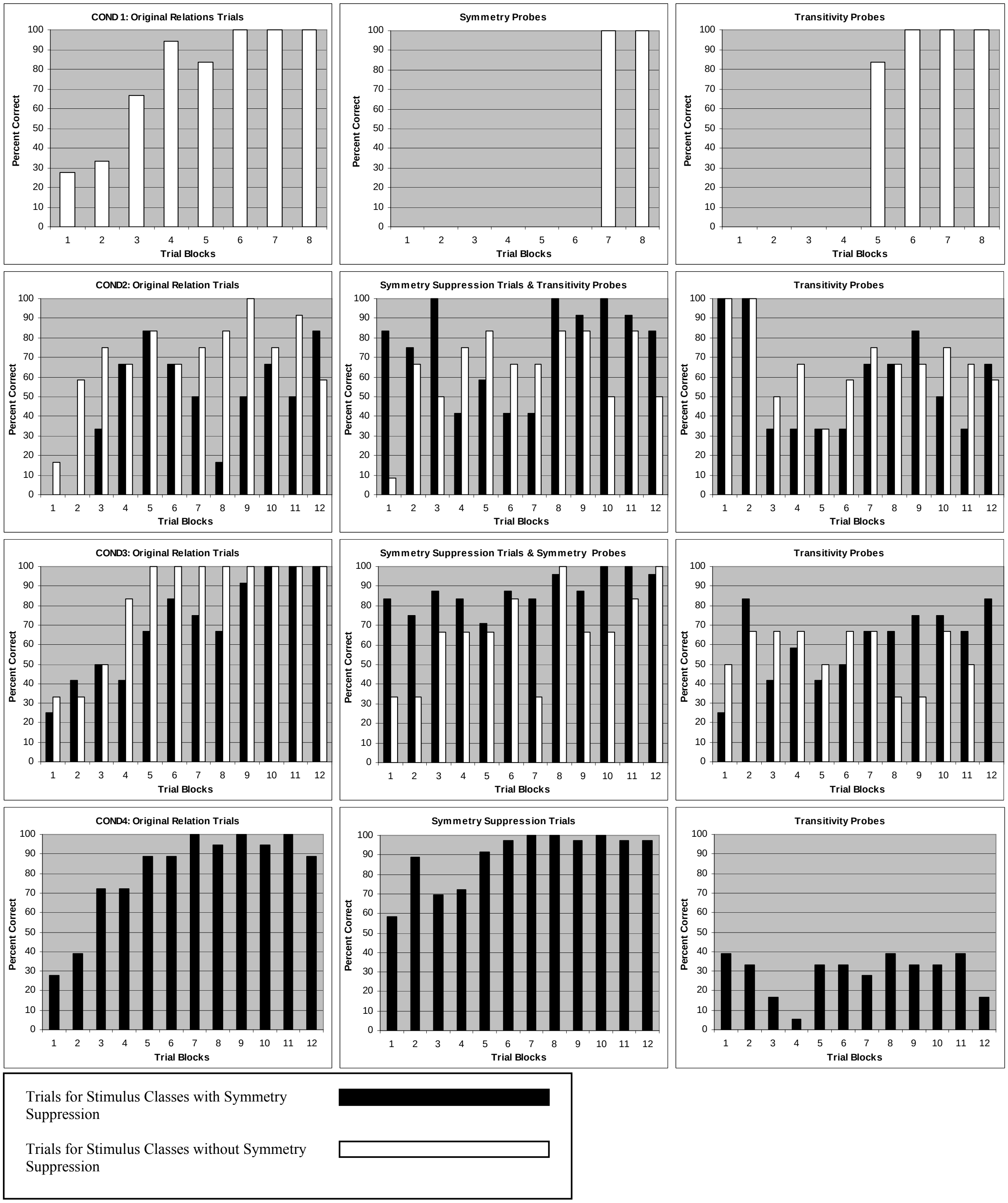


Figure 5. S3: Percentage of correct responses per trial block on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

(see Figure 8). More regularity is apparent in Condition 3 original relations trials for stimulus classes for which SSP was delivered. Transitivity still failed to emerge in Condition 3. A much different performance characterizes Condition 4. Correct responses on transitivity probe trials began to occur early and continued throughout the session in spite of relatively lower frequencies of correct responses on original relations trials and symmetry suppression trials. The high frequency of correct responses on transitivity probe trials cannot be interpreted as transitivity without a demonstration of accuracy on original relations trials upon which transitivity would be based. Thus, variables other than equivalence must account for the acquisition and maintenance of experimenter-designated correct responses on transitivity probe trials.

Latency data for Subjects 3 and 4 (Figures 6 and 9) were similar with one exception. Latencies on original relations trials in Condition 2 for Subject 3 decreased to less than 4 s at around trial 325 and remained at that level for the remainder of the session. Latencies tended to be longer on original relations trials for stimulus classes for which SSP was presented than on trials for stimulus classes without SSP trials. A large proportion of the original relations trials for stimulus classes without SSP appear to have latencies of just under 1 s. Other selection responses on these trials occurred over a range of latencies from about 1.5 s to almost 4 s. Figure 7 shows that this separation fell out across the two stimulus classes without SSP trials. The corresponding data for S2 are included for comparison. S2 also showed some apparent difference in latencies for some original relations trials on stimulus classes without SSP, however, the difference in latencies was not associated with particular stimulus classes as it apparently was for S3.

S5. Correct responses on all trial types for this subject (Figure 10) occurred at a high frequency throughout each condition. Unlike the other 4 subjects, SSP trials appeared to have no

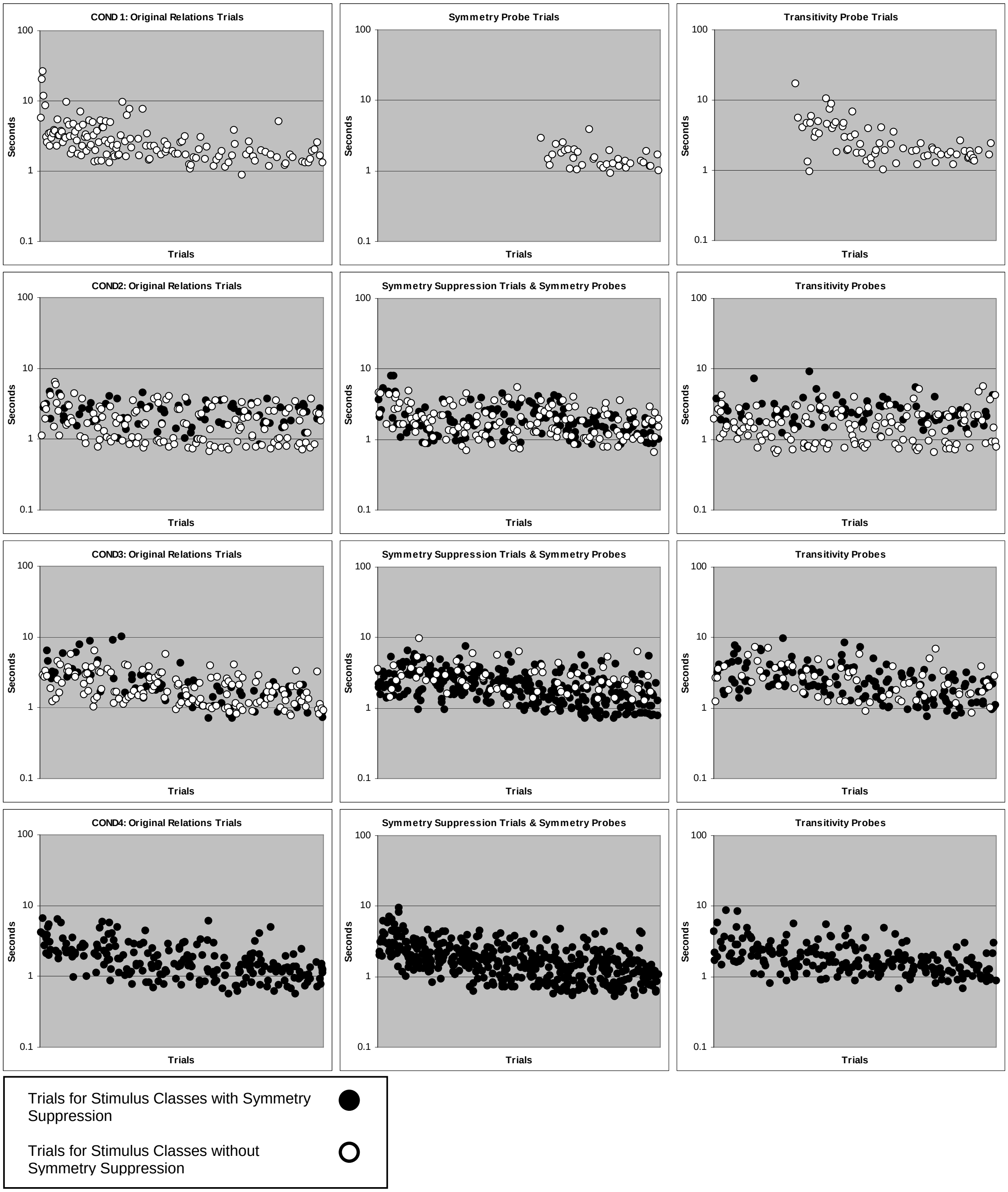


Figure 6. S3: Latency to respond on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

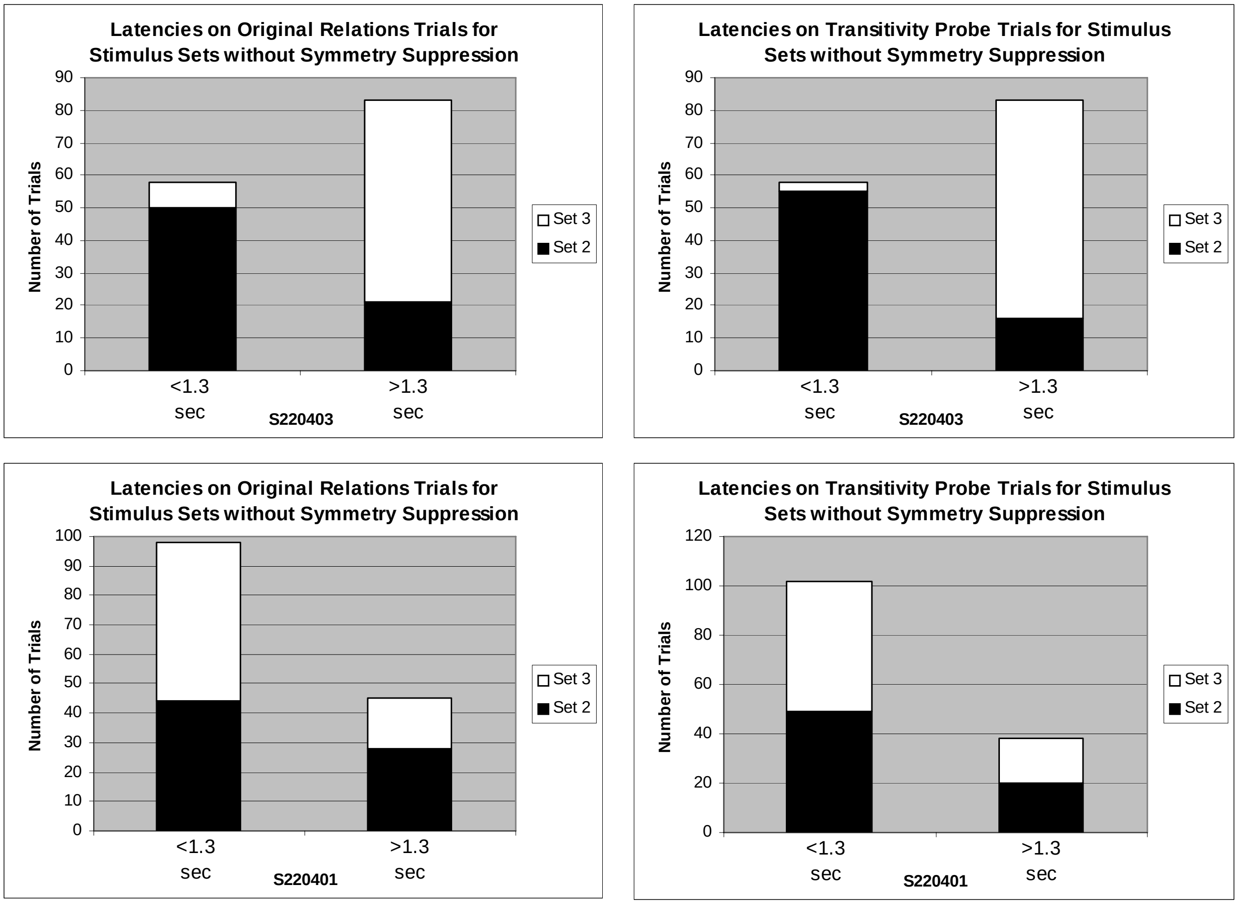


Figure 7. Latencies greater than and less than 1.3 seconds on original relations trials for stimulus sets without symmetry suppression (sets 2 and 3) in Condition 2 for S3 (top left panel) and S2 (bottom left panel), and on transitivity probe trials for stimulus sets without symmetry suppression (Sets 2 and 3) in Condition 2 for S3 (top right panel) and S2 (bottom right panel) grouped according to stimulus sets.

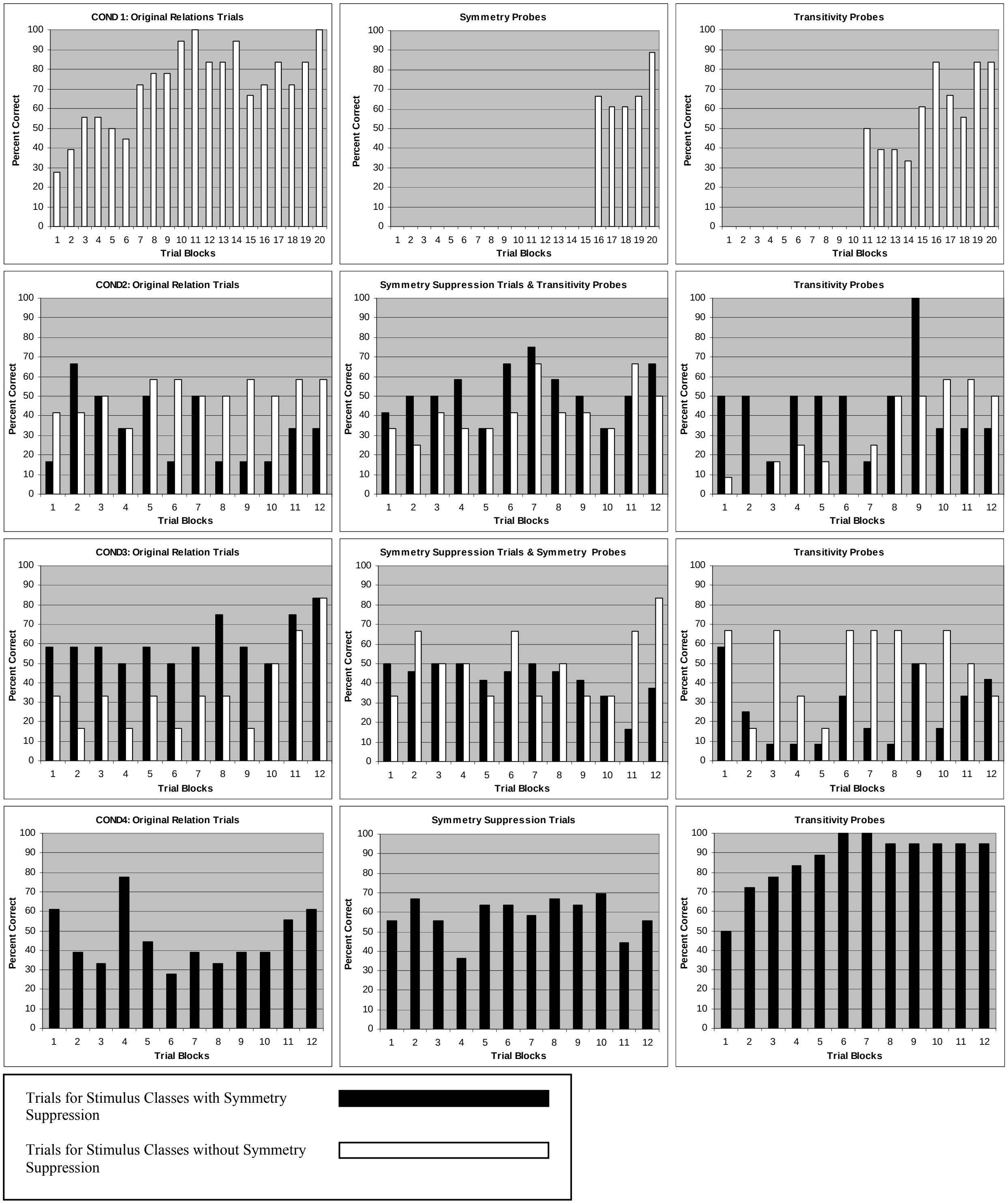


Figure 8. S4: Percentage of correct responses per trial block on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

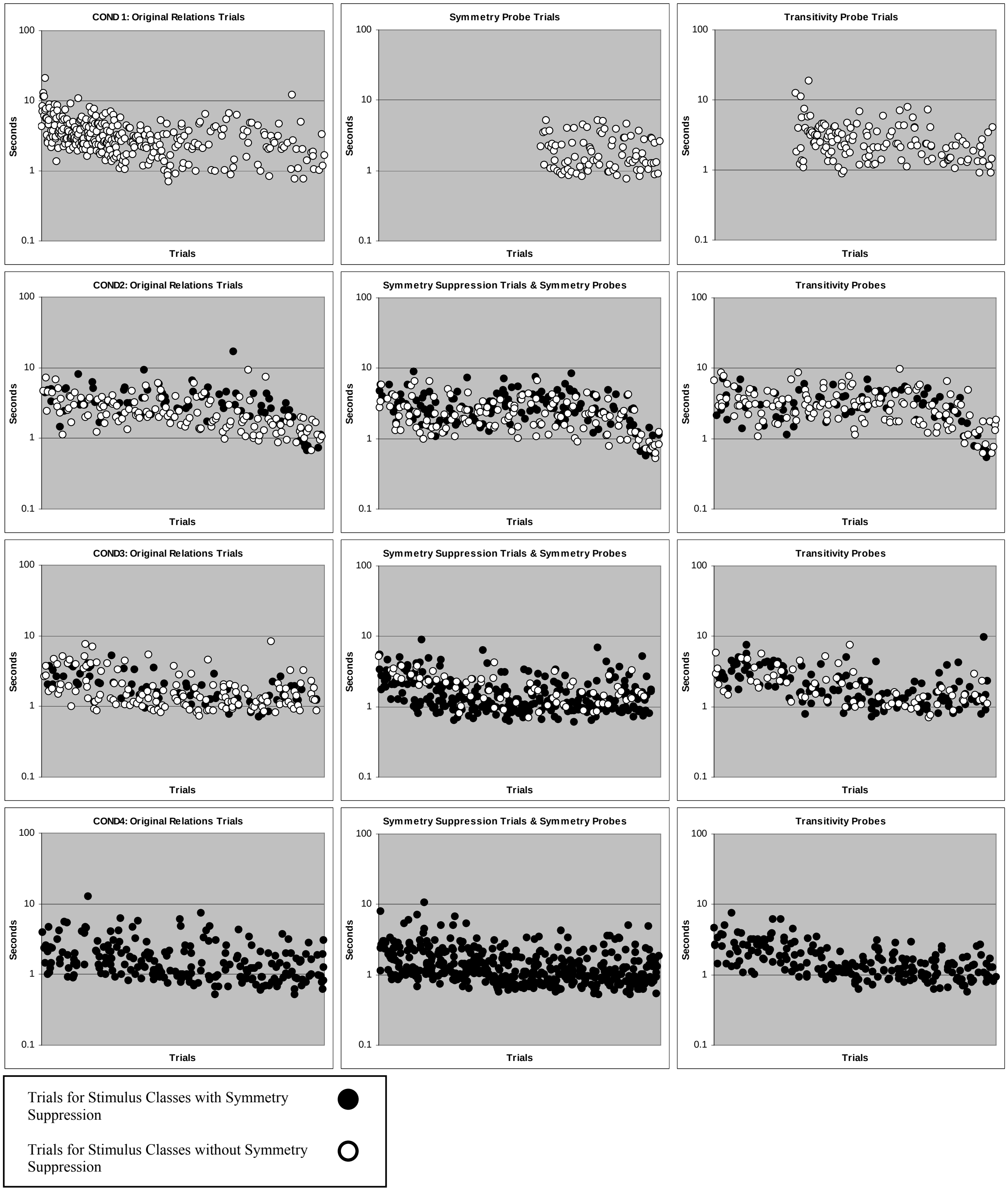


Figure 9. S4: Latency to respond on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

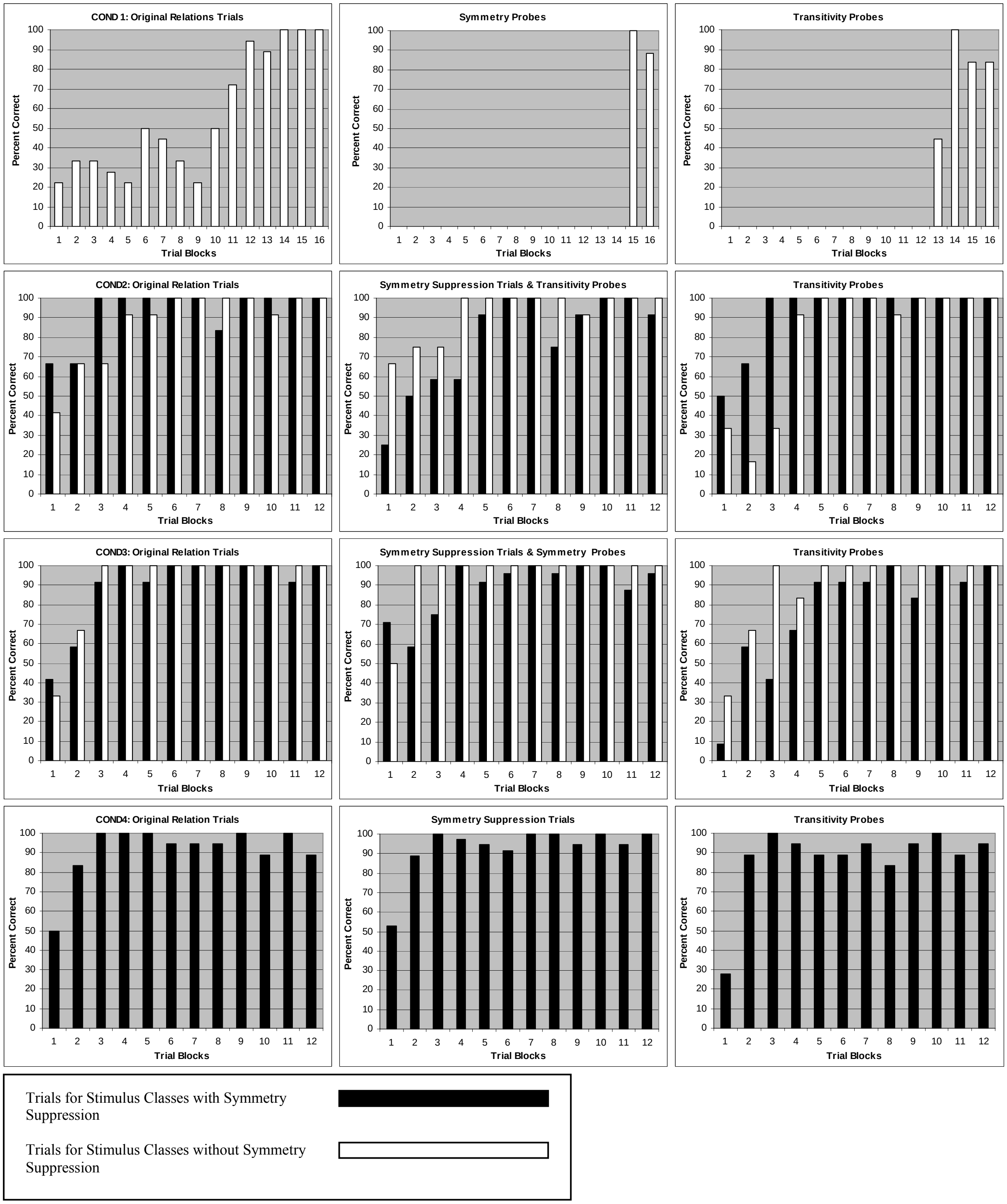


Figure 10. S5: Percentage of correct responses per trial block on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

effect on this subject's derivation of symmetrical and transitive relations based on original relations training. In fact, evidence of derived relations is stronger in Conditions 2 through 4 than it was in Condition 1. Latency data (Figure 11) reveals, however, that SSP trials did affect this subject's performance. Unlike the other subjects, Subject 5 continued to spend a greater amount of time on selection responses across conditions. That is, there was a less substantial decrease in latencies over the course of sessions than was seen for other subjects. Although the bulk of this subject's latencies in Condition 2 were less than 3 s on all trial types, many latencies were as long as 6 to 8 s. This pattern emerged again in Condition 3 (with a relatively smaller proportion of longer latencies) and again in Condition 4 (with a still smaller proportion of longer latencies, except on transitivity probe trials where the distribution of response latencies remained larger).

In general, symmetry suppression affected the performances of all 5 subjects when compared with their performances in Condition 1. All subjects derived both symmetrical and transitive relations in condition 1. This tendency was clearly disrupted in the remaining conditions, but the symmetry suppression procedure affected performances in two significantly different ways: transitivity and symmetry either emerged in spite of the suppression procedure, or the suppression procedure precluded the emergence of symmetry and/or transitivity.

Consistent with their performances in Condition 1, symmetry and transitivity emerged in the performances of Subjects 3 and 5 in subsequent conditions, but the SSP slowed this process and produced a less robust tendency to derive symmetrical and transitive relations. For Subject 5, for example, correct responses on symmetry probe trials reached 100 % by the 4^{th} trial block and continued at 100 % on all but one of the remaining trial blocks. Correct responses on symmetry suppression trials occurred less frequently, finally reaching 100 % by the 6^{th} trial block, but decreasing again later in the session. This suggests that the tendency to derive

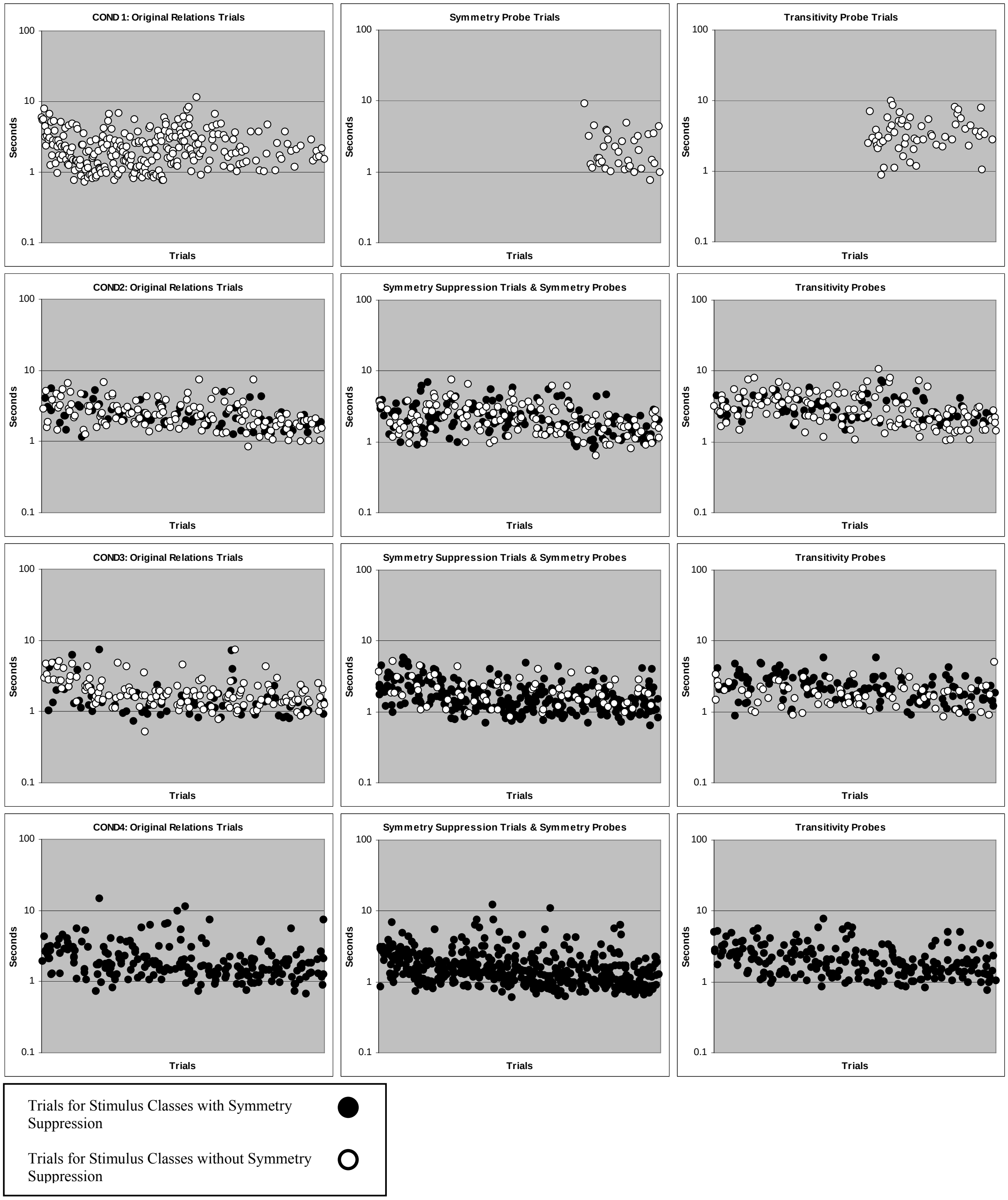


Figure 11. S5: Latency to respond on original relations trials, transitivity probe trials, symmetry probe trials, and symmetry suppression trials for all conditions.

symmetrical relations competed with the effect of the suppressive stimulus that was delivered for symmetrical responses. Transitivity emerged by the 4th trial block for stimulus classes with and without SSP and continued to occur throughout the session. The same pattern emerged in Condition 3 with an even greater tendency to derive symmetrical and transitive relations on the unsuppressed stimulus class. Finally, in Condition 4, little evidence can be seen of symmetry suppression for S5. Symmetrical and transitive relations emerged almost immediately and remained throughout the session.

A comparable performance was evident for S3. Acquisition of the original relations occurred at the beginning of Condition 2 and then disappeared over the next three trial blocks on the suppressed stimulus class, and then reemerged toward the end of the session. Responses on symmetry suppression trials followed this same pattern, as did responses on transitivity probe trials for the suppressed class. In Condition 3, acquisition of the original relations on the unsuppressed stimulus class occurred exactly as it did in Condition 1. Acquisition of the original relations for the suppressed class occurred much more slowly. Symmetrical relations emerged for both classes as well. Transitivity emerged less consistently in Condition 3, but correct responses on those trials occurred more frequently than chance for the suppressed stimulus class, and eventually disappeared for the unsuppressed class. In Condition 4, symmetry appears to have emerged, although this is less certain since correct responses on symmetry trials occurred more frequently than on original relations trials at the beginning of the session. Transitivity failed to emerge in Condition 4.

In contrast with their performances in Condition 1 where symmetry and transitivity were clearly evident, transitivity failed to emerge for Subjects 1, 2, and 4 in conditions in which SSP trials were presented. Whether symmetry emerged for these subjects is not certain. Subject 1 acquired the original relations on all stimulus classes in all 4 conditions. In Conditions 2 and 3, correct responses continued to occur at a high frequency on symmetry suppression trials. Correct responses occurred frequently on symmetry probe trials for the first half of the session and then ceased. Transitivity failed to emerge in this subjects performance in any of the conditions in which SSP was presented.

Acquisition of the original relations failed to occur for Subjects 2 and 4 in conditions in which SSP was presented, and a corresponding failure of transitivity to emerge occurred for these subjects. Subject 2, however, selected the experimenter-designated correct response more frequently on symmetry suppression trials than on symmetry probe trials. Subject 4 selected the experimenter-designated correct responses at a high frequency on transitivity probe trials in Condition 4. These performances cannot be interpreted as derived relational responding, however, because there is no corresponding evidence of accuracy on original relations upon which derived relations would be based.

CHAPTER 4

DISCUSSION

The goal of this study was to identify subjects who readily demonstrated derived relations of symmetry and transitivity in an experimental setting, and then to introduce experimental procedures that might be expected to interfere with the acquisition of those relations. Presumably these subjects would continue to derive stimulus relations based on continued conditional discrimination training, but how? What would these stimulus relations be? How would they compare to typical performances in a stimulus equivalence preparation?

Answers to these questions could not be precisely predicted because a range of response patterns was possible. For example, the simplest prediction was that the symmetry suppression procedure (SSP) would affect only the stimulus class to which it was applied. Equivalence relations would then emerge as usual for any stimulus class without SSP, and failed to emerge for any stimulus class that was suppressed. Another simple prediction was that the effects of suppression would generalize across classes such that equivalence would not be observed in any stimulus classes. In fact, neither of these outcomes occurred for any subject.

In Conditions 2 and 3, emergence of transitivity was not observed in the performances of 3 subjects, suggesting that the effect of SSP trials generalized across classes. An unexpected outcome, however, was that these 3 subjects tended to select the experimenter-designated correct response on symmetry trials for the stimulus classes targeted for suppression at a higher frequency than on stimulus classes for which no programmed consequence was delivered. That is, experimenter-designated correct responses on symmetry suppression trials occurred more frequently than on symmetry probe trials. Also, the frequency of correct responses was generally more consistent in Condition 4, usually with more correct responses on symmetry trials than transitivity trials.

One interpretation of these outcomes is that the buzz sound functioned to reinforce original relations as well as symmetrical responses. In fact, for all 5 subjects, a stimulus (the buzz sound) thought to be mildly aversive and also previously paired with a culture-typical conditioned punisher (the word WRONG), appeared to function as a reinforcing stimulus for symmetrical responding. Thus, after Condition 1, the buzz sound either lost its suppressive function to the more powerful tendency to derive symmetrical relations, or the pairing procedure was not effective in establishing it as a conditioned punisher and the buzz sound was not aversive enough to function as a punisher on its own. Statements by some participants that they attempted to respond in whatever manner they could to avoid the buzz sound suggest that it remained aversive, but not enough to function as a punisher. Instructions to consider the buzz sound as equal to “WRONG” may not have had the intended effect.

If the putative suppressive stimulus (the buzz sound) had a reinforcing function, though, high frequencies of correct transitive responses for the stimulus class to which SSP trials had been applied should be apparent in the data. That is, if the buzz sound functioned as a reinforcer, symmetry suppression trials would simply serve as part of the original conditional relations training, and equivalence should progress as expected. However, SSP trials appeared to interfere with the emergence of transitivity, suggesting that, in the face of conflicting consequences, trial types acquired discriminative control over subjects’ responses such that they responded one way on original relations trials, another way on symmetry suppression trials, and yet another way on symmetry and transitivity probe trials. Thus, an unplanned level of second-order conditional control emerged in subjects’ repertoires rather than equivalence classes. According to this interpretation, in cases in which equivalence did not emerge, original relations trials served as a differential reinforcement procedure utilizing reinforcement and punishment. Symmetry suppression trials, which, due to the fact that correct responses on those trials were consequated, served as a differential reinforcement procedure utilizing reinforcement and extinction. Symmetry and transitivity probe trials served as extinction trials regardless of response. Essentially, the different trial types served as separate and distinct learning scenarios, rather than one set of complimentary learning trials. The fact that the separate learning scenarios used common stimuli led to random patterns of responding on transitivity probe trials.

In cases in which equivalence did emerge, this discrimination between trial types appeared to control performances until the stronger tendency to derive equivalence relations took over. Subject 5, for example, demonstrated a stronger tendency to demonstrate derived relations in Condition 3, but when symmetry suppression was applied to all stimulus classes, the two trial-type-specific differential reinforcement contingencies controlled responses on original relations trials and symmetry suppression trials, resulting in a failure of transitivity.

Another contributor to inconsistent performances may have been the buzz sound common to both trial types. As a suppressive stimulus on original relations trials and a reinforcing stimulus on symmetry suppression trials, the function of the stimulus as a consequence reversed depending on which trial type was presented. The apparently inconsistent functions of the buzz sound in this experiment may shed some light on some puzzling outcomes of common parenting strategies. Parents of unruly children often complain that their children continue to engage in undesirable behavior despite the parents' best efforts to suppress that behavior. This phenomenon makes sense clinically. Aversive stimuli delivered by the parent contingent on the undesirable behavior is often delivered to the child along with a relatively large amount of attention. So even though the suppressive stimulus (spanking, reprimand, etc.) may be unpleasant for the child, the event reinforces the undesirable behavior that brought it about because of the reinforcing nature of parental attention. The difficulty in child behavior management, though, is that the child is also usually instructed to refrain from the proscribed behavior in the future. Thus, the aversive behavior management practices both reinforce the unwanted behavior while simultaneously declaring it bad, wrong, and forbidden. A possible effect is that "bad," "wrong," and "forbidden" may acquire a reinforcing function.

The results of this study suggests some possible insight into the variables responsible for the persistence of the behavior of the unruly child under the contingencies arranged by the parents' aversive behavior management strategies. The child may typically avoid aversive stimuli, but when those same stimuli are associated with the availability of parental attention, they acquire a reinforcing function, suggesting that discriminative stimuli affect not just behavior, but that they influence consequential stimuli as well. In this experiment, when the stimulus array included an A stimulus as the sample and B or C stimuli as comparisons, the buzz sound functioned as a punisher. When the stimulus array included A stimuli as comparisons, the buzz sounds functioned as a reinforcer. Rather than simply indicating that a particular type of consequence is available, contextual variables may affect, modify, and even reverse the *function* of consequences. This effect is normally attributed to motivating variables. The possibility that discriminative stimuli affect the function of consequences is considered below.

Equivalence is said to exist when reflexive, symmetrical, and transitive relations emerge after conditional discrimination training (Sidman, 1994). Sidman (1986) developed a detailed analysis of stimulus equivalence by starting with Skinner's (1935, 1938) two-term contingency and expanding his analysis to increasingly complex contingencies including as many as five terms. A summary of his conclusions that relate to this study is as follows: The addition of a third term to the two-term contingency introduces the phenomenon referred to as simple discrimination (SD and S△ control). Subjects learn to respond in the presence (but not in the absence) of some stimulus and to respond another way in the presence (but not the absence) of another stimulus.

Adding a fourth term, a conditional stimulus, allows for conditional discrimination training and offers researchers the opportunity to alter the roles of the fourth and third terms (conditional and discriminative stimuli) such that symmetry and transitivity may be demonstrated. When derived relations appear reliably, equivalence is said to be demonstrated. Sidman refers to control by the conditional stimulus as *contextual control*. That is, the fourth term provides the context that determines the function (SD or S△) of the third term. Sidman then discusses adding a fifth term that places the entire set of equivalence relations under control of yet another level of stimuli. He refers to this level as *second-order conditional control*, "a more powerful type of contextual control" than the 4-term unit (1986, p. 239).

Table 4.1 shows the various behavioral events in the 4-term contingencies of the trials in Condition 1 using a modified version of Sidman's format. Because no inconsistent consequences were delivered in Condition 1, four terms are sufficient to describe the conditions that controlled selection responses. Sidman's analysis assumes, however, that the first stimulus to appear on the screen functions as the sample (4^{th} term) in a match-to-sample preparation. This assumption works for original relations trials in Condition 1. On trials in which the original sample stimulus (A1, A2, or A3) appeared as a comparison, it is still possible that it functioned as the 4^{th} term regardless of its position. This is not necessarily what happened in subsequent sessions. Performances by subjects in Conditions 2 through 4, in which consequences inconsistent with derived relations were delivered, suggest that their responding came under control of an unplanned 5th term (conditional, contextual, etc.) not designated as such by the experimenter but as an unplanned effect of the programmed consequences.

Table 4.1

Function of Each Event within a Four-Term Contingency for Condition 1

Term 4	Term 3	Term 1	Term 2
A1	B1	R1 (click) →	S1 *BEEP*
	B2 or B3	R2 (click) →	S2 *BUZZ*
A2	B2	R1 (click) →	S1 *BEEP*
	B1 or B3	R2 (click) →	S2 *BUZZ*
A3	B3	R1 (click) →	S1 *BEEP*
	B1 or B2	R2 (click) →	S2 *BUZZ*
B1	A1 or C1	R1 (click) →	S3 *⊘*
	A2, A3, C2 or C3	R2 (click) →	S3 *⊘*
B2	A2 or C2	R1 (click) →	S3 *⊘*
	A1, A3, C1 or C3	R2 (click) →	S3 *⊘*
B3	A3 or C3	R1 (click) →	S3 *⊘*
	A1, A2, C1 or C2	R2 (click) →	S3 *⊘*
C1	A1 or B1	R1 (click) →	S3 *⊘*
	A2, A3, B2 or B3	R2 (click) →	S3 *⊘*
C2	A2 or C2	R1 (click) →	S3 *⊘*
	A1, A3, B1 or B3	R2 (click) →	S3 *⊘*
C3	A3 or C3	R1 (click) →	S3 *⊘*
	A1, A2, B1 or B2	R2 (click) →	S3 *⊘*

Note: R = Response; S = Consequence.

Because of the inconsistent consequences in Conditions 2 through 4, the sample stimulus alone would not have been sufficient to control accurate responding. It is possible that subjects learned to ignore the sample stimulus except to click it so that the rest of the array would appear and control the selection response. If this happened, we could interpret that clicking the sample stimulus was not an instance of observing the sample, but a response functioning merely to complete the stimulus array so that “equivalence” or “conditionally discriminated” responding could take place. In such a situation subjects would not begin to respond under control of antecedent stimuli until the entire stimulus array was available. Upon the presentation of the total stimulus array, the subject could then attend to the comparison stimuli each in turn until a simple match-to-sample consistent with original conditioning occurred. If this is how a subject makes symmetrical responses, then a fifth term must be included, as it is in Table 4.2, that describes the configuration of the array. The example presented in Table 4.2 describes the fifth term as a configuration of stimuli in an array with the location of A stimuli serving as a critical discriminative feature of the array.

Notice that according to this configuration of contingencies, two-thirds of the symmetry trials function the same as transitivity trials. When B or C stimuli are presented as sample stimuli, all responses other than clicking A1 produce no programmed consequence. Therefore, unconsequated symmetry trials can be collapsed into the transitivity trials due to their similar function. This configuration of contingencies is presented in Table 4.3. Two sets of learning scenarios are presented by this configuration. Trials in which an A stimulus appears as the sample are discriminative for a differential reinforcement procedure utilizing reinforcement and punishment. Trials in which the array does not include an A stimulus as the sample are discriminative for a differential reinforcement procedure utilizing reinforcement and extinction.

Finally, one more configuration of contingencies must be discussed. Because responses and consequences also entail stimulation, when discriminative and conditional stimuli become equivalent due to reinforcement contingencies, the response and reinforcer also become part of the equivalence unit (Dube & McIlvane, 1995; Sidman, 2000). The consequence common to stimulus configurations both with and without an A stimulus as the sample (the buzz sound), according to Sidman, has the possibility of equating all discriminative and conditional stimuli

Table 4.2

Function of Each Event within Five-Term Contingencies for Condition 2

Term 5	Term 4	Term 3	Term 1	Term 2
Stimulus array includes A stimulus as sample	A1	B1	R1 (click)	→ S1 *BEEP*
		B2 or B3	R2 (click)	→ S2 *BUZZ*
	A2	B2	R1 (click)	→ S1 *BEEP*
		B1 or B3	R2 (click)	→ S2 *BUZZ*
	A3	B3	R1 (click)	→ S1*BEEP*
		B1 or B2	R2 (click)	→ S2 *BUZZ*
Stimulus array includes A stimuli as comparisons	B1 C1	A1	R1 (click)	→ S2 *BUZZ*
		A2 or A3	R2 (click)	→ S3 *⊘*
	B2 C2	A2	R1 (click)	→ S3 *⊘*
		A1 or A3	R2 (click)	→ S3 *⊘*
	B3 C3	A3	R1 (click)	→ S3 *⊘*
		A1 or A2	R2 (click)	→ S3 *⊘*
Stimulus array does not include A stimuli	Any B stimulus	Any C stimulus	R1 (click)	→ S3 *⊘*

Note: R = Response; S = Consequence.

included in trials that produce that consequence, a possibility that becomes more likely when consequences are inconsistent. In this case, it would be more appropriate to group consequated symmetry trials with original relations trials, given that the stimuli associated with producing the buzz sound can function equivalently. This configuration is presented in Table 4.4. Notice that in this configuration, if the 5th term is an array that includes A2 or A3 as comparison stimuli, or the array does not include an A stimulus, there is no differential 4^{th} term or 3^{rd} terms. In this case, the stimulus array functions as the discriminative (3^{rd}) term and the subject simply learns that when that array appears, click any stimulus and nothing happens. This explains the more or less random patterns of responding for some participants.

Table 4.3

Function of Each Event within a Five-Term Contingency for Condition 2, with Symmetry Trials Collapsed into Transitivity Probe Trials

Term 5	Term 4	Term 3	Term 1	Term 2
Array includes A stimulus as sample	A1	B1	R1 (click)	→ S1 *BEEP*
		B2 or B3	R2 (click)	→ S2 *BUZZ*
	A2	B2	R1 (click)	→ S1 *BEEP*
		B1 or B3	R2 (click)	→ S2 *BUZZ*
	A3	B3	R1 (click)	→ S1*BEEP*
		B1 or B2	R2 (click)	→ S2 *BUZZ*
Array does not include A stimulus as sample	B1 C1	A1	R1 (click)	→ S2 *BUZZ*
		Any other comparison stimulus	R2 (click)	→ S3 *⊘*
	B2, B3, C2, or C3	Any comparison stimulus	R2 (click)	→ S3 *⊘*

Note: R = Response; S = Consequence.

The configurations represented in Tables 4.1-4.4 present the main contingencies that appeared to control selection responses on the various trial types. It is suggested here that a subject's total performance in this experiment was controlled by the subject's tendency to derive symmetrical and transitive relations based on original conditional discrimination training (outlined in Table 4.1) versus the competing sources of stimulus control that emerged as a function of undesignated controlling features of the stimulus array when consequences were inconsistent with derived relations. The emergence of the additional discriminative elements caused by these inconsistent consequences provides a degree of insight into the emergence of equivalence from conditional discrimination training. In this case, and possibly as a matter of course when learners begin to emit equivalence-consistentt responses under the control of different stimuli, a set of relations that would have otherwise emerged as equivalent came under conditional control of additional, unplanned features of the environment. Sidman (2000) predicted this effect:

> Our theory requires us to assume that when the two outcomes of the reinforcement contingency come into conflict, the analytic unit takes precedence over the equivalence relation, as it must if we are to learn to react effectively to the world around us. In order for the common response and reinforcer elements to retain their membership in the analytic unit, they must selectively drop out of the equivalence relation (p. 132).

Thus, the idiosyncratic performances of all subjects supports the prediction that, in complex conditional discrimination training, patterns of responding indicative of both equivalence and conditional discrimination are present in the learner's repertoire until enough learning has taken place that one or the other modes of responding eventually takes precedence (even if equivalent stimuli acquire functions that were not planned by the contingency manager). A learner, then, would ignore some stimuli if the conditional discrimination was too complex or inconsistent, until equivalence emerged based on more salient features of the contingency arrangement. Once this occurs, additional stimuli may be added to take control over the equivalence relations. That is, when varying configurations of stimulus features of the overall environment (e.g., terms 3, 4, and 5) combine into units, they take the place of a single functional term within the contingency as the new 3rd term (indicated by the arrow in Table 4.4), and the learner is then ready to learn additional levels of conditional control by other stimuli that may then occupy the 4th and 5th terms. The general conclusion is this: a contingency manager who uses inconsistent and/or suppressive contingencies fails to establish stimulus control by the intended learning contingencies, and instead relinquishes that control to factors in the learner's individual history, thus producing highly idiosyncratic and individualized response patterns. This may be desirable when the goal of a learning procedure is to produce creative behavior, but undesirable when the goal of the learning procedure is to train something more systematic such as historical facts, equipment or program operating procedures, social norms, or skills in natural science, mathematics, and logic.

Table 4.4

Function of Each Event within a Five-Term Contingency for Condition 2, with Consequated Symmetry Trials Collapsed into Original Relations Trials

Term 5	Term 4	Term 3	Term 1	Term 2
Array includes an A stimulus as sample or A1 as Comparison	A1	B1	R1 (click)	→ S1 *BEEP*
		B2 or B3	R2 (click)	→ S2 *BUZZ*
	A2	B2	R1 (click)	→ S1 *BEEP*
		B1 or B3	R2 (click)	→ S2 *BUZZ*
	A3	B3	R1 (click)	→ S1*BEEP*
		B1 or B2	R2 (click)	→ S2 *BUZZ*
	B1 or C1	A1	R1 (click)	→ S2 *BUZZ*
		Any other comparison stimulus	R2 (click)	→ S3 *⦸*
Array includes A2 or A3 as comparison or array does not include an A stimulus	B2, B3, C2, or C3	Any comparison stimulus	R2 (click)	→ S3 *⦸*

Note: R = Response; S = Consequence.

Two methodological considerations are suggested by these findings. First, the use of intermixed trial types throughout sessions probably more closely mimicked natural learning situations, the implications of which will be discussed below. Using the typical train-and-test method of earlier research may reveal more clearly the emergence of unplanned discriminative functions. This emergence might also be planned for and caused systematically using the train-and-test method. Second, the use of immediately consumable consequences (sounds and the "CORRECT" and "WRONG" messages) allowed the function of these events to change in accordance with the conflicting reinforcement contingencies that modified the stimulus control of selection responses as described above. The use of consequences that can accumulate or lose value dependent on subjects' performances (e.g., tokens) could be used to test the strength of one's tendency to derive stimulus relations when this tendency is suppressed by consequences that are more likely to retain their designated function.

Intermixed trial types and immediately consumable consequences were used in this study to attempt to approximate natural learning environments. Natural learning situations typically do not conform to a rigid train-and-test format as in experimental settings. "Trials" may be delivered more randomly in natural contexts, without consideration of the object that serves as the sample stimulus or the stimuli that are available as comparisons. The delivery of a suppressive stimulus as a consequence for correct symmetrical responses has direct correlations to the teaching methods used in a typical classroom. Imagine, for example, that a class of students is taught, when asked who George Washington was, to say "the first president of the United States." Later, the teacher asks the class, "Who was the first president of the United States?" Several students shout, "George Washington," and the teacher reprimands the students for failing to raise their hands. Repetition of this scenario (symmetrical responding subverted by coercive classroom management strategies) could lead to a failure of some students to derive transitive relations after reinforced conditional discrimination training, such as relations between other facts associated with both the name "George Washington" and the identity of the first president of the United States. One may recall the joke that starts "Who is buried in Grant's tomb?" and is successfully deployed when the jokester's mark fails to produce the name indicated in the question.

The effect of inconsistent and/or aversive contingencies in a conditional discrimination scenario could greatly impact basic intellectual functioning and cognitive development. In their monumental study, Hart and Risley (1995) found that the number of words spoken to a child during the first years of the child's life correlated strongly with the growth of the child's vocabulary (counted as number of words spoken by the child), and to the child's performance on intelligence tests. This finding was emphasized by the authors as the major contributor to language differences in their subjects, but another finding in that study revealed that the children who were talked to less frequently also received a higher number of discouraging statements regarding the child's behavior. Hart and Risley (1995) described encouragements and discouragements this way:

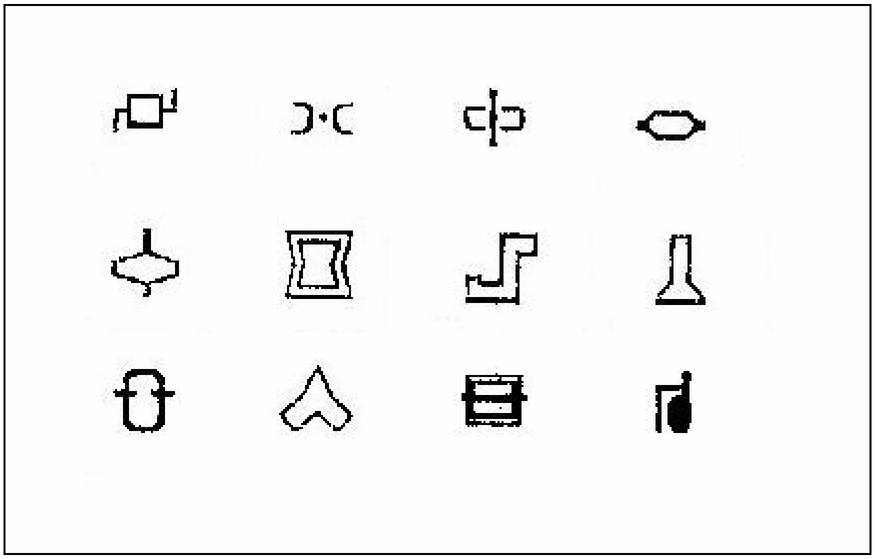
> Encouragements were affirmations that repeated, extended or expanded the child's utterances and expressions of approval of the child's behavior as "right" or "good." Discouragements were prohibitions directing the child "Don't," "Stop," "Quit," or "Shut up" and expressions of disapproval of the child's behavior as "bad" or "wrong" (p. 253).

Children who would later develop larger vocabularies heard hundreds of thousands more encouragements than those children whose vocabularies would remain relatively restricted. For those children, discouragements dominated the child's early language experience. While Hart and Risley emphasized the gap in language experience (number of words spoken to the child) as the dominant factor that accounted for language differences in the children they studied, the present results support the potential significance of the type of language experience (discouraging versus encouraging) the children received. Data on the cumulative growth of the children's vocabularies (see Appendix C) showed that the children who heard more encouragements developed verbal repertoires at an exponentially greater rate earlier in life, such that when the expansions of their vocabularies leveled off at around 23 months (i.e., grew linearly rather than exponentially) the trajectory of the curve at that point represented a vocabulary that continued to grow at a very high rate. Children who heard more discouragements had a much flatter vocabulary growth curve, and it is even difficult to find an exponential characteristic in the curve. We may assume that the language experience of children who heard more encouragements included conditional discrimination training that produced emergent equivalence relations among the words these children learned and accounted, in part, for the exponential growth of their vocabularies. This multiplicative growth of one's verbal repertoire is what one would expect if conditional discrimination training is conducted in a manner consistent with the tendency of humans to derive symmetrical and transitive relations. Recall Sidman's study in which training 15 relations produced 60 emergent relations (Sidman, Kirk, & Wilson-Morris, 1985).

We may similarly assume, due to the high frequency of discouragements that characterized the early verbal experience of the children with slower expanding vocabularies, that some, perhaps many, of those discouragements happened to be delivered following instances of symmetrical responding by the children. The relatively limited verbal development of the children whose behavior was discouraged more often resembles the performances of subjects in this study when the symmetry suppression procedure was applied in the normal course of their conditional discrimination training, thus hinting at the possibility that similar processes may account for both outcomes. Given the importance of something like verbal development, it is a question worth answering.

APPENDIX A

SAMPLE OF THE EXPERIMENTAL STIMULI



APPENDIX B

SCHEDULE OF SAMPLE AND COMPARISON STIMULI PRESENTATION, CONDITION 1

Original Relations Trials (A→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	B1	CORRECT	A2	B1	WRONG	A3	B1	WRONG
	B2	WRONG		B2	CORRECT		B2	WRONG
	B3	WRONG		B3	WRONG		B3	CORRECT
Original Relations Trials (A→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	C1	CORRECT	A2	C1	WRONG	A3	C1	WRONG
	C2	WRONG		C2	CORRECT		C2	WRONG
	C3	WRONG		C3	WRONG		C3	CORRECT
Symmetry Probe/Suppression Trials (B→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	A1	No Consequence	B2	A1	No Consequence	B3	A1	No Consequence
	A2	No Consequence		A2	No Consequence		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Symmetry Probe/Suppression Trials (C→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	A1	No Consequence	C2	A1	No Consequence	C3	A1	No Consequence
	A2	No Consequence		A2	No Consequence		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Transitivity Probe Trials (B→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	C1	No Consequence	B2	C1	No Consequence	B3	C1	No Consequence
	C2	No Consequence		C2	No Consequence		C2	No Consequence
	C3	No Consequence		C3	No Consequence		C3	No Consequence
Transitivity Probe Trials (C→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	B1	No Consequence	C2	B1	No Consequence	C3	B1	No Consequence
	B2	No Consequence		B2	No Consequence		B2	No Consequence
	B3	No Consequence		B3	No Consequence		B3	No Consequence

Schedule of Sample and Comparison Stimuli Presentation, Condition 2								
Original Relations Trials (A→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	B1	CORRECT	A2	B1	WRONG	A3	B1	WRONG
	B2	WRONG		B2	CORRECT		B2	WRONG
	B3	WRONG		B3	WRONG		B3	CORRECT
Original Relations Trials (A→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	C1	CORRECT	A2	C1	WRONG	A3	C1	WRONG
	C2	WRONG		C2	CORRECT		C2	WRONG
	C3	WRONG		C3	WRONG		C3	CORRECT
Symmetry Probe/Suppression Trials (B→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	A1	WRONG	B2	A1	No Consequence	B3	A1	No Consequence
	A2	No Consequence		A2	No Consequence		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Symmetry Probe/Suppression Trials (C→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	A1	WRONG	C2	A1	No Consequence	C3	A1	No Consequence
	A2	No Consequence		A2	No Consequence		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Transitivity Probe Trials (B→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	C1	No Consequence	B2	C1	No Consequence	B3	C1	No Consequence
	C2	No Consequence		C2	No Consequence		C2	No Consequence
	C3	No Consequence		C3	No Consequence		C3	No Consequence
Transitivity Probe Trials (C→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	B1	No Consequence	C2	B1	No Consequence	C3	B1	No Consequence
	B2	No Consequence		B2	No Consequence		B2	No Consequence
	B3	No Consequence		B3	No Consequence		B3	No Consequence

Schedule of Sample and Comparison Stimuli Presentation, Condition 3								
Original Relations Trials (A→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	B1	CORRECT	A2	B1	WRONG	A3	B1	WRONG
	B2	WRONG		B2	CORRECT		B2	WRONG
	B3	WRONG		B3	WRONG		B3	CORRECT
Original Relations Trials (A→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	C1	CORRECT	A2	C1	WRONG	A3	C1	WRONG
	C2	WRONG		C2	CORRECT		C2	WRONG
	C3	WRONG		C3	WRONG		C3	CORRECT
Symmetry Probe/Suppression Trials (B→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	A1	WRONG	B2	A1	No Consequence	B3	A1	No Consequence
	A2	No Consequence		A2	WRONG		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Symmetry Probe/Suppression Trials (C→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	A1	WRONG	C2	A1	No Consequence	C3	A1	No Consequence
	A2	No Consequence		A2	WRONG		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	No Consequence
Transitivity Probe Trials (B→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	C1	No Consequence	B2	C1	No Consequence	B3	C1	No Consequence
	C2	No Consequence		C2	No Consequence		C2	No Consequence
	C3	No Consequence		C3	No Consequence		C3	No Consequence
Transitivity Probe Trials (C→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	B1	No Consequence	C2	B1	No Consequence	C3	B1	No Consequence
	B2	No Consequence		B2	No Consequence		B2	No Consequence
	B3	No Consequence		B3	No Consequence		B3	No Consequence

Schedule of Sample and Comparison Stimuli Presentation, Condition 4								
Original Relations Trials (A→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	B1	CORRECT	A2	B1	WRONG	A3	B1	WRONG
	B2	WRONG		B2	CORRECT		B2	WRONG
	B3	WRONG		B3	WRONG		B3	CORRECT
Original Relations Trials (A→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
A1	C1	CORRECT	A2	C1	WRONG	A3	C1	WRONG
	C2	WRONG		C2	CORRECT		C2	WRONG
	C3	WRONG		C3	WRONG		C3	CORRECT
Symmetry Probe/Suppression Trials (B→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	A1	WRONG	B2	A1	No Consequence	B3	A1	No Consequence
	A2	No Consequence		A2	WRONG		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	WRONG
Symmetry Probe/Suppression Trials (C→A)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	A1	WRONG	C2	A1	No Consequence	C3	A1	No Consequence
	A2	No Consequence		A2	WRONG		A2	No Consequence
	A3	No Consequence		A3	No Consequence		A3	WRONG
Transitivity Probe Trials (B→C)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
B1	C1	No Consequence	B2	C1	No Consequence	B3	C1	No Consequence
	C2	No Consequence		C2	No Consequence		C2	No Consequence
	C3	No Consequence		C3	No Consequence		C3	No Consequence
Transitivity Probe Trials (C→B)								
Sample	Comparison		Sample	Comparison		Sample	Comparison	
C1	B1	No Consequence	C2	B1	No Consequence	C3	B1	No Consequence
	B2	No Consequence		B2	No Consequence		B2	No Consequence
	B3	No Consequence		B3	No Consequence		B3	No Consequence

APPENDIX C

REPRODUCED GRAPHS

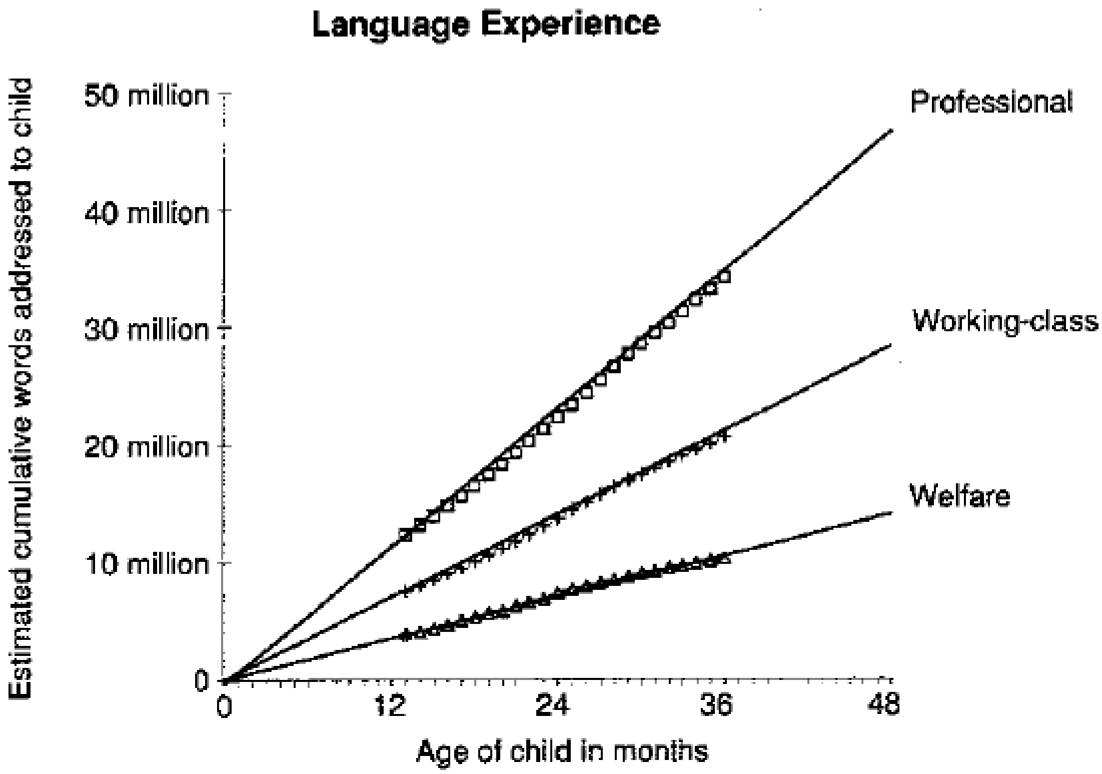


Figure 19. Cumulative number of words addressed to the child in 13 professional (squares), 23 working-class (plus signs), and 6 welfare families (triangles) extrapolated from birth to 12 months of age and from 37 to 48 months of child age. The linear regression line was fit to the actual average cumulative number of words addressed to the children per hour when they were 12–36 months old.

From *Meaningful Differences in the Everyday Experience of Young American Children* (p. 252), by B. Hart and T. R. Risley, 1995, Baltimore, MD: Paul H. Brookes Publishing Co, Inc. Copyright 1995 by Paul H. Brookes Publishing Co, Inc.

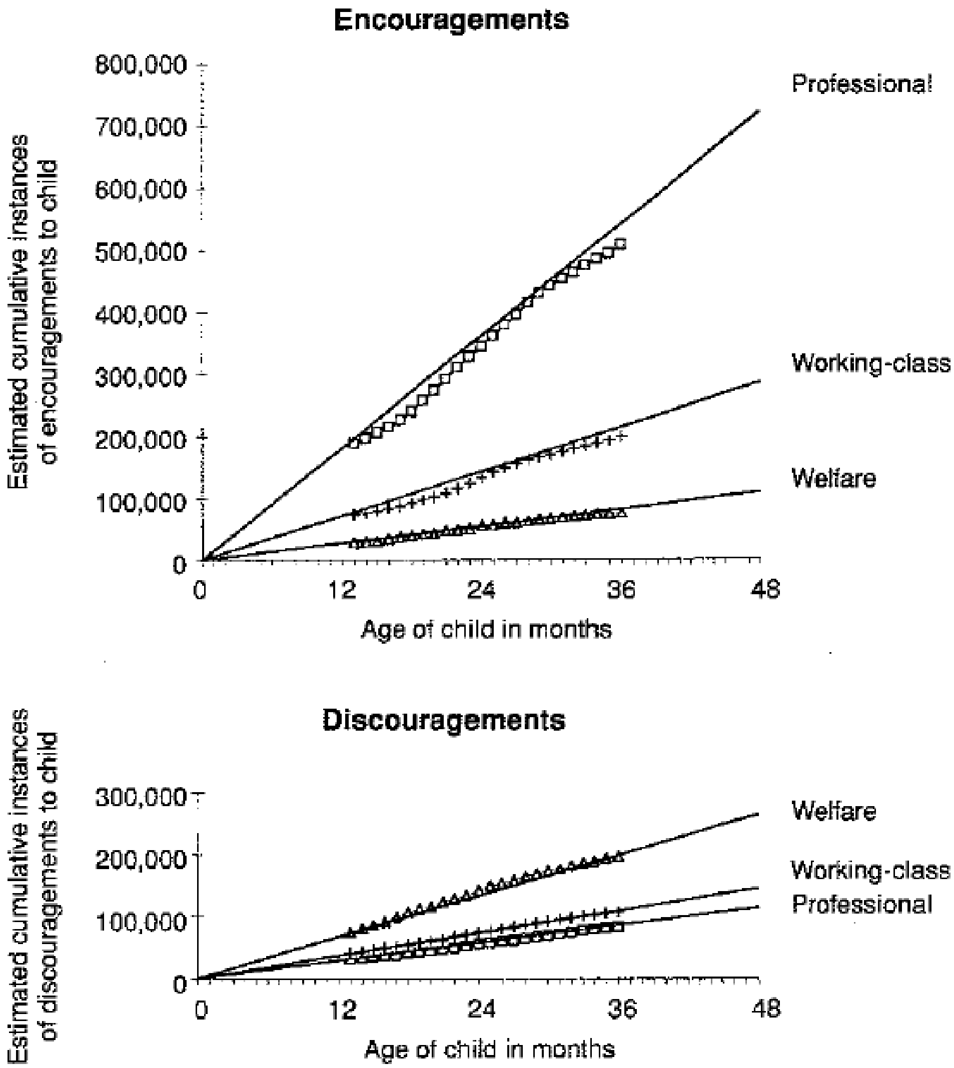


Figure 20. Cumulative instances of feedback containing encouragements (top graph) and discouragements (bottom graph) addressed to the child in 13 professional (squares), 23 working-class (plus signs), and 6 welfare (triangles) families extrapolated from birth to 12 months of age and from 37 to 48 months of child age. Encouragements were affirmations that repeated, extended, or expanded the child's utterances and expressions of approval of the child's behavior as "right" or "good." Discouragements were prohibitions directing the child "Don't," "Stop," "Quit," or "Shut up" and expressions of disapproval of the child's behavior as "bad" or "wrong." Note the reversal of the lines in the bottom graph, reflecting the prevailing negative Feedback Tone in the welfare homes. The linear regression lines were fit to the actual average cumulative numbers of affirmations and prohibitions addressed to the children per hour when they were 12–36 months old.

From *Meaningful Differences in the Everyday Experience of Young American Children* (p. 253), by B. Hart and T. R. Risley, 1995, Baltimore, MD: Paul H. Brookes Publishing Co, Inc.

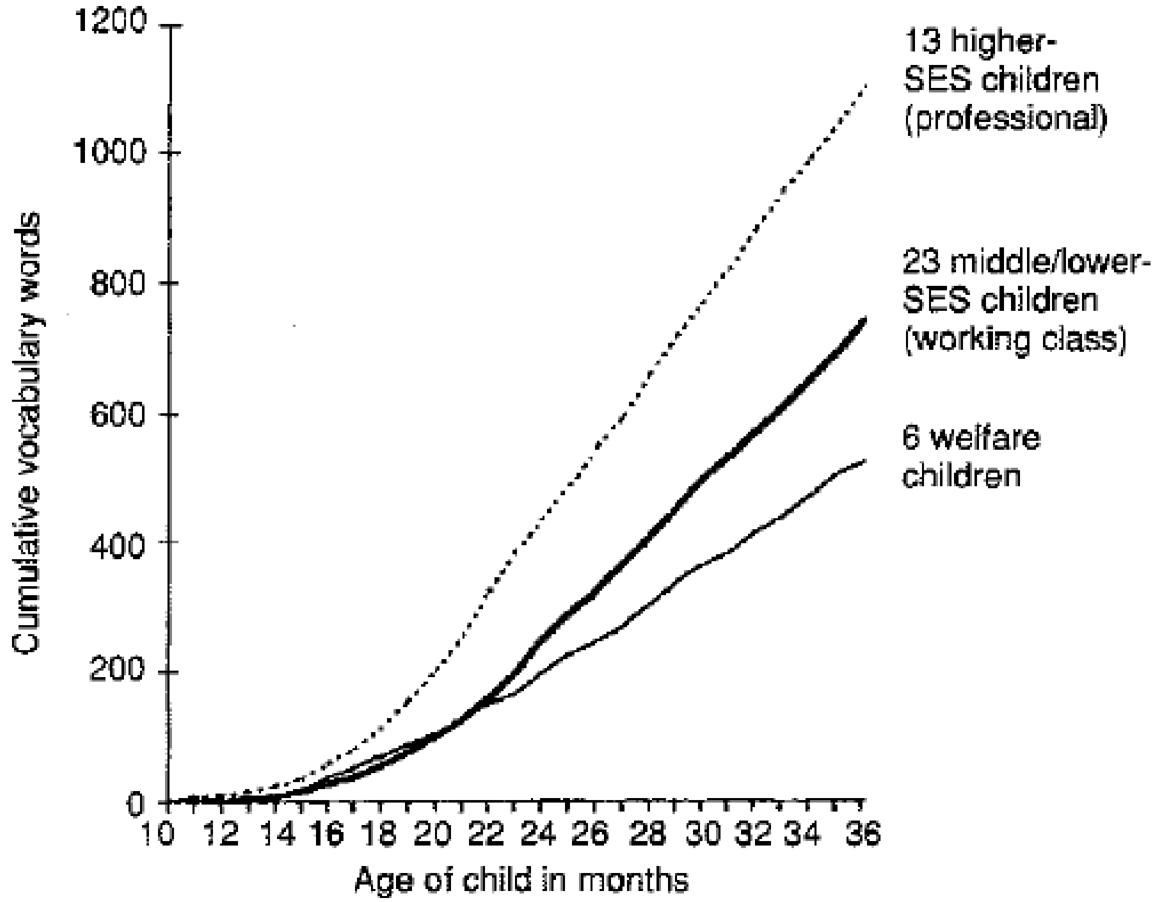


Figure 2. At each month the average number of vocabulary words recorded in that and all prior months for three groups of children from the time the children were 10 months old until they were 36 months old. The children were grouped by the socioeconomic index assigned to the occupation of their parents (see Chapter 4, endnote 3). The 13 higher-SES children (dotted line) were in professional families, 23 middle-lower SES children (heavy solid line) were in working-class families, and 6 welfare children (light solid line) were in families receiving welfare (Aid to Families with Dependent Children).

From *Meaningful Differences in the Everyday Experience of Young American Children* (p. 234), by B. Hart and T. R. Risley, 1995, Baltimore, MD: Paul H. Brookes Publishing Co, Inc.

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