

**The Respondent-Type Training Procedure and
Derived Relational Responding in
Adults and Children.**

Geraldine Leader

**Behaviour Analysis and Cognitive Science Unit,
Department of Applied Psychology
National University of Ireland, Cork.**

Supervisor: Dr. Dermot Barnes-Holmes.

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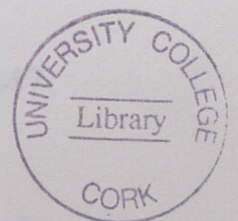


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Abstract

The training procedures employed in the investigation of stimulus equivalence typically incorporate some form of operant requirement. The purpose of this thesis was to develop a non-operant training procedure that successfully produces equivalence in human populations.

In Chapter 1, a brief literature review and rationale for the thesis is offered. In Chapter 2, the effectiveness of the respondent-type training procedure was investigated with adult subjects. Nine nonsense syllables were presented to the subject in the form of six stimulus pairs on a computer screen. The first stimulus of each pair was presented on the screen for 1-s. The screen then cleared for 0.5-s (the within-pair-delay) and the second stimulus of the pair appeared for 1-s. The screen then cleared for 3-s (the between-pair-delay) before the next stimulus pair was presented. All six stimulus pairs were presented in this fashion in a quasi-random order across 60 trials. Subjects were then presented with a standard matching-to-sample equivalence test, which tested for the emergent symmetry and equivalence relations. The majority of subjects reliably demonstrated equivalence responding after two, three of four exposures to the training and testing.

The experiments reported in Chapter 3 investigated the effects of varying the within- and between-pair-delays. It was demonstrated that the respondent-type training procedure is effective using a combination of within- and between-pair-delays and is not limited to the relatively short delays used in Chapters 2 and 3. It was also demonstrated that decreasing stimulus presentations, and increasing class size, did not adversely effect performance on equivalence tests.

In Chapter 4, the respondent-type training procedure was systematically compared to the matching-to-sample training procedure. On a trials for trial basis the respondent-type training procedure was shown to be more effective than the

matching-to-sample training procedure. The latter procedure was shown to be as effective as the respondent-type training procedure when negative comparisons during matching-to-sample training were removed.

Having identified the presence of negative comparisons as a source of disruption in the formation of equivalence classes using the matching-to-sample procedure, the experiments reported in Chapter 5 examined the effects of manipulation the functions of the negative comparisons on equivalence formation. Specifically, during one-to-many matching-to-sample training, the comparisons (e.g., B1-B2, C1-C2) are always presented together (comparison contiguity). When the stimulus configuration is manipulated during a matching-to-sample test, children are more likely to respond in accordance with contiguity while adults respond in accordance with the trained relations.

The experiments reported in Chapter 6 demonstrated that 5 year old children reliably form equivalence using the respondent-type training procedure. In this chapter class size was increased to a four member class and the effectiveness of the procedure using a linear, one-to-many and many-to-one protocol was also investigated.

In Chapter 7, five year old children were successfully taught to form fraction-decimal equivalence using the respondent-type training procedure. Subjects also showed generalisation based of physical similarity.

In Chapter 8, the theoretical issues arising from this thesis are discussed

Chapter 1: Introduction

The Issue of Untrained Behaviours

Psychologists have long recognised that particular features of human behaviour, such as language, reasoning and problem solving may emerge without direct training (e.g., Anderson, 1990; Benedict, 1979; Vygotsky, 1962). Therefore, psychologists are faced with the challenge of accounting for such untrained verbal and cognitive skills. Recently a growing behaviour-analytic literature has been addressing these issues. Much of this behavioural literature concerns the development of stimulus classes. What has been known as stimulus equivalence is a special case of stimulus class formation, and provides a rigorous means of predicting and assessing untrained cognitive and verbal performances. Perhaps for that reason, the equivalence paradigm has attracted increased attention. The current thesis is concerned primarily with developing and exploring a new methodology for establishing equivalence classes. Before focusing on this new procedure, I will first outline the phenomenon of stimulus equivalence.

Stimulus Equivalence

When humans are taught a series of related conditional discriminations, the stimuli that enter into these discriminations, often become connected to each other in novel ways not explicitly taught in training. The emergence of this untaught performance, which is not predicted by the traditional concept of conditional discrimination, is referred to as Stimulus Equivalence.

This phenomenon has been investigated using a "matching-to-sample" technique as developed by Murray Sidman (e.g., 1971, 1980, 1986, 1987). In a typical experiment, subjects are taught to select stimulus B and stimulus C (called the comparisons) in the presence of A (called the sample). During

testing, subjects may select A in the presence of A (reflexivity), A in the presence of both C and B (symmetry) and C in the presence of B and B in the presence of C (combined symmetry and transitivity), in the absence of differential reinforcement. Neither B nor C has a history of differential reinforcement as a conditional discriminative stimulus with regard to the other, and therefore neither stimulus should reliably control selection of the other (Barnes 1994).

Stimulus equivalence and its related phenomena have created much excitement and considerable research activity within the behaviour analytic community in recent years. It has merited this attention in part because stimulus equivalence is closely related to complex human behaviour and in particular verbal behaviour. Evidence to support this equivalence/language relationship has been provided by a number of recent studies. First, equivalence has not been clearly demonstrated in either non-verbal humans or non human populations (see Barnes, McCullagh & Keenan, 1990), although it has been widely observed in verbally- able subjects. Second, equivalence procedures have been successfully employed as a useful tool in treating language deficits in verbally disabled individuals (see Cowley, Green & Braulington-McMorrow, 1992; Sidman & Tailby, 1982). Third, children who previously failed an equivalence test, succeeded in passing when taught to verbally name the stimuli involved (e.g., Dugdale & Lowe, 1990). Finally, stimulus equivalence has been used in the investigation of symbolic meaning and the generative nature of grammar (e.g., Barnes & Hampson, 1992; Barnes & Holmes, 1991).

Alternative Interpretations

In the early days of equivalence research theorists attempted to explain equivalence in terms of respondent processes such as mediated generalisation.

Such theorists took it for granted that any instance of acquired stimulus equivalence had to be mediated by a response that both equivalent stimuli controlled in common.

In an early review, Cofer and Foley (1942) characterised mediated generalisation as not as depending on physical similarities among stimuli but on arbitrary stimulus equivalences that have been established by "previously conditioned (usually language) behaviour" (p.519). They suggested the following as a simplified pavlovian conditioned schema of mediated generalisation:

At some pre-experimental time, the subject has become conditioned either by direct reinforcement or by higher order conditioning, to make Rx to CS1, CS2, CS3...CSn. The subject is next experimentally conditioned by reinforcing CS1, with UCSy setting up a conditioned response, Ry. Generalisation is now found to CS2...CSn...(p.520).

Today we are more likely to attribute the behavioural practices to which we give the name language to operant rather than respondent conditioning processes (Skinner, 1938;1957;1974). Indeed, if we were to construct a schema similar to that of Cofer and Foley, we would derive mediated generalisation from the three-term operant contingency (Skinner 1938).

Cofer and Foley's unstated assumption was that generalisation among physically dissimilar stimuli has to be mediated by a response. That is to say, stimuli in the schema, CS1...CSn become members of the same class because each controls the same response, Rx. To account for this, they hypothesise the following non-observable mechanism:

When CS1 is conditioned to a new response Ry, it also produces the original response Rx; thus, the stimulus consequences of Rx come to

elicit Ry and so, when the stimuli CS2...CSn are tested, they will first produce Rx, which in turn will produce Ry (p.522).

This issue was empirically investigated by Sidman, Cresson & Wilson-Morris (1974). The purpose of this study was to investigate whether mediated generalisation demonstrated within the context of matching-to-sample requires a response as the mediator. Two severely retarded Down's syndrome boys were first taught to match A (auditory name dictated to the subject) to B (visual pictures). Subjects were then taught to match B to C (visual names printed). Subjects were then tested for the emergence of AC (auditory receptive reading) and CD (oral reading). If the direct absence of direct AC training prevented the subject from learning to name the printed words (CD) but AC itself still emerged from AB and BC training, then the possibility of response mediation would have to be considered. Subjects successfully completed both AC and CD tests. Response mediation as a basic mechanism of stimulus equivalence could no longer be accepted.

As research in the area of stimulus equivalence progressed, researchers began to use classes of stimuli larger than three members (Sidman & Tailby, 1982; Sidman, Kirby, & Wilson-Morris, 1985). If the mediated generalisation approach to stimulus equivalence was to continue, then this progression would have to be incorporated within their theoretical framework. Jenkins (1963) described 16 paired associate paradigms that would have to be shown to produce four-member classes if the mediation theory of stimulus and response equivalences was to be validated. In Jenkins study 16 subjects were studied in each of the 16 paradigms. No mediation effects were found. This marked the end of the mediated generalisation theory of stimulus and response equivalence.

Although we no longer appeal to respondent processes as a theoretical framework, respondent-type procedures may still be used in equivalence

research. The purpose of this thesis is to investigate whether a non-operant procedure may be used to generate derived relational responding. In the final chapter, this new procedure will be interpreted using Relational Frame Theory (e.g., Hayes 1991).

An Alternative Procedure

The training procedures employed in the investigation of stimulus equivalence typically incorporate some form of operant requirement. For example, simple discriminations (e.g., deRose, McIlvane, Dube, Galpin, & Stoddard, 1988), conditional discriminations (e.g., Barnes, McCullagh & Keenan, 1990; Devany, Hayes, S. C. & Nelson, 1986; Sidman, 1971; Sidman & Tailby, 1982; Smeets, Schenk & Barnes, 1995), and differentially reinforced sequence responses (Green, Stromer & Mackay, 1993) have all been used in equivalence research. Although a number of recent equivalence studies have also employed multi-element or compound stimuli in training and testing for equivalence relations (Markham & Dougher, 1993; Smeets et al., 1995; Stromer & Mackay, 1993; Stromer, McIlvane & Serna, 1993), all of these experiments employed some form of operant training (i.e., presenting differential consequences contingent upon certain responses) before testing for equivalence relations.

To date, no published experimental study has attempted to generate equivalence responding using a respondent, rather than an operant, training procedure. Consequently, one important step in identifying the necessary and/or sufficient conditions for producing equivalence responding, would be to determine whether stimulus equivalence emerges when a respondent-type training procedure is used. Consider, for example, one such procedure in which an arbitrary stimulus A reliably predicts the appearance of a second arbitrary stimulus B (i.e., $A \rightarrow B$). Following sufficient exposure to this stimulus pairing, would a subject reliably choose stimulus A in the presence of

B on a matching-to-sample task? In effect, having been exposed to A->B respondent-type training, would the subject respond in accordance with the B-A symmetry relation? Furthermore, if stimulus A always precedes B and B always precedes C in a respondent-type training procedure (A->B->C), would a subject reliably choose A in the presence of C on a subsequent matching-to-sample task? In other words, having been exposed to A->B->C respondent-type training, would the subject respond in accordance with the C-A equivalence relation? This thesis aimed to investigate this and related issues.

The Current Thesis

The program of research reported in the current thesis started by addressing the basic procedural question of whether respondent-type training would establish symmetry and equivalence responding in adult humans. In some of the experiments reported in Chapter 2, nine nonsense syllables were presented to human adult subject in the form of six stimulus pairs. The first stimulus of each pair was presented for 1-s. The screen then cleared for 0.5-s (the within-pair-delay) and the second stimulus of the pair appeared for 1-s. The screen then cleared for 3-s (the between-pair-delay) before the next stimulus pair was presented. All six stimulus pairs were presented 10 times in a quasi-random order across 60 trials. Subjects were then presented with a standard matching-to-sample equivalence test that tested for the emergent symmetry and equivalence relations. The majority of subjects successfully demonstrated equivalence responding after two, three or four exposures to the training and testing. Having demonstrated that the respondent procedure reliably produces equivalence classes, the experiments reported in Chapter 3 examined the effects of varying both the within and between-pair delays. For example, in one condition, 1 and 3 mins was used, and adults subjects still demonstrated the reliable formation of equivalence classes under these conditions. Thus, it was shown that the respondent procedure was not limited

to the relatively short delays used in the experiments reported in the previous chapter. It was also demonstrated that decreasing stimulus pair presentations and increasing class size did not adversely effect performance on equivalence tests.

The majority of research in the area of stimulus equivalence has employed the matching-to-sample methodology. Thus the experiments reported in Chapter 4, systematically compared the effectiveness of the respondent-type procedure with the matching-to-sample training procedure. On a trial-for-trial basis the respondent-type procedure was found to be superior to the matching-to-sample training procedure. The latter procedure, however, was found to be as effective as the respondent-type procedure when the negative comparisons used during matching-to-sample training were removed.

Having identified the presence of the negative comparison as a source of disruption in the formation of equivalence classes using the matching-to-sample procedure, the experiments reported in Chapter 5 examined the effects of manipulating the functions of the negative comparisons on equivalence class formation. Specifically, various types of matching-to-sample arrangements were used that inadvertently promoted instances of contiguity between the positive and negative comparisons that either facilitated or competed against the formation of equivalence classes in young children and adults. For example, when subjects were trained, using a standard matching-to-sample procedure, to pick the comparison B1 given A1 as a sample, with C2 as a negative comparison, and C1 given A1, with B2 as a negative comparison, during a test trial in which B1 was presented with C1 and C2 as comparisons, young subjects normally selected C2, rather than the equivalent C1. Older subjects, however, did not respond in this way (i.e., they responded in accordance with the B1-C1 equivalence relations). A number of experiments in Chapter 5 showed that the children's performances were due to the fact that

B1 and C2 were presented contiguously as comparisons during the training trials.

In most of the experiments reported in Chapter 5 young children were used as subjects. At this point in the research program, therefore, it was deemed important to use this subject population with the respondent-type training procedure. The experiments reported in Chapter 6 investigated whether young children are capable of successfully forming equivalence classes using this procedure. The results showed that they were, and a number of other procedural issues were also addressed. For example, it was shown that children readily formed four-member equivalence classes using the respondent-type training procedure.

Given the high success rate reported in Chapter 6, the experiments reported in Chapter 7 sought to apply the respondent-type training procedure in an educational context. Across three experiments, five year old children were successfully taught to form fraction and decimal equivalencies using the respondent-type training procedure.

In the final Chapter of the thesis, some of the theoretical issues arising from all of this empirical work is considered. In brief, the current results are interpreted using Relational Frame Theory (e.g., Hayes, 1991). This theory suggests that the respondent-type procedure produces equivalence class formation in both children and adults based, in part, on the subjects' histories of interaction with the verbal community.

Finally, experimental procedures are outlined in detail in each chapter. This may result in some repetition but this was deemed necessary, as cross-referencing of procedures between chapters is confusing to the reader.

Chapter 2:

Developing the Respondent-type Training Procedure

The purpose of Experiment 1 was to discover whether adult subjects would respond in accordance with symmetry and equivalence relations having been exposed to A->B->C respondent-type¹ training.

In Condition 1 (Experiment 1) 5 subjects were provided with detailed instructions that specified that the first part of the experiment (the respondent training) was related to the second part (the equivalence test). The 5 subjects were exposed to a respondent training procedure in which six stimulus pairs (A1->B1, B1->C1, A2->B2, B2->C2, A3->B3, B3->C3) were presented to the subjects on a computer screen (i.e., no overt observing responses were required). A 0.5-s 'within-pair-delay' separated the presentation of the stimulus pairs (e.g., A1 → blank screen for 0.5 s → B1), and a 3-s 'between-pair-delay' separated the presentation of stimuli from separate stimulus pairs (e.g., B1 → blank screen for 3 s → B2). At this point in the research program we assumed that the within-pair-delays would have to be discriminably shorter than the between-pair-delays, otherwise subjects would be unable to discriminate six distinct stimulus pairs, and they would therefore fail to respond in accordance with the predicted equivalence relations. Following respondent training subjects were exposed to a standard matching-to-sample procedure that tested for responding in accordance with symmetry relations (i.e., B1-A1, B2-A2, B3-A3, C1-B1, C2-B2, C3-B3) and equivalence relations (C1-B1, C2-B2, C3-B3).

¹ I have included the suffix "type" to indicate that the respondent training procedure described in this paper departs somewhat from traditional respondent conditioning experiments. For example, the complete respondent-type training procedure (described in the next section) presents nine conditional stimuli (i.e., nonsense syllables) in various sequences, whereas a typical respondent conditioning experiment presents one or two conditional stimuli and an unconditional stimulus. For ease of communication, however, the suffix, "type" will not be used in the remaining text.

In Condition 2, an additional 5 subjects were exposed to the same procedures, except that minimal instructions were used (i.e., the instructions did not specify a relationship between the first and second parts of the experiment). This condition allowed us to assess whether specifying a link between respondent training and equivalence testing, facilitates, suppresses, or does not effect the emergence of equivalence responding (see Green, Sigurdardottir, & Saunders, R. R., 1991; Saunders, K. J., Saunders, R. R. Williams, & Spradlin, 1993; Sigurdardottir, Green, & Saunders, R. R., 1990).

Finally, in Condition 3 another 5 subjects were exposed to the same procedures employed in Condition 2 (minimal instructions), except that the 3-s between-pair-delay was reduced to 0.5-s (i.e., all stimuli were separated by 0.5-s). This final condition allowed us to test our assumption that shorter within-pair-delays, relative to between-pair-delays, were required for equivalence responding to emerge.

In the interests of clarity each of the remaining two experiments will be introduced separately.

General Method

Subjects

Forty five students, 25 female and 20 male, of University College Cork served as subjects. Their ages ranged from 18 to 25 years. All participants were recruited through personal contacts and faculty board advertisements and were randomly assigned to one of the seven experimental conditions (i.e., five in each condition), across three separate experiments. All subjects were experimentally naive and were non-psychology majors. Sessions were arranged so that participants would not meet each other in the vicinity of the laboratory, and all were instructed not to inform or discuss their participation in the study with anyone. If a subject did not complete the experiment during the first visit to the laboratory, he or she was asked to return on a subsequent day

(usually the next day). In fact, only two subjects (6 and 14) had to attend more than once to complete their participation in the study.

Apparatus

Each subject was seated in a small experimental room, with an Apple Macintosh SE microcomputer, which displayed black characters on a white background. Stimulus presentation and the recording of responses were controlled by the computer which was programmed in BBC BASIC. The Z, V, and M keys were marked with white paper dots to designate them as response keys. Nine nonsense syllables (CUG, ZID, VEK, YIM, DAX, PAF, ROG, MAU, JOM; see Barnes & Keenan, 1993) were randomly assigned to their respective roles as sample and comparison stimuli for each subject in the study.

Experiment 1

Procedure

Condition 1

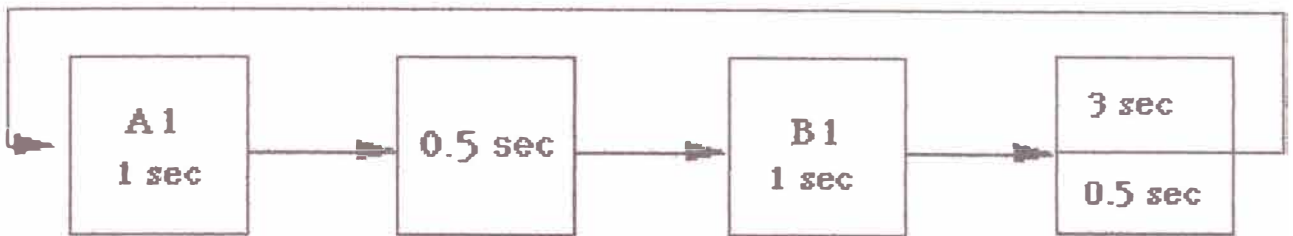
In Condition 1 (detailed instructions/random sequence of stimulus pairs/3-s between-pair-delays), participants were seated in the experimental room and the following instructions were presented on the computer screen (the instructions are described as detailed because they related the first part of the experiment to the second part):

During the first stage of this experiment you will be presented with nonsense syllables on the computer screen. You should pay close attention to this first stage because it is relevant to the second stage of the experiment. Press the space-bar twice when you are ready to begin.

Each session was divided into two stages: (a) respondent training and (b) equivalence testing.

Respondent training: During the respondent training nine nonsense syllables were presented to the subjects in the form of six stimulus pairs (see Figure 1, panel 2). The stimulus pairs were designated A1→B1, B1→C1, A2→B2, B2→C2, A3→B3, B3→C3. Each stimulus pair was presented in the following sequence (see Figure 1, panel 1). The first stimulus of each pair was presented for 1- s (e.g., A1), and the computer screen was then cleared for 0.5-s (i.e., the within-pair-delay). The second stimulus in the pair (i.e., B1 always followed A1) was presented for 1-s and the screen was then cleared for 3-s (i.e., the between-pair-delay). Following the 3-s between-pair-delay the next stimulus pair was presented (e.g., B3-C3). All six stimulus pairs were presented in this fashion, in a quasi-random order for 60 trials, the only constraint being that each stimulus pair was presented once in each successive block of 6 trials (i.e., each stimulus pair was presented 10 times). When all 60 trials had been presented, the screen went blank for 5- s; the equivalence testing instructions then appeared immediately on the screen (see next section).

Equivalence testing: During this stage subjects were presented with a standard, matching-to-sample equivalence test that examined the six symmetry relations (B1-A1, B2-A2, B3-A3, C1-B1, C2-B2, C3-B3) and the three equivalence relations (C1-A1, C2-A2, C3-A3). The test consisted of the nine matching-to-sample tasks. The sample was always presented in the centre, top half of the computer screen (5 cm from the upper edge). The three comparison stimuli appeared 1.5 s after the sample stimulus was presented; no overt observing response was required and the sample remained on the screen with the comparisons. The comparisons were presented in a line, 3 cm from the lower edge of the screen. The three comparisons appeared 6 cm from the right, 6 cm to the left, and directly below the sample. The location of the comparisons was counterbalanced across test trials. Participants selected the left, middle, or right comparison by pressing the “Z,” “V,” or “M,” keys, respectively. When a comparison had been selected, the screen cleared



EXPERIMENT 1

Condition 1 and 2: Random Sequence/ 3s Between-Pair-Delays
A3→B3 / B1→C1 / A1→B1 / B3→C3 / B2→C2 / A2→B2

Condition 3: random Sequence / 0.5s Between-Pair-Delays
A3→B3/B1→C1/A1→B1/B3→C3/B2→C2/A2→B2

EXPERIMENT 2

Condition 4: Linear Sequence/ 3s Between-Pair-Delays
A1→B1 → B1→C1 → A2→B2 → B2→C2 → A3→B3 → B3→C3

Condition 5: Linear Sequence/ 0.5s Between-Pair-Delay
A1→B1→B1→C1→A2→B2→B2→C2→A3→B3→B3→C3

EXPERIMENT 3

Condition 6: Nonlinear Sequence/ 3s Between-Pair-Delays
A1→B1 → A2→B2 → A3→B3 → B1→C1 → B2→C2 → B3→C3

Condition 7: Nonlinear Sequence/ 0.5s Between-Pair-Delays
A1→B1→A2→B2→A3→B3→B1→C1→B2→C2→B3→C3

EXPERIMENT 4

Condition 8: One-To-Many/Random Sequence/3s Between-Pair-Delay
A1→C1/ A2→B2/ A3→C3/ A1→B1/ A3→B3/ A2→C2

Condition 9: Many-To-One/Random Sequence/3s Between-Pair-Delay
C1→A1/ B2→A2/ C3→A3/ B1→A1/ B3→A3/ C2→A2

Figure 1: Diagrammatic representation of the respondent training procedure (top panel). Lower panels represents the sequence in which the stimulus pairs were presented across nine conditions in the four experiments.

immediately and remained blank for 3-s. The next matching-to-sample trial was then presented (i.e., no feedback was presented during the equivalence test). Before participants were exposed to the equivalence test the following

instructions appeared on the computer screen (i.e., 5-s after the last respondent training trial:

That is the end of the first stage of the experiment. In the next stage one of the three nonsense syllables at the bottom by pressing one of the marked keys on the keyboard. To choose the left syllable, press the marked key on the left. To choose the middle syllable, press the marked key in the middle. To choose the right syllable, press the marked key on the right.

Press the space-bar twice to continue.

The nine matching-to-sample tasks were presented in a quasi-random order for 90 trials, the only constraint being that each of the nine tasks occurred once within each block of 9 trials (i.e., each matching-to-sample task was presented 10 times; 60 symmetry test trials and 30 equivalence test trials). A consistency criterion was used that required each participant must choose the same but not necessarily correct comparison at least 9 times out of 10 on each of the 9 tasks (for ease of communication, “correct” will be used to describe responses that are in accordance with the symmetry and equivalence relations). This consistency criterion was used to control for the effects of inadvertent feedback provided by repeated training and testing (see Barnes & Keenan, 1993). If a subject produced an inconsistent performance (i.e., less than 9 out of 10 “same responses” on any of the tasks) he or she was immediately re-exposed to the entire experimental procedure (i.e., respondent training and equivalence testing with the same instructions). Because of time constraints, however, Subjects 6 and 14 were allowed a 24-hr break between Exposures 4 and 5. If a subject did not produce a consistent performance by the fourth exposure to the entire experimental sequence, and the performance was less than 50% correct (i.e., the subject produced less than 45 correct responses), the

performance was classified as inconsistent and the subject's participation in the study was terminated. If, however, a subject produced more than 50% correct responding on a fourth exposure to the equivalence test, additional exposures to the training and testing were provided until he or she either produced less than 50% correct or produced a consistent performance (with three comparison stimuli, 50% correct was 17 points above chance). This criterion thereby ensured that a subject who produced an inconsistent performance, that was considerably higher than chance, would not be prevented from retraining and retesting.

Condition 2

Condition 2 (minimal instructions/random sequence of stimulus pairs/3-s between-pair-delays) was identical to Condition 1, except that subjects did not receive the detailed instructions that were given before the respondent training phase of Condition 1 (see Figure 1, panel 2). Instead, the words "Look at the screen" (i.e., minimal instructions) were presented on the computer monitor before the respondent training was initiated. All remaining conditions (3 to 7) across the three experiments also used minimal instructions. Note, however, that the instructions given before the matching-to-sample equivalence test in Condition 1 were also used in this and in all other conditions.

Condition 3

Condition 3 (random sequence of stimulus pairs/0.5-s between-pair-delays) was identical to Condition 2, except that the between-pair-delay of 3-s was reduced to 0.5-s (see Figure 1, panel 3). In effect, there was a 0.5-s delay between the presentation of each stimulus during the respondent training in this condition.

Results and Discussion

Percentages of correct responses on the 60 symmetry test trials (i.e., B-A and C-B tasks) and on the 30 equivalence test trials (i.e., C-A tasks) for each individual exposure to the equivalence test for Subjects 1 to 15 are presented in Tables 1, 2 and 3. Subjects in Conditions 1, 2, and 3 (except Subjects 10 and 15) produced almost perfect symmetry and equivalence responding. Subjects 10 and 15 showed a consistently incorrect performance on their third and second exposures respectively, and thus their participation in the study was terminated. Six exposures was the maximum required (Subjects 6 and 14) and two was the minimum (Subjects 3, 9, and 15). These data clearly show that the respondent training procedure, combined with either detailed or minimal instructions, can reliably generate equivalence responding in the absence of explicit operant conditioning in the experimental context (because the use of detailed instructions proved to be unnecessary for producing equivalence responding, the remaining experiments reported here utilised only minimal instructions).

Interestingly, in Condition 3, Experiment 1 (random sequence of stimulus pairs/0.5-s between-pair-delays) four participants produced almost perfect equivalence responding. As indicated in the introduction, this outcome was not predicted; it was assumed that reducing the 3-s between-pair-delays to 0.5-s (i.e., to the same value as the within-pair-delays) would prevent subjects from discriminating the six separate stimulus pairs and would thus prevent the formation of equivalence relations. Imagine, for example, that a subject is presented with the following sequence A3→B3/A1→B1 during the first block of six respondent training trials; how might this subject discriminate the A3→B3 pairing from the A1→B1 pairing if each stimulus is separated by the same time interval of 0.5-s (i.e., from the subject's perspective, is B3 paired with A3 or A1)? To answer this question we considered the consistency versus

Table 1
 Random Sequence/Detailed Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 1.

Subject	1		2		3		4	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S1	37	67	15	67	95	97	100	100
S2	17	20	68	43	100	100		
S3	47	30	100	100				
S4	60	30	97	93	100	100		
S5	42	27	83	13	100	100		

Table 2
 Random Sequence/Minimal Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 2.

Subject	1		2		3		4		5		6	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S6	37	10	98	63	98	27	100	3	98	93	100	100
S7	27	23	40	43	47	23	67	27	98	100		
S8	42	27	100	87	100	100						
S9	43	23	100	100								
S10	25	37	33	33	33	30 (consistently incorrect)						

Table 3
 Random Sequence/Minimal Instructions/0.5-s Between-Pair- Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 3.													
Subject	1		2		3		4		5		6		
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		
S11	55	27	92	57	88	43	100	100					
S12	37	17	70	37	98	97							
S13	28	40	68	87	85	20	77	93	97	100			
S14	35	23	63	37	87	47	87	27	68	93	100	100	
S15	98	3	98	0 (consistently incorrect)									

inconsistency of the stimulus pairings across the entire respondent training procedure. In effect, although a subject might not discriminate the A3→B3 pairing from the A1→B1 pairing across the first block of six respondent training trials, in the next block of six trials (and every block thereafter) A3→B3 may be followed by any of the other stimulus pairs (e.g., B2→C2), and thus across blocks of six trials A3→B3 and A1→B1 are paired consistently whereas B3→A1 are not. Experiment 2 was designed to examine this issue.

Experiment 2

Experiment 2 consisted of Conditions 4 and 5. In both of these conditions the respondent training was modified so that the stimuli were always presented in the same fixed sequence, so that subjects could not discriminate the six stimulus pairs based on the consistency versus inconsistency of the

stimulus pairings. In Condition 4, the within-pair-delays were shorter than the between-pair delays (0.5-s and 3-s, respectively), but in Condition 5 both delays were the same (0.5-s). It was predicted that subjects in Condition 4 would produce equivalence responding (based on the differential within-and between-pair-delays), but subjects in Condition 5 would not (because both types of delays are set to the same value).

Procedure

Condition 4

Condition 4 (linear sequence of stimulus pairs/3-s between-pair-delays) was identical to Condition 2, except that the stimulus pairs were always presented in the same, fixed sequence during the training phase (A1 → B1, B1 → C1, A2 → B2, B2 → C2, A3 → B3, B3 → C3; see Figure 1, panel 4). The term “linear” is used to describe this sequence because the stimuli participating in each predicted equivalence relation were presented in the same A → B → C, linear-like sequence. Presenting the stimuli in this way ensures that each stimulus always appears in a consistent position in the sequence relative to the others; subjects can not, therefore, discriminate the six stimulus pairs based on the consistency versus inconsistency of the stimulus pairings. In this condition, however, it was predicted that the 3-s between-pair-delays, relative to the 0.5-s within-pair-delays, would allow the subjects to discriminate the six pairs of stimuli and therefore demonstrate equivalence responding.

Condition 5

Condition 5 (linear sequence of stimulus pairs/0.5-s between pair-delays) was identical to Condition 4, except that the 3-s between-pair-delays were reduced to 0.5- s (Figure 1, panel 5). It was predicted that the between-pair-delays of 0.5- s, combined with the fixed linear sequence, would prevent reliable discrimination of the six stimulus pairs. For example, how might

subjects discriminate reliably the B1→C1 pairing from the C1→A2 pairing if each stimulus presentation is separated by 0.5- s and the stimuli are always presented in the same fixed order (i.e., from the subjects' perspective, is C1 paired with B1 or A2)? Furthermore, if the subjects fail to discriminate reliably the six stimulus pairs, it is also likely that they will fail to demonstrate reliably the formation of the predicted equivalence relations. For example, when C1 is presented as a sample with A1, A2, and A3 as comparisons, will subjects select A1 based on the A1→B1→C1 stimulus pairings, A2 based on the C1→A2 stimulus pairings, or A3 based on the C1→A2→B2→C2→A3 stimulus pairings?

Results and Discussion

The percentages of correct responses on the symmetry and equivalence test trials for each individual exposure to the equivalence test for Subjects 16 to 25 are presented in Tables 4 and 5. In Condition 4 (linear sequence/3-s between-pair-delays), Subjects 16, 17, 18, and 19 produced near perfect symmetry and equivalence responding on either the first, second, or third exposure to the test. Subject 20 produced consistently incorrect responding on the first exposure. In Condition 5 (linear sequence/0.5-s between-pair-delays), Subject 21 was the only one of the five subjects to demonstrate equivalence responding (on the second exposure to the test). Subjects 22 and 23 produced near perfect symmetry responding, but did not produce any equivalence responding on their second and third exposures, respectively (i.e., consistently incorrect performances). Subject 24 was consistently incorrect on the first exposure. Subject 25 produced inconsistent responding across 4 exposures to the test, and failed to exceed 50% correct responding; hence the subject's participation in the study was terminated.

The fact that two subjects produced almost perfect symmetry but no equivalence responding in the linear/0.5-s between-pair-delays condition

suggests that the stimulus pairings during this respondent training procedure may sometimes facilitate the formation of symmetry but not equivalence relations (see Table 5, Subjects 22 and 23). Inspection of Figure 1 (Condition 5) allows us to see how this might have happened. Consider, for example, the first five stimuli in the respondent training (A1→B1→B1→C1→A2). In this sequence, B1 is always paired with A1 and C1, and C1 is always paired with B1 and A2. Consequently, during a symmetry test, in which B1 is presented as a sample and A1, A2, and A3 are presented as comparisons, A1 is the only stimulus that has been paired with the sample B1. Similarly, on a symmetry test in which C1 is presented with B1, B2, and B3, B1 is the only comparison that has been paired with the sample C1. Insofar as some subjects are likely to select a comparison that was directly paired with the sample during the respondent training, symmetry responding may sometimes emerge following this procedure. Consider now, the equivalence test trial where C1 (the sample) is presented with A1, A2, and A3 (the comparisons). During the respondent training, C1 has been paired directly with A2 but not A1 (i.e., it is removed from A1 by B1). Thus, subjects may choose the directly paired A2 comparison, rather than the A1 comparison that is paired indirectly to C1 through the B1 stimulus (i.e., A1-B1-C1). (Note, however, that the symmetry and equivalence responding produced by Subject 21 suggests that in some instances the symmetry-facilitating effect of the linear sequence may also produce equivalence responding). In summary, therefore, symmetry responding in the absence of equivalence responding may be predicted for the linear/0.5-s between-pair-delays condition, if we accept that some subjects are likely to match comparisons to samples that were directly paired during the respondent training. The next experiment was designed to examine this issue.

Table 4
 Linear Sequence/Minimal Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 4.

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	
S16	98	100				
S17	27	17	100	100		
S18	33	23	100	100		
S19	68	7	85	90	98	97
S20	100	0 (consistently incorrect)				

Table 5
 Linear Sequence/Detailed Instructions/0.5-s Between-Pair- Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 5.

Subject	1		2		3		4	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S21	95	97	100	100				
S22	80	19	95	0 (consistently incorrect)				
S23	27	20	3	0	97	0 (consistently incorrect)		
S24	48	0 (consistently incorrect)						
S25	23	53	30	27	25	20	17	20 (inconsistent)

Experiment 3

Experiment 3 consisted of Conditions 6 and 7. In both of these conditions, the fixed linear sequence employed in Experiment 2 was modified so that the stimuli were presented in a fixed nonlinear sequence (i.e., A1→B1, A2→B2, A3→B3, B1→C1, B2→C2, B3→C3). The term “nonlinear” is used to describe this sequence because the A and B stimuli participating in each of the predicted equivalence relations were presented before the B and C stimuli from each of the predicted relations. The nonlinear sequence training ensured that on four of the six tasks that tested for symmetry responding, two of the comparison stimuli (one “correct” and the other “incorrect”) had been directly paired, during training, with the sample stimulus (e.g., B1 was directly paired with A1 and A2). In effect, either comparison was equally correct based on direct pairing. It was predicted, therefore, that reliable symmetry responding, in the absence of equivalence responding, would not occur with any subject using the nonlinear training procedure.

In Condition 6, the within-pair-delays were shorter than the between-pair-delays (0.5- s and 3- s, respectively), but in Condition 7 both delays were the same (0.5- s). It was predicted that subjects in Condition 6 would produce equivalence responding (based on the differential within-and between-pair-delays), but subjects in Condition 7 would not (because both types of delays are set to the same value). Furthermore, subjects in Condition 7 should produce neither symmetry nor equivalence responding.

Procedure

Condition 6

Condition 6 (nonlinear sequence of stimulus pairs/3-s between-pair-delays) was identical to Condition 4, except that the stimulus pairs were always presented in the same nonlinear sequence during the respondent training procedure (i.e., A1→B1, A2→B2, A3→B3, B1→C1, B2→C2, B3→C3; see

Figure 1, panel 6). Presenting the stimuli in this way ensured that each stimulus always appeared in a consistent position in the sequence relative to the others, and thus, as in the previous experiment, the subjects could not discriminate the six stimulus pairs based on the consistency versus inconsistency of the stimulus pairings. Although Condition 6 employed a fixed, nonlinear sequence, it also used 3-s between-pair-delays. Consequently, it was predicted that these delays, relative to the 0.5-s within-pair-delays, would allow the subjects to discriminate the six stimulus pairs and therefore demonstrate equivalence responding.

Condition 7

Condition 7 (nonlinear sequence of stimulus pairs/0.5-s between-pair-delays) was identical to Condition 6, except that the between-pair-delays of 3 s were reduced to 0.5 s (Figure 1, panel 7). It was predicted that the 0.5-s between-pair-delays combined with the nonlinear sequence would prevent the “symmetry facilitating effect” of Condition 5. Consider, for example, the first five stimuli in the nonlinear sequence (i.e., A1->B1->A2->B2->A3). In this sequence, B1 is directly paired with both A1 and A2, and thus during a symmetry test in which B1 is presented as a sample with A1, A2, and A3 as comparisons, both A1 and A2 are equally likely choices if a subject simply selects the comparison that was directly paired with the sample during respondent training.

Results and Discussion

The percentage of correct responses on the symmetry and equivalence test trials for each individual exposure to the equivalence test for Subjects 26 to 35 are presented in Tables 6 and 7. In Condition 6, Subjects 26 and 29 produced perfect symmetry and equivalence responding on their second exposures, and Subjects 27 and 28 were almost perfect on their third

exposures. Subject 30 produced a consistently incorrect performance on the third exposure. In Condition 7, Subjects 31, 32, and 35 produced inconsistent (and below 50% correct) responding, and their participation was terminated after their fourth exposures, in accordance with the consistency criterion. Subjects 33 and 34 were consistently incorrect on their third and second exposures respectively, and neither of these subjects produced symmetrical responding (see Table 3). As predicted, therefore, the “symmetry generating effect” of the linear/0.5-s between-pair-delays condition was absent in the nonlinear/0.5-s between-pair-delays condition. The seven experimental conditions presented thus far clearly show that it is possible to establish equivalence using a respondent-type training procedure. This demonstration opens new avenues of research to the experimentalist. One important avenue would involve an examination of those variables which have been found either to facilitate or suppress the formation of equivalence relations in human subjects. Experiment 4 adopted this strategy.

Experiment 4

In studies performed by Saunders, Wacher and Spradlin (1988) and Spradlin and Saunders (1986), it has been found that multiple-sample single-comparison conditional discrimination training (many-to-one) appears to produce equivalence responding more readily than single-sample multiple-comparison training (one-to-many). In condition 1 of the Saunders et al. study three subjects were exposed to many-to-one training in which they were taught to select from a single pair of comparison stimuli (A1, A2) in response to eight sample stimuli that were trained in pairs (B1, B2; C1, C2; D1, D2; E1, E2). In Condition 2 three subjects were exposed to one-to-many training in which they were taught to choose from 4 pairs of comparisons (B1, B2; C1, C2; D1, D2; E1, E2) in response to a single pair of comparison stimuli (A1, A2).

Table 6
 Nonlinear Sequence/Minimal Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 6.

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	
S26	97	97	100	100		
S27	52	47	68	43	97	100
S28	83	97	92	90	100	97
S29	80	83	100	100		
S30	10	17	48	0	52	0 (consistently incorrect)

Table 7
 Nonlinear Sequence/Minimal Instructions/0.5-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Condition 7.

Subject	1		2		3		4	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S31	52	10	50	17	52	33	35	33 (inconsistent)
S32	38	33	45	3	62	27	52	10 (inconsistent)
S33	35	3	47	37	50	30 (consistently incorrect)		
S34	60	0	65	53 (consistently incorrect)				
S35	42	13	35	27	18	20	28	33 (inconsistent)

During testing, all three subjects were exposed to the many-to-one training procedure showed the formation of equivalence relations, but only one of the three subjects exposed to the one-to-many training showed equivalence responding. Although these data were obtained with a small number of mentally retarded individuals, other data indicates that this training effect can be replicated with larger numbers of university undergraduates (Barnes, 1994). In this study, 10 subjects were exposed to many-to-one training, and an additional 10 subjects were exposed to one-to-many training. After meeting a 90% correct training criterion, all 20 subjects were then exposed to a single equivalence test. Nine of the 10 subjects who received the many-to-one training demonstrated equivalence responding, whereas only 4 of the 10 one-to-many subjects showed this performance. Furthermore, recent studies have also found that many-to-one training (relative to one-to-many) facilitates derived performances in non humans subjects such as pigeons (see Urcioli and Zentall, 1993; Zentall and Urcioli, 1993). The present study examined whether the facilitative or suppressive effects of these training arrangements are also evident with the respondent training procedure.

Procedure

Condition 8

This condition was identical to Condition 2 (minimal instructions/ 3-s between-pair-delay/quasi random sequence) except that this condition employed a one-to-many protocol (e.g., present A1->B1, A1->C1 and test B1-A1, C1-A1, B1-C1; see Figure 1, panel 8).

Condition 9

This condition was identical to Condition 8, except that this condition employed a many-to-one protocol (e.g., present B1->A1, C1->A1, and test A1-B1, A1-C1, B1-C1; see Figure 1, panel 9).

Results and Discussion

Percent of correct responses on symmetry and equivalence test trials for each individual exposure to the equivalence test for Subjects 41-50 are presented in Tables 8 and 9.

In Condition 8, Subject 36 produced perfect symmetry and equivalence responding on the third exposure, while Subjects 37, 38 and 39 were successful on the second exposure. Subject 40 produced an inconsistent performance on the fourth exposure.

In Condition 9, Subjects 41 and 43 both produced perfect symmetry and equivalence responding on their second exposures while Subject 42 was almost perfect on the second exposure. Subjects 44 and 45 both produced almost perfect responding on their first exposure. These data tentatively suggest that the many-to-one training facilitated equivalence responding more readily than the one-to-many training. Specifically, all five many-to-one subjects demonstrated equivalence on either their first or second exposure to the equivalence test, whereas four out of five of the one-to-many subjects produced equivalence on their second or third exposure to the test. These data are consistent with previous research (Saunders et al., 1988; Spradlin & Saunders, 1986).

General Discussion

The current study clearly demonstrates that it is possible to produce equivalence responding in adult human subjects using a respondent training procedure. Furthermore, it was shown that the effectiveness of the respondent procedure in producing equivalence is dependent upon (a) the presence of longer between-pair-delays relative to the within-pair-delays and (b) the sequence in which the stimulus pairs are presented. Subjects produced equivalence responding after the random sequencing of stimulus pairs, both with and without detailed instructions (Conditions 1 and 2).

Table 8
 One-to-Many Protocol/Minimal Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Condition 8.

Subject	1		2		3		4	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S36	10	20	100	50	100	100		
S37	62	40	100	97				
S38	25	23	100	100				
S39	97	97	100	100				
S40	13	43	27	33	48	47	28	33 (inconsistent)

Table 9
 Many-to-One Protocol/Minimal Instructions/3-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Condition 9.

Subject	1		2	
	Sym/Equiv		Sym/Equiv	
S41	93	63	100	100
S42	92	97	98	100
S43	93	30	100	100
S44	98	100		
S45	100	100		

Interestingly, when the 3-s between-pair-delay was reduced to 0.5-s, subjects continued to produce equivalence. This finding suggested that the consistency versus inconsistency of stimulus pairing during the random sequencing produced the appropriate discriminations between stimulus pairs (in the absence of the 3-s between-pair-delays) necessary for the formation of equivalence relations. Evidence for this was produced in Experiments 2 and 3 in which most subjects formed equivalence relations when provided with 3-s between-pair-delays, but failed when these delays were reduced to 0.5-s (i.e., the fixed linear and nonlinear sequences prevented the appropriate discriminations between stimulus pairs and thus the formation of equivalence relations observed in the random sequencing conditions).

An interesting issue arising from this study is that the majority of subjects exposed to the respondent training procedure produced symmetry and equivalence responding (i.e., excluding the fixed-sequence, “control” Conditions 5 and 7, 31 out of 35 subjects produced equivalence). This represents an 88% success rate, which compares favourably with the standard matching-to-sample training procedure. For example, Wulfert, Dougher, and Greenway (1991, Experiment 1) reported that 24 out of 29 subjects exposed to a standard matching-to-sample training procedure produced equivalence responding on a subsequent test (i.e., 82.7% success rate). Of course, comparing across studies from different laboratories in this manner can only ever be suggestive, and thus future research will need to compare systematically the respondent training procedure with traditional matching-to-sample training.

Conditions 8 and 9 demonstrated that presenting stimulus pairs in a many-to-one sequence, produced a greater number of equivalence responses during the subjects first exposure to the equivalence test, than that obtained following the one-to-many sequence. These data support the work of previous researchers who have found a many-to-one superiority effect with both human

and non-human subjects (e.g., Saunders, Wachter and Spradlin 1988; Urcuioli and Zentall 1993). The fact that this effect was replicated here using a respondent-type conditioning procedure, supports the idea that the effect may be traced to respondent processes that normally occur unnoticed on the standard matching-to-sample procedure (Barnes, 1994,p.106-117). A further explanation for this effect is offered in Chapter 8.

A related issue concerns the fact that most of the subjects required repeated exposures to the training and testing (i.e., only one subject produced equivalence responding on the first exposure to the test). In other words, subjects required at least two exposures to the training *and* testing stages before equivalence responding emerged. These data indicate that for the majority of the subjects, respondent training alone was necessary, but not sufficient, to produce equivalence responding. Interestingly, a number of equivalence studies that have used matching-to-sample training procedures have reported similar effects (e.g., Cullinan, Barnes, Hampson, & Lyddy, 1994; Dymond & Barnes, 1994; Saunders, K. J., et al., 1993). In a very recent study, however, the need for repeated training and testing was significantly reduced by using a simple-to-complex protocol, in which subjects were trained and tested for symmetry relations, before being trained and tested for more complex relations (i.e., transitivity, and combined symmetry and transitivity) (Fields, Adams, Newman, & Verhave, 1992). Within the context of the current study, the gradual emergence of the predicted performances may have been related to the fact that subjects were trained and then tested for symmetry and combined symmetry and transitivity responding within single blocks. Perhaps, therefore, equivalence would have emerged far more rapidly in the present study, if subjects had been respondently trained on the three A->B tasks and tested for B-A symmetry; then trained on the B->C tasks and tested for C-B symmetry; then tested for A-C transitivity; and then finally tested for C-A combined

symmetry and transitivity. Future studies in this area should certainly examine this possibility.

Perhaps the most remarkable feature of the current study is that explicit, differential reinforcement was not provided for selecting any of the stimuli in a matching-to-sample context before the equivalence test. Previous research has shown that mentally retarded individuals and normally developing children may demonstrate the merger and development of equivalence relations by unreinforced conditional selection of comparison stimuli following a history of explicitly reinforced matching-to-sample responding and successful equivalence testing (Saunders, R. R., Saunders, K. J., Kirby, & Spradlin). In Saunders et al. study, for example, following the formation of equivalence relations subjects were allowed to choose (in the absence of differential reinforcement) which novel comparisons “went with” the previously trained samples, and having done so they consistently related these novel comparisons in a ‘relation-consistent-manner’ to the remaining stimuli participating in the previously established equivalence relations. The procedures of the current study, however, demonstrated reliable equivalence responding without an experimental history of explicit differential reinforcement for matching-to-sample responding, and without an experimental history of successful equivalence testing (furthermore, in all but one condition, only minimal instructions were provided).

In the work reported in this chapter, it was clearly demonstrated that it is possible to produce equivalence responding in adult human subjects using a respondent-type training procedure. Furthermore, it was shown that the effectiveness of the respondent procedure in producing equivalence responding was dependent upon; (a) the presence of longer between-pair-delays (0.5-s) relative to the within-pair-delays (3-s), and (b) the sequence in which the stimulus pairs were presented. In all of the experiments reported in this previous chapter, the duration of the between-and within-pair-delays was

confined to 0.5 and 3 seconds, respectively (both types of delay were set at 0.5 seconds in Conditions 3, 5 & 7). In the research reported in the next chapter these delays were manipulated in order to determine whether the effectiveness of the respondent training procedure was limited to relatively small delays.

Chapter 3:

Varying the Within- and Between-Pair- Delays

Having identified a new training procedure that readily establishes equivalence classes, an important next step in the research program was to address a number of questions that were raised by the development of this new procedure. The intention here was not to explore exhaustively every aspect of the procedure, but rather to sample, if only briefly, a number of the key issues that came up during the early stages of the research program. Four main questions were identified, and these were as follows:

- (1) Is the respondent procedure only effective given the presence of fixed longer between-pair-delays relative to fixed within-pair-delays?
- (2) Will the respondent procedure be as effective if the duration of the within- and between-pair delays is increased?
- (3) Will the respondent procedure be effective if the number of stimulus-pair presentations is reduced?
- (4) Will the respondent procedure be effective if the number of stimulus-pair presentations is reduced and the class size increased?

The experimental work reported in this chapter addressed these questions.

General Method

Subjects

Fifty students, 25 female and 25 male, of University College Cork served as subjects. Their ages ranged from 18 to 25 years. All participants were recruited through personal contacts and faculty board advertisements and were randomly assigned to one of the ten experimental conditions (i.e., five in each condition), across four separate experiments. All subjects were experimentally naive and were non-psychology majors. Sessions were arranged so that participants would not meet each other in the vicinity of the

laboratory, and all were instructed not to inform or discuss their participation in the study with anyone.

Apparatus

Each subject was seated in a small experimental room, with an Apple Macintosh SE microcomputer, which displayed black characters on a white background. Stimulus presentation and the recording of responses were controlled by the computer which was programmed in BBC BASIC. The Z, V, and M keys were marked with white paper dots to designate them as response keys. In Experiments 1, 2, and 3 nine nonsense syllables (CUG, ZID, VEK, YIM, DAX, PAF, ROG, MAU, JOM) were randomly assigned to their respective roles as sample and comparison stimuli for each subject in the study. In Experiment 4, an additional three stimuli were included (BEH, EOG, FIM)

Experiment 1

Procedure

In Experiment 1 (Random Delays: between- and within-pair-delays varied from 0-s to 8-s), participants were seated in the experimental room and the words “Look at the computer screen” (minimal instructions) appeared on the screen before the respondent training was initiated.

Each session was divided into two stages: (a) respondent training, and (b) equivalence testing.

During respondent training nine nonsense syllables were presented to the subject in the form of six stimulus pairs. The stimulus pairs were designated A1->B1, B1->C1, A2->B2, B2->C2, A3->B3, B3->C3. Each stimulus pair was presented in the same linear sequence (i.e., A1->B1, B1->C1, A2->B2, B2->C2, A3->B3, B3->C3). The first stimulus of each pair was presented for 1-s (e.g., A1), and the computer screen was then cleared for a period that varied randomly between 0 and 4-s (i.e., across trials, the average

within-pair-delay was 2-s). The second stimulus in the pair (i.e., B1 always followed A1) was presented for 1-s and the screen was then cleared for a period that varied between 0 and 8-s (i.e., across trials, the average between-pair-delay was 4-s). Following the between-pair-delay the next stimulus pair was presented (e.g., B3->C3). All six stimulus pairs were presented in this fashion, in a fixed order across 60 trials (i.e., each stimulus pair was presented 10 times). When all 60 trials had been presented, the screen went blank for 5-s; the equivalence testing instructions then appeared on the screen.

During the equivalence test the subjects were presented with a standard, matching-to-sample equivalence test that examined the six symmetry relations (B1-A1, B2-A2, B3-A3, C1-B1, C2-B2, C3-B3) and the three equivalence relations (C1-A1, C2-A2, C3-A3). The test consisted of the nine matching-to-sample tasks. The sample was always presented in the centre, top half of the computer screen (5 cm from the upper edge). The three comparisons were presented in a line, 3 cm from the lower edge of the screen. The three comparisons appeared 6 cm to the right, 6cm to the left, and directly below the sample. The locations of the comparisons were counterbalanced across test trials. Participants selected the left, middle, or right comparison by pressing the “Z”, “V”, or “M” keys, respectively. When a comparison had been selected, the screen cleared immediately and remained blank for 3-s. The next matching-to-sample trials was then presented (i.e., no feedback was presented during the equivalence test).

Before participants were exposed to the equivalence test the following instructions appeared on the computer screen (i.e., 5-s after the last respondent training trial):

That is the end of the first stage of the experiment. In the next stage you must look at the nonsense syllable at the top, and then choose one of the three nonsense syllables at the bottom

by pressing one of the marked keys on the keyboard. To choose the left syllable, press the marked key on the left. To choose the middle syllable, press the marked key in the middle. To choose the right syllable, press the marked key on the right.

Press the space-bar twice to continue.

The nine matching-to-sample tasks were presented in a quasi-random order across 90 trials, the only constraint being that each of the nine tasks occurred once within each block of 9 trials (i.e., each matching-to-sample task was presented 10 times; 60 symmetry test trials and 30 equivalence test trials). A consistency criterion was used that required each participant to choose the same but not necessarily correct comparison at least 9 times out of 10 on each of the 9 tasks (for ease of communication “correct” will be used to describe responses that are in accordance with the symmetry and equivalence relations). If a subject did not produce a consistent performance by the fourth exposure to the entire experimental sequence, and the performance was less than 50% correct, the performance was classified as inconsistent and the subject’s participation in the study was terminated. If, however, a subject produced more than 50% correct responding on a fourth exposure to the equivalence test, additional exposures to the training and testing were provided until he or she either produced less than 50% correct or produced a consistent performance.

Results and Discussion

Percentage of correct responses on symmetry and equivalence test trials, for each individual exposure for Subjects 1-5 are presented in Table 1. Subjects 1 and 5 produced inconsistent response patterns on their fourth exposure, and thus their participation in the study was terminated. Subjects 2, 3, and 4, however, showed perfect symmetry and equivalence responding on their fourth exposures to the test. The results of Experiment 1 demonstrated

that the respondent training procedure may have established equivalence classes using a linear pattern, when the difference between the within- and between-pair-delays varied from trial to trial. In effect, on most trials the between-pair-delay, we assume, was longer than the within-pair-delay, but on some trials the reverse was probably true (and perhaps on a very small number of trials there was no difference between the delays). Under these conditions the effectiveness of the respondent-type training procedure appeared to be slightly less effective relative to that seen in Chapter 2, when the between- and within-pair-delays were of different fixed values.

Table 1
Random Sequence/Average Within-Pair-Delays of 2-s / Average Between-Pair Delays of 4-s

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 1.									
Subject	1		2		3		4		
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		
S1	23	24	15	20	17	15	15	10 (inconsistent)	
S2	80	66	96	85	95	90	100	100	
S3	47	30	53	60	96	85	100	100	
S4	60	30	97	93	97	98	100	100	
S5	25	50	30	27	25	20	17	10 (inconsistent)	

Experiment 2

In the previous experiment and in the previous chapter all of the experiments employed relatively short delays (the maximum was 8 seconds). The purpose of this second experiment was to determine whether the respondent training procedure would be effective if the duration of fixed within- and between-pair-delays was increased to relatively high values. There were five conditions in this experiment. Each condition employed the same procedure, but differed in the length of the within- and between-pair-delays. The procedure of each condition was similar to that employed in Experiment 1, except that stimulus pairs were presented in a quasi-random sequence rather than a fixed linear sequence. The general details of the respondent training were as follows.

During respondent training nine nonsense syllables were presented to the subject in the form of six stimulus pairs. The stimulus pairs were designated A1->B1, B1->C1, A2->B2, B2->C2, A3->B3, B3->C3. Each stimulus pair was presented in the following sequence. The first stimulus of each pair was presented for 1-s (e.g., A1), and the computer screen was then cleared for the within-pair delay (see below for actual values). The second stimulus in the pair (i.e., B1 always followed A1) was presented for 1-s and the screen was then cleared for the between-pair-delay (see below for actual values). Following the between-pair-delay the next stimulus pair was presented (e.g., B3->C3). All six stimulus pairs were presented in this fashion, in a fixed order across 60 trials (i.e., each stimulus pair was presented 10 times). When all 60 trials had been presented, the screen went blank for 5-s; the equivalence testing instructions then appeared on the screen.

The five conditions in this experiment differed only in terms of the between- and within-pairs-delays, and these were as follows:

Condition 1: 5-s within-pair-delays / 15-s between- pair- delays.

Condition 2: 5-s within-pair-delays / 30-s between-pair-delays

Condition 3: 5-s within-pair-delays / 1-m between-pair-delays

Condition 4: 30-s within-pair-delays/ 1-m between-pair-delays

Condition 5: 1-m within-pair-delays / 3-m between-pair-delays.

Results and Discussion

Percentage of correct responses on symmetry and equivalence test trials, for each individual exposure for Subjects 6-30 are presented in Tables 2, 3, 4, 5 and 6. In Condition 1, all five subjects were 100% successful on all symmetry and equivalence probes on their first exposure to the test. In Condition 2, Subjects 11, 12 and 13 were successful on all tests on their first exposure, while subjects 14 and 15 were successful on their third. In Condition 3, Subject 16 was successful on the first exposure to the symmetry and equivalence tests while Subjects 17, 18 and 19 were successful on their third exposures. Subject 20 was successful on the second exposure. In Condition 4, Subjects 21, 22, and 23 were successful on their third exposures, while Subjects 24 and 25 were successful on their second exposures. In Condition 5, Subjects 26, 27, 28 and 29 were successful on all tests on their second exposures, while Subject 30 was successful on the third exposure.

This experiment clearly demonstrated that the respondent procedure is effective even when the within- and between-pair-delays are increased to relatively high values, and thus relatively short delays are not an essential feature of the respondent training procedure. However, another feature of the procedure that remains to be manipulated experimentally is the number of exposures to the stimulus pairs during any one training phase. In all of the previous experiments subjects were always exposed to 60 respondent training trials per training session (i.e., 10 exposures to each stimulus pair). Perhaps, therefore, the success of the procedure could be attributed in some part to these

Table 2
 Random Sequence/5-s Within-Pair-Delays/15-s Between-Pair-Delays.

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 2, Condition 1.

Subject	1	
	Sym/Equiv.	
S6	100	100
S7	100	100
S8	100	100
S9	100	100
S10	100	100

Table 3
 Random Sequence/5-s Within-Pair-Delays/ 30-s Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 2, Condition 2

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	
S11	100	100				
S12	100	100				
S13	100	100				
S14	70	67	95	97	100	100
S15	68	87	96	98	100	100

Table 4
 Random Sequence/5-s Within-Pair-Delays/ 1-m Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 2, Condition 3

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	

S16	100	100				
S17	65	55	70	98	100	100
S18	80	60	98	80	100	100
S19	90	95	95	90	100	100
S20	98	80	100	100		

Table 5
 Random Sequence/30-s Within-Pair-Delays/ 1-m Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 2, Condition 4

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	

S21	75	80	90	95	100	100
S22	65	55	65	75	100	100
S23	80	60	98	80	100	100
S24	95	90	100	100		
S25	98	80	100	100		

Table 6
 Random Sequence/1-m Within-Pair-Delays/ 3-m Between-Pair-Delays

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 2, Condition 5

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	
S26	90	95	100	100		
S27	80	75	100	100		
S28	80	60	100	100		
S29	95	70	100	100		
S30	90	40	90	98	100	100

multiple exposures. The next experiment addressed this issue by reducing the number of exposures to each stimulus pair during the respondent training.

Experiment 3

The procedure of this experiment was identical to the previous experiment, except that; (a) the within-and between-pair delays were set to a fixed 5-s and 15-s respectively, and (b) the number of stimulus pair presentations was reduced. There were two conditions in the experiment and they were;

Condition 1: 5-s within-pair-delays/15-s between-pair-delays/ 5 stimulus pair presentations per training session.

Condition 2: 5-s within-pair-delays/15-s between-pair-delays/ 1 stimulus pair presentation per training session.

Results and Discussion

Percentage of correct responses on symmetry and equivalence test trials, for each individual exposure for Subjects 31-40 are presented in Tables 7 and 8. In Condition 1, Subjects 31, 32, and 34 were 100% successful on all symmetry and equivalence probes on their third exposures. Subjects 33 and 35 were successful on their first exposure to the test. In Condition 2, Subjects 36, 37, 38, and 39 were successful on their second exposures to the test while Subject 40 was successful on the first exposure. This experiment clearly demonstrated that the respondent training procedure is effective in the absence of multiple exposures to stimulus-pairs. In Condition 1, each stimulus pair was presented five times. In effect, the number of stimulus-pair presentations was reduced by 50% relative to all of the previous experiments reported thus far. Under these conditions, the respondent training procedure was as effective as previously observed. In Condition 2, stimulus-pair presentations were reduced further, to a single stimulus-pair presentation. This condition clearly demonstrated that a single stimulus-pair presentation in the presence of long delays is sufficient to produce accurate responding on equivalence tests. As in Experiments 1 and 2 reported in this chapter, the minimum number of exposures needed was 1 while the maximum was 3.

Experiment 4

In Experiment 2, it was established that the respondent procedure functions effectively when using long delays. In Experiment 3, it was demonstrated that the procedure produced impressive results given a single stimulus-pair presentation in the presence of long delays. The purpose of this experiment was to determine whether this procedure would be still effective if the three classes were increased from three to four members, given a single stimulus pair presentation in the presence of long delays. Previous research has shown that equivalence responding is a negative function of increasing

Table 7
 Random Sequence/5-s Within-Pair-Delays/15-s Between-Pair-Delays/5
 Stimulus Pair Presentations

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 3, Condition 2

Subject	1		2		3	
	Sym/Equiv		Sym/Equiv		Sym/Equiv	
S31	38	68	90	95	100	100
S32	65	55	80	98	100	100
S33	100	100				
S34	92	57	95	90	100	100
S35	100	100				

Table 8
 Random Sequence/5-s Within-Pair-Delays/15-s Between-Pair-Delays/1 Stimulus-Pair
 Presentation

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 3, Condition 2

Subject	1		2	
	Sym/Equiv		Sym/Equiv	
S36	95	65	100	100
S37	98	55	100	100
S38	90	80	100	100
S39	95	90	100	100
S40	100	100		

class size (Fields, 1990), and thus manipulation class size in this way presents another opportunity to determine the effectiveness of the respondent training procedure. In other words, will the procedure produce equivalence responding in all subjects when class size is increased.

The procedure in this experiment was identical to the previous experiment except that; (a) the each class was increased from three to four members, (b) the within- and between-pair-delays were 5-s and 30-s in Condition 1 and 2-s and 10-s in Condition 2, and (c) subjects were administered 1 stimulus-pair presentation in Condition 1 and 5 stimulus-pair presentations in Condition 2. In summary, there were two conditions in this experiment and they were;

Condition 1: 3, 4 member classes / 5-s within-pair-delays /30-s between-pair-delays/ 1 stimulus-pair exposure.

Condition 2: 3, 4 member classes / 2-s within-pair-delays / 10-s between-pair-delays / 5 stimulus-pair exposures.

Results and Discussion

Percentage of correct responses on symmetry and equivalence test trials, for each individual exposure for Subjects 41-50 are presented in Tables 9 and 10.

In Condition 1, Subjects 41, 42, and 44 were successful on their sixth exposures to the symmetry and equivalence tests. Subject 43 failed to reach the criterion after six exposures while Subject 45 was successful on the third exposure to the test. In Condition 2, Subjects 46, 48, 49, and 50 were successful on their third exposure to the symmetry and equivalence tests. Subject 47 was successful on the second exposure. In Condition 1 it was demonstrated that the respondent training procedure may establish equivalence classes when; (a) the three classes were increased to four members each, (b) within-and between-pair-delay were 5-s and 30-s respectively, and (c) subjects are presented with 5 stimulus-pair presentations per training session. Under

Table 9
 Random Sequence/5-s Within-Pair-Delays/ 30-s Between-Pair-Delays/1
 Stimulus Pair Presentation/3, 4 Member Class

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 4, Condition 1												
Subject	1		2		3		4		5		6	
	Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv		Sym/Equiv	
S41	42	27	60	35	98	30	100	10	95	65	100	100
S42	35	25	92	57	98	60	100	50	98	55	100	100
S43	37	10	27	23	43	27	63	60	65	65	70	60
S44	38	25	65	35	85	46	77	93	95	90	100	100
S45	42	25	100	87	100	100						

Table 10
 Random Sequence/2-s Within-Pair-Delays/ 10-s Between-Pair-Delays/5
 Stimulus Pair Presentations/3, 4 Member Class

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 4, Condition 2												
Subject	1		2		3							
	Sym/Equiv		Sym/Equiv		Sym/Equiv							
S46	100	30	95	65	100	100						
S47	80	55	100	100								
S48	63	60	90	65	100	100						
S49	65	93	95	60	100	100						
S50	80	45	100	85	100	100						

these conditions the effectiveness of the respondent training procedure appeared to be slightly less effective relative to the previous experiments in this chapter -- the maximum of 6 exposures were required for three of the subjects, and one failed to reach the criterion. The results of Condition 2, however, are similar to those of the previous experiments. This outcome suggests that when class size is increased, the effectiveness of the respondent training procedure may be maximised when shorter delays are used and more than one exposure to each stimulus pair is presented per training session. Of course, without further research it remains uncertain whether one or both of these variables are needed to facilitate the effects of the respondent procedure with larger class sizes. This issue was not examined in the current research program because other questions arose that were deemed to be more important.

General Discussion

In Chapter 2, it was demonstrated that the effectiveness of the respondent training procedure was dependent upon; (a) the presence of longer between-pair-delays (3-s) relative to within-pair-delays (0.5) and (b) the sequence in which the stimulus pairs were presented. In Condition 4, a 3-s between-pair-delay allowed subjects to distinguish the six stimulus pairs and therefore show equivalence given a linear presentation of stimulus pairs. In Condition 5, the reduction of the 3-s between-pair-delay to 0.5-s prevented reliable discrimination between stimulus pairs and thus the reliable formation of equivalence relations. In Experiment 1 of this study, the within-and between-pair-delays were not fixed but varied between 0-s and 8-s. Using a linear presentation of stimulus pairs the within-pair-delay varied randomly between 0 to 4 seconds (i.e., across trials, the average within-pair-delay was 2 seconds). The between-pair-delay varied randomly between 0 to 8 seconds (i.e., across trials, the average between-pair-delay was 4 seconds). The results of Experiment 1, revealed that the respondent training procedure may establish

equivalence classes using a linear pattern when the difference between the within- and between-pair-delays varied from trial to trial, but there was an average difference of 2 seconds between the two types of delay. However, the results of this experiment suggested that varying the delays in this way was slightly less effective than when they remained constant (as seen in Chapter 2). The most likely explanation for this reduction in effectiveness, is that on most trials the within-pair-delay was longer than the between-pair-delay, but on a small number of trials the reverse may have been true, and perhaps on only very few trials there was little or no difference between the two types of delay. Clearly, the lack of a consistent difference between the two types of delay would have made the discrimination between the relevant stimulus pairs more difficult. Nevertheless, the fact that equivalence responding still emerged is testimony to the power of the respondent procedure.

The effectiveness of the respondent procedure reported in Chapter 2, could be attributed, in some part, to the multiple exposures to stimulus pairs and to the presence of relatively short delays (the maximum was 3 seconds). The purpose of Experiment 2 in the current chapter, was to determine whether the respondent procedure would be effective if the duration of fixed within-and between-pair-delays was increased to relatively high values. Across five conditions, the respondent procedure was seen to be very effective and slightly more effective, relative to that seen in Chapter 2. Indeed the results of Condition 5, seem somewhat surprising. In this condition the within-pair-delay was 1 minute and the between-pair-delay was 3 minutes. Initially a positive outcome was not predicted in this condition (i.e., it was thought that such long delays would disrupt the discrimination between stimulus pairs).

Up to this point in the research program, all experiments involved presenting subjects with nine nonsense syllables in the form of six stimulus pairs. All six stimulus pairs were presented in a quasi-random order for sixty trials (i.e., each stimulus pair was presented 10 times). The purpose of

Experiment 3 was to determine whether the procedure would be effective if the number of stimulus pairs was reduced in the presence of fixed long delays. Across two conditions, reducing the number of stimulus pair presentations did not appear to adversely affect the respondent training procedure. Indeed, the results in Condition 2 revealed that a single stimulus pair presentation was sufficient for subjects to perform accurately on equivalence tests.

The purpose of Experiment 4 was to determine whether the procedure would be effective, if the three classes used thus far were increased from three to four members in the presence of long delays, given single stimulus pair presentations per training session. In Condition 1, it was demonstrated that the respondent training procedure may establish equivalence classes when; (a) class size was increased from three to four members, (b) within-and between-pair-delays were 5-s and 30-s respectively, and (c) subjects were presented with a single stimulus-pair presentation. However, these results suggest that the procedure was slightly less effective relative to the procedure reported in the previous chapter. The results of Condition 2, however, suggest that reducing the delays and/or increasing the exposures to each stimulus pair constitutes an effective means of facilitating the equivalence generating power of the respondent training procedure.

In conclusion, the experiments reported in the current chapter show that the equivalence-generating effect of the respondent training procedure is not restricted to a particular range of between- and within-pair- delays, and neither is it restricted to a particular range of stimulus pair presentations per training session. Of course, the current experiments do not constitute a systematic, parametric analysis of the effects of the delays or the stimulus pair presentations, but the general effectiveness of the respondent procedure in producing equivalence class formation was demonstrated. At this point in my research program, I could have pursued the relevant parametric analyses, but at the time other issues had arisen that seemed more pressing in terms of

exploring and developing the scope of the respondent procedure. The first of these was concerned with the effectiveness of the respondent procedure relative to the traditional matching-to-sample procedure. As indicated in Chapter 1, the vast majority of work conducted in the area of stimulus equivalence has employed the matching-to-sample methodology. Given that the experimental work conducted thus far in my research program had identified an alternative and apparently highly effective training procedure, the next logical step appeared to require that the two procedures be compared in a systematic fashion. This was the aim of the work reported in the next chapter.

Chapter 4:

Respondent-type Training Versus Matching-to-Sample Training.

One interesting issue that arises from the previous two chapters is the relative ease with which the respondent training procedure produces equivalence responding. In fact, when compared to the traditional MTS procedure, the respondent training is perhaps slightly more effective than matching-to-sample training (e.g., Wulfert, Dougher & Greenway, 1991, reported a 82.7% success rate versus 88% in the equivalence-generating conditions in Chapter 2). The next important step in the research program, therefore, was to analyse systematically the relative effectiveness of the respondent versus matching-to-sample training procedures in producing equivalence responding in human adult subjects.

In Experiment 1 of the current study, subjects were exposed to a MTS training procedure that presented the same number of training trials to each subject as was presented during the respondent training procedure presented in Chapters 2 and 3. These data will allow us to compare the relative effectiveness of the two training procedures across studies conducted within the same laboratory. In Experiments 2 to 4 within subjects designs were used to compare the relative effectiveness of the two training procedures. In the interests of clarity, the details of these latter experiments will be outlined after Experiment 1 has been reported.

General Method

Subjects

Twenty nine subjects, 14 female and 15 male, of University College Cork served as subjects. Their ages ranged from 18 to 25. All subjects were experimentally naive, and were non-psychology majors. Subjects were recruited through faculty notice-board advertisements and were randomly

assigned to one of three experimental groups. Experimental sessions were arranged so that subjects would not come into contact with each other in the vicinity of the laboratory, and were instructed not to discuss their participation with anyone.

Apparatus

Each subject was seated in a small experimental room, with an Apple Macintosh SE microcomputer, which displayed black characters on a white background. The Z, V, and M keys were marked with white paper dots to designate them as response keys. A pool of 9 nonsense syllables (CUG, ZID, VEK, YIM, DAX, PAF, ROG, MAU, JOM) were randomly assigned to their respective roles as sample and comparison stimuli for each subject in the study. Stimulus presentation and the recording of responses were controlled by the computer which was programmed in BBC BASIC.

Procedure

The experimental sequence was divided into two stages: (1) MTS training, and (2) MTS testing.

(1) At the beginning of the experiment the following text appeared on the screen:

In this experiment you will be shown an item at the top of the screen along with three items below it.

Your task is to learn which of these items goes with the one at the bottom of the screen.

To choose the left syllable, press the marked key on the left. To choose the middle, syllable press the marked key in the middle. To choose the right, syllable press the marked key on the right.

Press the space-bar twice to continue

Using the matching-to-sample procedure each subject was trained in the following conditional discriminations; see A1 choose B1, A2-B2, A3-B3, B1-C1, B2-C2, B3-C3. Each task was presented in the following fashion. The sample stimulus appeared at the top centre of the monitor screen, and the three comparison stimuli, which appeared 1-s later, were displayed 4 cm below the sample; one comparison appeared 6 cm to the left, one 6 cm to the right, and the third directly below the sample stimulus. Subjects were instructed at the beginning of the experiment to select a comparison by pressing one of the three designated keys (see instructions above). After a correct response the screen cleared and the word "CORRECT" appeared on the screen. This was accompanied by a high pitched tone. When subjects responded incorrectly the screen cleared and the word "WRONG" appeared. All six stimulus combinations were presented in this fashion in a quasi-random order for sixty trials, the only constraint being that each combination was presented once in each successive blocks of six trials (i.e., each combination was presented ten times). The spatial position of the correct comparison stimuli was counterbalanced across training trials. Unlike the standard MTS procedure, subjects were not trained to reach a specific success criterion; instead they were simply presented with sixty training trials, and no more. This non-criterion training procedure was deliberately used so that we could compare the MTS training with the respondent-type training reported in Chapters 2 and 3. Subjects were simply exposed to sixty training trials in which each stimulus pair (e.g., A-B1, A2-B2) was presented ten times in a block of sixty trials (i.e., no performance criterion was employed). It was important, therefore, that the matching-to-sample training used in the current chapter replicated this procedure and simply presented sixty training trials.

(2) When all tasks had been presented, the following instructions appeared on the screen:

That is the end of the first stage of the experiment.

In the next stage you must look at the nonsense syllable at the top of the screen, and then choose one of the three nonsense syllables at the bottom of the screen.

Press the space-bar twice to continue.

During this stage of the experiment the six symmetry relations (B1-A1, B2-A2, B3-A3, C1-B1, C2-B2, C3-B3), and the three combined symmetry and transitivity relations (C1-A1, C2-A2, C3-A3) were tested using the same MTS format that was used during training, except that no feedback was presented after any of the test trials. Tasks were presented in a quasi-random order, the only constraint being that each task occurred 10 times across 90 trials. The spatial position of the "correct" comparison stimulus was counterbalanced across test trials. The same stability criterion that was used in Chapters 2 and 3 was also used here. This required that a subject must choose the same but not necessarily correct comparison at least 9 times out of 10 on each of the 9 tasks. If a subject produced an inconsistent performance (i.e., less than 9/10 responses), he or she was re-exposed to the entire experimental sequence (i.e., matching-to-sample training and matching-to-sample testing). If a subject did not produce a consistent performance on their fourth exposure to the entire sequence and their performance was less than 50% correct, they were classified as inconsistent and their participation was terminated. If, however, they produced more than 50% correct responses on their fourth exposure, they were given two additional exposures (maximum of six), at which they either achieved the stability criteria or completed their participation in the study, and were fully debriefed.

Results and Discussion

Percent correct on all test trials for each individual exposure and mean percent correct calculated across all exposures is presented in Table 1. Subject 1 produced perfect responding on the second exposure. Subjects 2 to 5, however, failed to reach the stability criterion after the maximum of six exposures. In Chapter 2, 31 subjects out of 35 successfully passed the equivalence test using a respondent training procedure, representing an 88% success rate (excluding the fixed sequence “control” conditions). In the current experiment, however, only 1 subject out of 5 successfully passed the equivalence test using a MTS training procedure (a 20% success rate). These data suggest that, on a trial-for-trial basis, the respondent training procedure facilitates equivalence responding more readily than the typical MTS procedure. The current conclusion, however, is based on a between subjects comparison (i.e., between the data from this and a previous study). A more robust test of the possible superiority of the respondent training procedure over MTS would involve a within-subjects comparison. This was the aim of Experiment 2.

Experiment 2

In Experiment 2, three subjects were exposed to the respondent training procedure in which the following stimulus pairs were presented; A1->B1, A2->B2, A3->B3, B1->C1, B2->C2, B3->C3. Subjects were then given a MTS test which test for the emergence of symmetry relations; B1-A1, B2-A2, B3-A3, C1-B1, B2-C2, C3-B3 and the equivalence relations (C1-A1, C2-A2, C3-A3). Subsequently, subjects were exposed to a MTS procedure in which the following conditional discriminations were trained; A1-B2, A2-B3, A3-B1, B1-C2, B2-C3, B3-C1.

Table 1
 Matching-to-Sample Training and Testing

Percent Correct per Exposure on all Test Trials in Experiment 1.							
Subject	1	2	3	4	5	6	
	MTS	MTS	MTS	MTS	MTS	MTS	MEAN
S1	71	100					85
S2	35	23	28	11			24
S3	32	36	39	47	48	67	45
S4	42	44	70	78	73	57	60
S5	37	28	38	50	57	67	46

Subjects were then presented with a MTS test which tested for the emergence of the symmetry relation; B2-A1, B3-A2, B1-A3, C2-B1, C3-B2, C1-B3 and the equivalence relations; C1-A2, C2-A3, C3-A1. In effect, the stimulus pairs presented during the respondent training did not correspond with the reinforced stimulus pairs presented during the MTS training. This experimental sequence allowed us to determine; (i) Is respondent training is more powerful than MTS training?, (ii) Is MTS training is more powerful than respondent training?, (iii) Neither of the above (i.e., both procedures are equally effective). Three other subjects were exposed to the same procedures, except that the training sequence was reversed (i.e., MTS followed by respondent training).

Procedure

Experiment 2 was divided into two conditions, and each condition was divided into four phases. In Condition 1, subjects were exposed to the respondent training procedure followed by a MTS equivalence test, and then

subjects were presented with the MTS training procedure followed by a second MTS equivalence test. Condition 2 was the same, except that the MTS and respondent training were presented in reverse order (i.e., i. MTS training; ii. equivalence test; iii. respondent training; iv. equivalence test).

At the beginning of Condition 1, subjects were presented with the following instructions:

In the first stage of this experiment your task is to simply watch the screen.

Stimulus pairs were then presented using the respondent training procedure. Nine nonsense syllables were presented to subjects in the form of six stimulus pairs. The stimulus pairs were; A1->B1, B1->C1, A2->B2, B2->C2, A3->B3, B3->C3. Each stimulus pair was presented in the following sequence. The first stimulus of each pair was presented for 1-s (e.g., A1) and the computer screen then cleared for 0.5-s (within pair delay). The second stimulus (i.e., B1 always followed A1) of the pair was then presented for 1-s and the screen was cleared for 3-s (between pair delay) before the next stimulus pair was presented (e.g., B2). All six stimulus pairs were presented in this sequence in a quasi-random order for sixty trials, the only constraint being that each stimulus pair was presented once in each successive block of six trials. When all 60 respondent training trials had been presented, the screen cleared and the following message was displayed on the computer screen:

That is the end of the first stage of the experiment.

In the next stage, you must look at the nonsense syllable at the top, and then choose one of the three nonsense syllables at the bottom, by pressing one of the marked keys on the keyboard. To choose the left

syllable press the marked key on the left. To choose the middle syllable press the marked key in the middle. To choose the right syllable press the marked key on the right.

Press the space-bar twice to continue.

Subjects were then exposed to the same equivalence test that was employed in Experiment 1, where the following relations were tested; B1-A1, B2-A2, B3-A3, C1-B1, C2-B2, C3-B3, C1-A1, C2-A2, C3-A3. When subjects had completed the MTS test the following instructions appeared on the screen.

That is the end of the second stage of the experiment.

In the next stage, you must look at the nonsense syllable at the top, and then choose one of the three nonsense syllables at the bottom, by pressing one of the marked keys on the keyboard. To choose the left syllable press the marked key on the left. To choose the middle syllable press the marked key in the middle. To choose the right syllable press the marked key on the right.

Press the space-bar twice to continue.

The subject was then presented with a MTS training procedure, identical to that used in Experiment 1, during which the following conditional discriminations were reinforced; A1-B2, A2-B3, A3-B1, B1-C2, B2-C3, B3-C1. After the final conditional discrimination training trial, the subject was presented with same equivalence test employed in Phase 2, where the following relations were tested; B1-A3, B2-A1, B3-A2, C1-B3, C2-B1, C3-B2, C1-A2, C2-A3, C3-A1. The stability criteria for completing the MTS tests was

identical to that adopted in Experiment 1. If a subject failed to reach this stability criteria, s/he was re-exposed to all four phases of the experiment in exactly the same order, for a maximum of eight exposures.

Subjects in Condition 2 were exposed to the same four experimental phases, except that they received the conditional discrimination training before the respondent training.

Results and Discussion

Percent correct on all test trials and mean percent correct calculated across all exposures is presented in Tables 2 and 3. Three out of six subjects produced a greater number of correct responses in favour of respondent training (Subjects 8, 9, and 10). The three remaining Subjects (6, 7, and 11), whilst failing to produce a response pattern in favour of respondent training also failed to produce a clear result in favour of matching-to-sample training. On their final exposures to the equivalence tests, all three responded in accordance with both the respondent and MTS training (i.e., they changed their test patterns dependent upon the type of training that immediately preceded the current equivalence test). These data tentatively suggest a trend in favour of respondent training. In summary, the data from Experiments 2 indicate that the respondent training procedure more readily facilitated equivalence responding than did the MTS training.

Experiment 3

One possible criticism of Experiments 2 might be that the MTS training used here departed somewhat from the standard procedures reported in the equivalence literature. Specifically, in both experiments subjects were exposed to a "criterion-independent" form of MTS training, that required that they

Table 2
 Respondent Training and Testing followed by Matching-To-Sample Training and Testing.

Percent Correct per Exposure on all Test Trials in Experiment 2, Condition 1.														
Subject	1		2		3		4		5		6		Mean	
	RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS	
S6	100	98												
S7	99	88	99	100									99	94
S8	38	62	55	35	61	24	93	15	61	21	93	14	67	28

Table 3
 Matching-To-Sample Training and Testing followed by Respondent Training and Testing.

Percent Correct per Exposure on all test trials in Experiment 2, Condition 2.														
Subject	1		2		3		4		5		6		Mean	
	MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES	
S9	34	68	33	95	44	100	47	100	54	100	68	100	47	94
S10	20	43	40	74	68	100	68	100	60	100	60	100	53	86
S11	57	50	53	73	98	99	98	100					76	80

complete exactly 60 training trials, irrespective of performance accuracy, before moving onto the next stage of the experiment. In most equivalence studies, MTS training continues until the subject produces a predetermined number of consecutively correct responses (e.g., 12 out of 12 correct). Experiment 4 addressed this issue. Experiment 4 replicated Experiment 3, except that; (a) for the matching-to-sample training each subject was required to produce 12 consecutively correct responses before an equivalence test, and (b) only 12 trials were presented during each exposure to the respondent training. The number of consecutively correct matching-to-sample training trials was thus matched to the number of respondent training trials.

Procedure

Experiment 3 was divided into two conditions. In Condition 1 each subject was presented with the respondent procedure, where each subject received 12 stimulus-pair presentations. The subject was then presented with a matching-to-sample test. The subject was then presented with the MTS procedure, where each subject was required to produce 12 consecutively correct responses prior to an equivalence test. When this had been achieved the subject was presented with the MTS equivalence test. Condition 2 was identical to Condition 1, except the procedure was reversed (i.e., i. MTS training; ii. equivalence test; iii. respondent training; iv. equivalence test).

Results and Discussion

Percent correct on all test trials and mean percent correct calculated across all exposures is presented in Tables 4 and 5. All six subjects produced a greater number of correct responses in favour of respondent training. In Condition 1 and 2 all subjects produced 100% correct responding during the respondent equivalence test. During the final matching-to-sample equivalence

test, Subjects 12, 13, and 14 produced 10%, 0%, and 12% correct responding, respectively, while Subjects 15, 16, and 17 produced 30%, 25%, and 35% correct responses, respectively.

In Experiment 3 the respondent procedure was clearly more effective than the traditional MTS procedure. When subjects were required to produce a predetermined mastery criterion of 12 out of 12 correct responses during MTS training, and when subjects were only presented with 12 training trials during respondent training, they performed in favour of respondent training. Indeed, upon closer inspection of the raw data it appears that subjects "adopted" respondent training during the MTS test (i.e., subjects responded in accordance with the respondent training during the MTS testing).

Experiment 4

The results of Experiment 3 raise an interesting question. What makes the respondent procedure more effective, at least in the context of the current study, than the traditional MTS method? One explanation might be that the MTS procedure is "overly complicated" compared to the more simplified temporal pairing procedure of the respondent training method. For example, during traditional MTS training the subject is presented with a sample and three comparisons, and he or she is required to choose one of the three comparisons. When the subject chooses the correct comparison "correct" appears on the screen accompanied by a beep, but when the incorrect comparison is chosen there is an absence of a beep and "incorrect" appears on the screen. In contrast, the respondent training procedure simply involves presenting the "correct" stimulus pairs, and thus the subject never has the opportunity to observe a sample and an incorrect comparison during the training. Perhaps, the absence of incorrect comparisons during the respondent training can account for the apparent superiority of this procedure.

Table 4
 Respondent Training and Testing (12 stimulus pair presentations) followed by
 Matching-To-Sample Training and Testing (12 in a row correct)

Percent Correct per Exposure on all tests in Experiment 3, Condition 1.														
Subject	1		2		3		4		5		6		Mean	
	RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS	
S12	45	12	44	0	48	0	100	0	100	0	100	10	73	4
S13	37	34	47	8	99	33	100	24	100	0	100	0	80	16
S14	42	33	43	21	34	5	63	8	100	10	100	12	64	15

Table 5
 Matching-To-Sample Training and Testing (12 in a row correct) followed by
 Respondent Training and Testing (12 stimulus pair presentations).

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 3, Condition 2.														
Subject	1		2		3		4		5		6		Mean	
	MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES	
S15	3	86	3	90	3	98	0	100	33	100	30	100	12	96
S16	8	80	10	95	12	100	30	100	40	100	25	100	29	91
S17	3	60	10	70	8	75	12	80	20	100	35	100	15	81



Experiment 4 was designed to test this suggestion. In this experiment, during matching-to-sample training the negative comparisons were removed from training. That is, the sample appeared on the screen followed by the correct comparison. The subject was then required to make a response, (i.e., press the key "V"). The word "correct" then appeared on the screen with a beep. The next training trial then appeared on the screen.

Procedure

The procedure of Experiment 4 was identical to Experiment 3 except that the MTS training was modified. During MTS training the sample appeared on the screen for approximately 1-s. This was then followed by the appearance of the correct comparison again for 1-s. This comparison always appeared in the centre, below where the sample had appeared, and no other comparison was presented during the trial. The subject was then required to make a response (i.e., press the key "V") before the next training trial began. In effect, the subject simply had to press the "V" key on each MTS trial. At the beginning of the modified MTS training the following instructions appeared on the screen.

At the beginning of this stage of the experiment you
will be shown an item on the top of the screen. An item
will be then appear below this item. Your task is to learn
that the item at the top of the screen goes with the item below it.
To choose this item, press the marked key "V" at the centre.
Press the space-bar twice to continue.

The subject was required to make 12 consecutively correct responses before the subject was allowed to progress on to the matching-to-sample test.

In Condition 1, each subject received 12 respondent training trials followed by a MTS test. Subjects then received the modified MTS training procedure followed by a MTS test. Condition 2 was identical to Condition 1 except that the subjects received the modified MTS training and MTS test first, followed by the respondent training procedure followed by a MTS test.

Results and Discussion

Percent correct on all test trials and mean percent correct calculated across all exposures is presented in Tables 6 and 7. For both mean percent correct across all exposures and percent correct on the final exposure all six subjects produced a greater number of responses in favour of respondent training. In Conditions 1 and 2, on the final exposure all subjects produced 100% correct responding in favour of respondent training. In the matching-to-sample equivalence test, Subjects 18, 19, and 20 of Condition 1 produced 36%, 33%, and 38% correct responses respectively. In Condition 2 Subjects 21, 22, and 23 produced 28%, 30%, and 36% correct responses respectively during the MTS equivalence test.

It was expected that the two training procedures would prove equally effective under the conditions of this experiment, but the respondent training procedure proved again to be more effective than the traditional MTS training procedure. Experiment 4 maybe criticised, however, on the grounds that the correct comparison always appeared in the same position (i.e., centred below the sample), and thus the subject was always required to press the same key ("V") after each sample-comparison presentation. Consequently, subjects could produce consistently correct responses by simply pressing the V key without attending to the contents of the computer screen. Experiment 5 was designed to eliminate this possibility. This experiment was identical to Experiment 4 except that the comparison stimuli appeared, across trials, to the right, centre, or left of the screen.

Table 6
 Respondent Training and Testing followed by Matching-to-Sample Training
 and Testing (1 comparison)

Percent Correct per Exposure on 60 symmetry and 30 Equivalence Test Trials per
 Exposure in Experiment 4, Condition 1.

Subject	1		2		3		4		5		6		Mean	
	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS	RES/MTS
S18	32	30	47	36	55	25	62	37	84	42	100	36	63	34
S19	30	30	42	25	60	30	78	33	85	40	100	33	66	31
S20	40	28	45	31	60	35	72	36	84	37	100	38	67	34

Table 7
 Matching-To-Sample Training and Testing Followed by Respondent Training
 and Testing (1 comparison).

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 4, Condition 2.														
Subject	1		2		3		4		5		6		Mean	
	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES	MTS/RES
S21	28	42	30	59	29	65	38	85	38	100	28	100	31	75
S22	25	55	30	65	35	70	40	85	35	95	30	100	32	78
S23	30	35	28	40	25	62	30	85	35	90	36	100	28	68

When the comparison appeared to the left of the screen the subject was required to press the key “Z”, when the comparison appeared in the centre of the screen the subject was required to press the key “V,” and when the comparison appeared to the right of the screen the subject was required to press the key “M.”

Experiment 5

Procedure

Experiment 5 was identical to Experiment 4 except that the comparison stimuli appeared to right, centre, or left of the screen and three response keys were used (i.e., Z, V, and M). When a comparison appeared to the left, centre, or right of the screen, pressing the Z, V, and M keys, respectively, produced the "Correct" feedback. Pressing any other key produced the “wrong” feedback (e.g., pressing V when the comparison appeared on the left or right). At the beginning of the modified MTS training the following instructions appeared on the screen.

In this experiment you will be shown an item at the top of the screen. Another item will then appear below this item, and will be positioned either on the right, centre or the left of the screen. Your task is to learn that the item at the top of the screen goes with the item below it.

To choose the item at the left of the screen, press the key marked on the left. To choose the item at the centre of the screen, press the key marked on the centre. To choose the item at the right of the screen , press the key marked on the right.

Press the space-bar twice to continue.

The subject was required to make 12 consecutively correct responses before progressing on to the MTS test.

In Condition 1 of this experiment each subject was first exposed to the respondent training procedure followed by a MTS test. Subjects were then exposed to the modified MTS procedure followed by a matching-to-sample test. Condition 2 was identical to Condition 1 except that each subject was first exposed to the modified MTS training procedure.

Results and Discussion

Percent correct on all test probes and mean percent correct calculated across all exposures is presented in Tables 8 and 9. All six subjects produced correct responding on their final exposure for both respondent and MTS training. Although all subjects were successful on both training procedures the acquisition of correct responding was faster during respondent training than during matching-to-sample training (Subjects 25, 28 produced accurate responding on their third exposures to the respondent training and testing, Subjects 24, 26, and 27 on their fourth exposures while Subject 29 required six exposures. All six subjects required the maximum of six exposures to attain perfect responding during matching-to-sample training and testing). For mean percent correct all six subjects produced a marginally greater number of correct responses in favour of respondent training.

Under the conditions of this experiment both procedures succeeded in producing accurate responding. Thus the removal of the two incorrect comparisons during matching-to-sample training, and varying the position of the correct comparison, appeared to render it as effective as the respondent training procedure, although the latter produced relatively rapid derived responding in comparison to the former.

Table 8
 Respondent Training and Testing followed by Matching-To-Sample Training
 and Testing (1 comparison, three response keys)

Percent Correct per Exposure on all tests in Experiment 5, Condition 1.														
Subject	1		2		3		4		5		6		Mean	
	RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS		RES/MTS	
S24	40	30	50	42	64	46	100	64	100	74	100	100	75	59
S25	25	32	41	40	100	50	100	54	100	60	100	100	78	56
S26	50	41	54	48	60	50	100	60	100	86	100	100	77	64

Table 9
 Matching-To-Sample Training and Testing followed by Respondent Training
 and Testing (1 comparison, three response keys).

Percent Correct on 60 Symmetry and 30 Equivalence Test Trials per Exposure in Experiment 5, Condition 2.														
Subject	1		2		3		4		5		6		Mean	
	MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES		MTS/RES	
S27	25	35	39	45	47	54	69	100	84	100	100	100	61	72
S28	30	38	42	50	50	100	64	100	75	100	100	100	60	81
S29	33	40	40	42	52	61	71	70	85	86	100	100	63	66

General Discussion

The current study clearly demonstrated (as Chapters 2 and 3) that it is possible to produce reliable equivalence responding using a respondent training procedure. In Experiment 1 of this study, when subjects were exposed to a matching-to-sample training procedure that presented the same number of training trials to each subject as was presented during the respondent training used in Chapters 2 and 3, only one out of five subjects successfully passed the equivalence test. This outcome did not compare favourably with the 88% success rate previously generated by the respondent procedure in Chapter 1. To examine the differential effectiveness of the two procedures, a within-subject comparison in Experiment 2 was conducted. In Experiment 2, three subjects produced a result clearly in favour of respondent training, and the three remaining subjects responded in accordance with both the respondent and matching-to-sample training. In effect, the three latter subjects changed their response patterns dependent upon the type of training that preceded the equivalence test, whereas the three former subjects produced response patterns that were consistently in accordance with the respondent training. At the end of Experiment 2, the test results indicated that the respondent training procedure facilitated equivalence responding more readily than did the matching-to-sample training procedure. However, Experiment 2 could be criticised on the grounds that it departed somewhat from the traditional matching-to-sample training. Specifically, in both experiments subjects were exposed to a “criterion-independent” form of matching-to-sample training (i.e., subjects were given 60 training trials irrespective of their performance accuracy before moving on to the next stage of the experiment). To circumvent this problem Experiment 3 was conducted.

In this third experiment, subjects were required to produce 12 consecutively correct responses during the matching-to-sample training before

progressing to the matching-to-sample equivalence test. Subjects were previously given 60 respondent training trials, but in this experiment they were given 12 training trials. In effect, the number of consecutively correct matching-to-sample training trials was matched to the number of respondent training trials. Under the conditions of this experiment the respondent training again proved to be more effective than matching-to-sample. In fact, all six subjects responded in accordance with respondent training during the matching-to-sample test. This is a particularly surprising result in that the subjects were exposed to only one fifth of the respondent training trials used in Experiments 2 and 3. This result indicated that the important variable in establishing equivalence using a respondent training procedure is not the amount of training trials per exposure, but the repeated exposure to training and testing (i.e., no subject produced equivalence after one exposure to the training and testing). Indeed, these data are consistent with the results reported in Chapter 3.

The data of Experiment 3 raises the question, what variables make the respondent procedure more effective than the matching-to-sample procedure? In the matching-to-sample training procedure both positive and negative comparisons are presented on each trial, and thus at least on some occasions a subject will observe the sample stimulus and then immediately observe an incorrect comparison. Even if that comparison is not chosen on that trial, the sample may acquire some of the perceptual functions of the comparison through respondent-type processes. In other words, seeing a sample and then an incorrect comparison may lead a subject to see privately that comparison when subsequently presented with the sample (see Barnes, 1994, for a detailed discussion). This effect, if it occurs, would constitute a form of competing stimulus control during test trials. Imagine, for example, a subject who is presented with B1 as a sample and A1 and A2 as comparisons, during a symmetry test trial. Seeing A2 may elicit seeing B1 if the subject had

previously scanned A2 and then B1 during at least some of the training trials. Insofar as this occurs, A2 may then compete with A1 as the correct comparison. This type of competing stimulus control cannot occur with the respondent procedure, however, because only one correct comparison is presented on any given training trial. In Experiment 4, therefore, we decided to eliminate the potential for competing stimulus control by removing the negative comparisons from the matching-to-sample training procedure.

In Experiment 4 the respondent procedure again proved more effective than the modified matching-to-sample procedure. The removal of the negative comparisons from the matching-to-sample training procedure did not appear to augment the matching-to-sample test performance. Experiment 4 could be criticised because the correct comparison always appeared at the centre of the screen, and thus the subject was simply required to press the same key after each sample-comparison presentation. Consequently, subjects may have simply pressed the response key without attending to the stimulus presentations on the screen. Experiment 5 addressed this criticism.

In Experiment 5, the subject was required to press one of the three marked keys contingent upon the location of the comparison on the screen, thereby facilitating attention to the comparison stimulus on each trial. In this experiment, both training procedures succeeded in producing accurate responding. In effect, the removal of the negative comparisons from the matching-to-sample training rendered the matching-to-sample training almost as effective as respondent training. These data support the suggestion that the presentation of negative comparisons during the traditional matching-to-sample procedure may sometimes provide a source of competing stimulus control over the formation of equivalence classes among positive sample-comparison stimuli.

The results of the current study highlight a number of avenues for future research. Fields and others have reported high failure rates on equivalence

tests without staggering the training and testing. It would be interesting, therefore, to examine interactions between training design and the respondent procedure (i.e., simultaneous versus simple-to-complex with respondent and MTS training protocols). Other issues relate to class size. In the current study three, three-member classes were used, but many equivalence studies have used four or more members per class, and/or four or more classes. How would these variables interact with the respondent procedure? Would the superiority of the respondent procedure increase, decrease, or remain constant across different class sizes or numbers of classes. Other researchers have also examined the role of instructions on equivalence formation (Saunders et al. 1988; Dymond 1995), and thus here again we might examine interaction effects between levels of instruction and training procedure.

Another issue that requires further study is whether continued exposure to the training and testing phases of Experiment 2 would produce responding in accordance with both the respondent and MTS procedures. In the current study, the experiment was terminated whenever subjects responded consistently following both types of training or after six exposures. The results showed a clear superiority for the respondent procedure, but perhaps this was temporary rather than permanent. That is, perhaps the respondent procedure produced derived relational responding more rapidly than MTS, and thus continued exposure to the experimental procedures would have eventually produced equivalence responding in accordance with both types of training. From the point of view of understanding the behavioural processes at work here, it may be that equivalence classes were formed relatively quickly with the respondent procedure, and were thus difficult to modify with the less rapid MTS procedure. This interpretation would certainly be consistent with the previous research that has shown that it is difficult to modify previously established derived relations (Pilgrim & Galizio, 1990, 1995; Roche, Barnes, & Smeets, 1997). Pilgrim & Galazio found that baseline and symmetry probe

performance were extremely sensitive to baseline modification. In contrast equivalence probes remained predominately consistent with the originally established equivalence classes. An interesting avenue of research would therefore be to investigate the susceptibility of the respondent training procedure to the reversal of equivalence relations.

Addressing these and possibly other issues raised by the current study would shed even further light on the equivalence effect itself, and help to identify those key variables that either facilitate or interfere with the formation of equivalence classes in laboratory settings. Clearly, such a program of research would also have important applied implications (e.g., see Chapter 7). Only by systematically tracking down the controlling variables over equivalence class formation by comparing and contrasting different training and testing procedures in combination with other variables (such as training protocols, and level of instruction) will we be in a position to design the most effective educational interventions for applied settings.

Chapter 5:

Comparison-Contiguity as a Source of Stimulus Control in the Matching-to-Sample Procedure

The experiments reported in the previous chapters demonstrated that the respondent training procedure reliably produces equivalence in adult humans. Perhaps the most important implication arising from these findings is that when stimulus events are correlated in time and/or space (referred to as contiguity), the formation of equivalence relations becomes likely. Contiguity is thus a powerful means of establishing equivalence classes. The important role played by contiguity is bolstered by the results reported in the previous chapter. These data showed that the presence of the negative comparisons during matching-to-sample training appear to be largely responsible for the reduced effectiveness of MTS relative to the respondent procedure. This is indeed an interesting finding, and has important implications for the study of stimulus equivalence. In particular, the data suggest that not enough attention has been paid in the literature to the effects of the negative comparisons on equivalence class formation. At this point in my research program, therefore, I decided to address this issue directly within the context of the MTS procedure itself. Rather than comparing MTS with the respondent procedure, as was done in the previous chapter, the experiments reported here examined the effects of the negative comparisons directly by manipulating the stimulus configurations presented within the MTS procedure itself.

Imagine, for example, a subject who is presented with B1 and C2 as comparisons on some trials and C1 and B2 as comparisons on other trials (i.e., across trials, the samples are A1 and A2). Insofar as contiguity is a determinant of equivalence class formation, then the contiguous presentations of B1 and C2 together, and C1 and B2 together, on each trial, may cause these two pairs of stimuli to partition into two separate classes (B1-C2 and C1-B2).

If such an effect occurred, then this would clearly disrupt the emergence of equivalence responding. For example, when B1 was presented as a sample with C1 and C2 as comparisons, based on comparison contiguity, C2 would be the correct choice. The experiments reported in the current chapter were designed to explore this possibility using both children and adults as subjects.

In the first experiment, five year old children were trained and tested on a standard matching-to-sample procedure using a one-to-many protocol (i.e., train A-B and A-C relations, and test for B-A, C-A, B-C, and C-B relations). This experiment constituted a "baseline condition" that served as a comparison for the subsequent experiments in which the training and/or training tasks were modified to examine the effects of contiguity between the comparison stimuli. Experiment 2 was identical to Experiment 1 except that the contiguously paired comparison stimuli, B1-B2 and C1-C2, were included in the matching-to-sample test probes. Thus subjects were given the opportunity to respond in accordance with the trained relations or with the contiguously paired comparisons that were observed during training. In Experiment 3, subjects were trained on a many-to-one protocol. This protocol was used because the stimuli B1-B2 and C1-C2 are never seen together during training. Thus, if contiguity is a key variable, using a many-to-one protocol should produce results in which its effect are not evident. Experiment 4 was identical to Experiment 3 except that 116 identity test trials were inserted prior to the matching-to-sample test trials -- these trials involved B1-B2 and C1-C2 contiguity. This experiment was conducted to determine whether contiguity can have an effect, irrespective of whether it is embedded within training or test trials. Experiment 5 was identical to Experiment 4 except that symmetry trials were used to establish contiguity. Experiment 6 was identical to Experiments 1 and 2, except that adults were used as subjects. This experiment investigated whether adults would respond in a manner similar to children.

General Method

Subjects

Forty normal functioning five year old Dutch pre-school children served as subjects. The children were randomly assigned to one of five experimental conditions. Age (years and months) and sex of subjects are shown in Tables 1, 2, and 3.

Apparatus

The stimuli (3.0 x 3.0 cm) consisted of 6 black Greek letters and symbols (see Figure 1), and are indicated by alphanumerical codes (e.g., A1, B1). The stimuli were presented on white cards (14.5 x 20.0 cm) covered with plastic to prevent staining. Training and testing cards displayed three stimuli, two horizontally aligned (e.g., B1 and B2) 9 cm apart, and one centred 3 cm below (e.g., A1). Additional materials were a tray with beads and a standing transparent glass tube which displayed a mark. Filling to tube to the mark required 50 beads.

Sessions and Settings

Sessions were conducted in a quiet room in the school building, once a day, 5 days a week, typically for a duration of 10 to 15 mins. Three adults participated in the study, one as experimenter, and two as reliability observers. The experimenter and subject were seated at a table facing each other. One of three reliability observers were present in the same room but situated so that she could clearly observe the stimuli and the subjects responses, but not the experimenters data sheet.

Trials, Response Recordings, and Contingencies

Training: Two types of matching-to-sample training trials were used: demonstration and no help trials. A demonstration trial began with the experimenter presenting a matching card and pointing to the sample and designated correct comparison saying, "If you see this, point to that." The experimenter then requested the subject to point to the sample and correct comparison. During the matching-to-sample no help trials, the subject did not receive instruction or modelling -- the experimenter simply presented the matching card to the subject without any comment. Responses on the matching-to-sample training trials were scored as correct, incorrect, or invalid. Correct or incorrect responses were defined as pointing to the correct or incorrect comparison while invalid responses were recorded when the subject pointed, for example, to the sample only, to both comparisons, or when the subject pointed to the comparison without looking at the sample. Correct responses were followed by verbal praise and the delivery of a token ("Good, take a bead"). Incorrect responses were followed by verbal disapproval ("Wrong, no bead"), while invalid responses were followed by corrective feedback. (e.g., "look at the picture when pointing"). When the subject succeeded in filling the glass tube to the mark (50 beads), the subject was allowed to exchange the beads for a preselected card (cartoon character, soccer player, animal).

Testing: Matching-to-sample test trials were the same as the no help trials (silent presentation of matching cards) except that (a) responses consistent with the matching-to-sample training were simply recorded and no programmed consequences delivered. In addition to the nonverbal responses (pointing to the comparison stimuli), the experimenter also recorded the subjects' verbal comments on the matching-to-sample training and test trials.

Experiment 1: One-To-Many Training

Procedure

In Steps 1 and 2 of this experiment subjects received matching-to-sample training, during which they were trained on the conditional discriminations A1-B1, A2-B2, A1-C1, and A2-C2.

Step 1A: One block of 18 matching-to-sample training trials was used. The step began with two demonstration trials in which A1 and A2 served as samples and B1 and B2 as comparisons. This was followed by 16 no-help trials. In this step the B1 and B2 comparisons were always placed in the same position (i.e., B1 to the left and B2 to the right). A stability criterion of 15 out of 16 correct responses on the no-help trials was required. If a subject failed to reach this criterion then he or she was re-exposed to the step. If the subject was not successful at this point he or she was dropped from the study.

Step 1B: This step consisted of 16 no help trials. This step was identical to Step 1A except that no demonstration trials were used and the position of the comparison stimuli was reversed (i.e., B2 to the left and B1 to the right).

Step 1C: In this step 16 no help trials were used. The position to the comparison stimuli was randomised (i.e., 8 trials with B1 to the left and B2 to the right quasi-randomly mixed with 8 trials with B2 to the left and B1 to the right).

Steps 2A, 2B, and 2C were identical to Steps 1A to 1C, respectively, except that the A1-C1 and A2-C2 conditional discriminations were trained.

Step 3: This step tested the emergence of accurate responding on B-A and C-A conditional discriminations. This step consisted of four blocks. Block 1 consisted of 2 A-B matching-to-sample training trials quasi-randomly mixed with 2 A-C training trials. Block 2 consisted of 4 B-A matching-to-sample test trials quasi-randomly mixed with 4 C-A test trials. Blocks 3 and 4 were identical to Blocks 1 and 2 respectively.

Prior to the commencement of a test block the experimenter removed the tray of beads and glass tube and said, "Now we are going to play the game without me telling you whether you are right or wrong. You won't get any beads. Later on we will play the game with beads. Do your best". The experimenter then proceeded with the test trial and refrained from any communication with the subject. Criterion was reached if the subject produced a minimum of 7/8 correct responses on matching-to-sample training (Blocks 1 & 3) and 14/16 correct responses on matching-to-sample test trials (Blocks 2 & 4). If a subject failed to reach the criterion s/he was re-exposed to this step. If the subject was not successful following a second exposure participation in the study was terminated.

Step 4: This step examined whether subjects matched both directly and indirectly paired stimuli. This step consisted of four blocks. Block 1 consisted of 2 A-B matching-to-sample training trials quasi-randomly mixed with 2 A-C training trials. Block 2 consisted of 4 B-C matching-to-sample test trials quasi-randomly mixed with 4 C-B test trials. Blocks 3 and 4 were identical to Blocks 1 and 2 respectively. The subject reached the criterion if s/he produced a minimum of 7/8 correct responses on matching-to-sample training (Blocks 1 & 3) and 14/16 correct responses on matching-to-sample test trials (Blocks 2 & 4).

Results and Discussion

Number of correct responses on symmetry and equivalence tests for each individual exposure for each subject are presented in Table 1. All eight subjects in Condition 1 required one block of training trials in Steps 1A, 1B, and 1C to establish the A-B conditional relations, and they maintained this performance throughout the experiment. Similarly, all subjects required one block of training trials in Steps 2A, 2B, and 2C to establish the A-C conditional relations, and they also maintained this performance throughout the

Table 1

Sex, Age and Number of Correct Responses on Symmetry and Equivalence Tests for each Subject in Experiment 1.

Subject	Step 3		Step 4	
Sex	B-A	C-A	B-C	C-B
Age				
S1 F 5.1	8	8	8	8
S2 F 5.6	8	8	8	8
S3 M 5.2	8	8	8	8
S4 M 5.7	8	8	8	8
S5 M 5.1	8	8	8	8
S6 F 5.3	8	8	8	8
S7 F 5.4	8	8	8	8
S8 M 5.0	8	8	8	8

experiment. In Step 3, all subjects produced 16/16 correct responses on the B-A and C-A test trials on their first exposure. Similarly in Step 4, all eight subjects successful matched the B-C and C-B stimuli on their first exposure. Reliability checks were made on 30% of all matching-to-sample training and test trials. Experimenter and reliability observer always agreed. This condition clearly demonstrated that five year old children readily match both directly and indirectly paired stimuli using a one-to-many training procedure. Experiment 2 was designed to investigate the effects of comparison contiguity on derived relational responding

Experiment 2

This Experiment was identical to Experiment 1, except that the matching-to-sample test in Step 4 was modified. In Experiment 1, subjects received B-C and C-B test probes. In this experiment, however, the contiguously paired comparison stimuli, B1-B2 and C1-C2, were included in the matching-to-sample test probes. In effect, subjects were presented with the following four matching-to-sample tasks: B1/C1-B2 (i.e., B1 as a sample with C1 and B2 as comparisons), B2/C2-B1, C1/B1-C2, and C2/B2-C1. If subjects respond in accordance with the trained relations, then they would pick C1 in the presence of B1, C2 in the presence of B2, B1 in the presence C1, and B2 in the presence of C2. If, however, contiguity between the comparison stimuli is a more powerful source of stimulus control, then they would choose B2 in the presence of B1, B1 in the presence of B2, C2 in the presence of C1, and C1 in the presence of C2.

Results and Discussion

Number of correct responses on symmetry and equivalence tests are presented in Table 2. All eight subjects in Experiment 2 required one block of training trials in Steps 1A, 1B, and 1C to establish the A-B conditional relations and they maintained this performance throughout the experiment. Similarly in Step 2 all subjects reached criterion performance after one block of A-C conditional discriminations, and also maintained this performance throughout the experiment. In Step 3, Subjects 9-16 produced 16/16 correct responses on the B-A and C-A test trials on their first exposure. In Step 4, Subjects 9-14 responded in accordance with contiguity (e.g., choose B2 in the presence of B1), on their first exposure to the test. Subjects 15 and 16 responded in accordance with the trained conditional relations, producing 14/16 correct responses, respectively, on their first exposure to the test.

Table 2

Sex, Age and Number of Correct Responses on Symmetry and Equivalence Tests for each Subject in Experiment 2.

Subject	Step 3		Step 4			
	B-A	C-A	B-C	B-B	C-B	C-C
Sex						
Age						
S9 M 5.1	8	8		8		8
S10 F 5.6	8	8		8		8
S11 M 5.3	8	8		8		8
S12 F 5.7	8	8		8		8
S13 M 5.1	8	8		8		8
S14 M 5.3	8	8		8		8
S 15 F 5.1	8	8	7		7	
S16 F 5.0	8	8	7		7	

Reliability checks were made on 40% of all matching-to-sample training and test trials. Experimenter and reliability observer disagreed on one matching-to-test trial. This experiment demonstrated that contiguity during matching-to-sample training may exert a powerful influence over the emergence or non-emergence of derived relational responding.

In Experiment 3, subjects were trained on a many-to-one protocol (i.e., train B-A and C-A relations, and test A-B, A-C, and C-B relations). This protocol was used because, during training, the contiguously paired stimuli B1-B2 and C1-C2 are never seen together -- subjects only observe them during the symmetry probes of Step 3. Step 4 in this experiment was identical to Experiment 2, in that subjects received a modified matching-to-sample test. If

contiguity is the key variable involved in the different performances obtained between Experiments 1 and 2, then its absence during training, using a many-to-one protocol, will produce results similar to those obtained in Experiment 1.

Experiment 3

Steps 1, 2, 3, and 4 of Experiment 3 were identical to Experiment 2, except that subjects were trained on the following conditional discriminations, B1-A1, B2-A2, C1-A1, and C2-A2, and were then tested on the conditional relations, A1-B1, A2-B2, A1-C1, and A2-C2.

Results and Discussion

Number of correct responses on symmetry and equivalence tests are presented in Table 3. All eight subjects in Experiment 3 required one block of training trials in Steps 1A, 1B, and 1C to establish the B-A conditional relations, and they maintained this performance throughout the experiment. In Steps 2A, 2B, and 2C all subjects reached criterion performance after one block of C-A conditional relations, and they also maintained this performance throughout the experiment. In Step 3, Subjects 17, 19, and 20 required one exposure to the test to attain 16/16 correct responses on A-B and A-C tests, while Subjects 18, 21, 22, 23, and 24 required two exposures. In Step 4, all eight subjects responded in accordance with the trained and derived relations and produced 16/16 correct responses on their first exposure. Reliability checks were made on 35% of all matching-to-sample training and testing. Experimenter and reliability observer disagreed on one matching-to-sample test trial. This experiment showed that when the contiguously paired comparison stimuli B1-B2 and C1-C2 were not presented during training (i.e., using a many-to-one protocol), normal equivalence responding emerged.

Table 3

Sex, Age and Number of correct responses on symmetry and equivalence tests for each subject in Experiment 3.

Subject	Step 3			Step 4		
	A-B	A-C	B-C	B-B	C-B	C-C
Sex						
Age						
S17 F 5.4	8	8	8		8	
S18 F 5.4	6 8	7 8	8		8	
S19 F 5.0	8	8	8		8	
S20 M 5.3	8	8	8		8	
S21 M 5.8	7 8	6 8	8		8	
S22 M 5.0	6 8	6 8	8		8	
S23 F 5.0	7 8	6 8	8		8	
S24 M 5.1	6 8	6 8	8		8	

One issue that arises from these data is the possibility of an interaction between contiguity and conditional discrimination training. In Experiment 2, subjects were trained using a one-to-many preparation during which they observed the contiguously paired stimuli B1-B2, C1-C2, a maximum of 132 times, and then during the test phases, 6 of the 8 subjects responded in accordance with contiguity rather than the trained conditional discriminations. In Experiment 3, B1-B2 and C1-C2 contiguity was not present when subjects were trained on a many-to-one preparation.

However, contiguity between these pairs was present during the 16 symmetry probes of Step 3. Under these conditions normal conditional responding emerged for all 8 subjects, indicating the presence of contiguity

during symmetry testing was not effective in disrupting emergent conditional discriminations. Was the absence of an effect due to the low number of trials during which contiguity was present, or was it due to the fact that contiguity was present during test rather than training trials. To answer this question, Experiment 4 was a replication of Experiment 3 except that 116 identity test trials were inserted after Step 3 and prior to Step 4. These test trials presented the B1-B2 and C1-C2 stimuli contiguously, so that each subject was exposed to them 132 times across the entire experiment (i.e., 116 identity trials plus 16 symmetry probes). If subjects respond in accordance with contiguity, this would indicate that contiguity can have an effect irrespective of whether it is embedded within training or test trials.

Experiment 4

This experiment was identical to Experiment 3, except that subjects received 116 identity test trials after Step 3 and prior to Step 4.

Results and Discussion

Number of correct responses on symmetry and equivalence tests are presented in Table 4. All eight subjects in Experiment 4 required one block of training trials in Steps 1A, 1B, and 1C to establish the B-A conditional relations, and they maintained this performance throughout the experiment. In Steps 2A, 2B, and 2C all subjects reached criterion performance after one block of C-A conditional relations, and also maintained this performance throughout the experiment. In Step 3, Subjects 25, 26, and 27 required one exposure to the step to achieve 16/16 correct responses on the A-B and A-C tests, while Subjects 28, 29, 30, 31, and 32 required two exposures. All subjects responded accurately on all identity probes. In Step 4, Subjects 25, 26, 28, 29, 30, 31, and 32 responded in accordance with contiguity, while Subject 27, responded in accordance with the trained conditional relations.

Table 4

Sex, Age and Number of correct responses on symmetry and equivalence tests for each subject in Experiment 4.

Subject	Step 3			Step 4		
Sex	A-B	A-C	B-C	B-B	C-B	C-C
Age						
S25 F 5.2	8	8		8		8
S26 F 5.1	8	8		8		8
S27 M 5.3	8	8	8		8	
S28 M 5.7	6 8	5 8		8		8
S29 M 5.8	6 8	6 8		8		8
S30 F 5.6	7 8	6 8		8		8
S31 F 5.4	7 8	6 8		8		8
S32 M 5.2	7 8	6 8		8		8

Reliability checks were made on 30% of all matching-to-sample training and test trials. Experimenter and reliability observer disagreed on one matching-to-sample test trial. This experiment demonstrated that when subjects are trained using a many-to-one protocol, where the contiguously paired stimuli are not seen during training, but are observed during a test phase of the experiment, contiguity over-rides (in most cases) the trained conditional relations. Contiguity does not, therefore, have to occur within a training context in order to compete successfully with conditional discrimination training.

This finding is particularly remarkable because during the B-B identity probes, for example, B2 was the S- comparison when B1 was the sample, but subjects selected B1 on C1/B2-B1 trials and B1 on C2/B2-B1 trials. In effect,

the S+/S- functions of the comparison stimuli appeared to flip across the different test phases of the experiment. One way to approach this finding is to focus on the way in which the test probes allow for particular types of stimulus control to emerge. That is, responding in accordance with contiguity was simply not possible during the identity probes, but this form of stimulus control became available during the equivalence test (see General Discussion for further speculation on this issue).

One caveat that may arise from Experiment 4, however, is that it differed from the previous three experiments in that it included identity probes. Perhaps, therefore, the presence of identity matching per se interacted in some undefined way with contiguity, thus increasing its effect on the subject's test performances. To address this concern, Experiment 5 replicated Experiment 4, except that the required exposure to B1-B2 and C1-C2 contiguity was provided by including symmetry probes, rather than including 116 identity probes.

Experiment 5

This experiment was identical to Experiment 4 except that symmetry probes were used instead of identity probes.

Results and Discussion

Number of correct responses correct on symmetry and equivalence tests are presented in Table 5. All eight subjects in Experiment 5 required one block of training trials in Steps 1A, 1B, and 1C to establish the B-A conditional relations, and they maintained this performance throughout the experiment. In Steps 2A, 2B, and 2C all subjects reached criterion performance after one block of C-A conditional relations, and also maintained this performance throughout the experiment. In Step 3, all subjects produced 16/16 correct responses on A-B and A-C test probes, and during the following 116 additional symmetry probes subjects responded accurately on all trials. During Step 4, all

Table 5

Sex, Age and Number of correct responses during symmetry and equivalence tests for each subject in Experiment 5.

Subject	Step 3		Step 4			
	A-B	A-C	B-C	B-B	C-B	C-C
Sex						
Age						
S33 M 5.2	8	8		8		8
S34 F 5.1	8	8		8		8
S35 F 5.4	8	8		8		8
S36 F 5.5	8	8		8		8
S37 F 5.6	8	8		8		8
S38 M 5.2	8	8		8		8
S39 M 5.3	8	8		8		8
S40 M 5.2	8	8		8		8

8 subjects responded in accordance with contiguity. Reliability checks were made on 40% of all matching-to-sample training and test trials. Experimenter and reliability observer always agreed.

This experiment demonstrated, as did Experiment 4, that given sufficient exposure to B1-B2 and C1-C2 contiguity, subjects normally respond in accordance with this contiguity rather than the trained conditional relations.

Thus far in the current study, the subjects have all been five year old, normally functioning children. At this point in our research, we asked whether the effects of contiguity would also be seen with normally functioning adults. Experiment 6 was designed to determine whether contiguity would exert a

similar effect to that observed in the previous experiments, using normally functioning adults as subjects.

Experiments 6

Subjects

Sixteen subjects, 8 female and 8 male, of University College Cork served as subjects. Their ages ranged from 18 to 25. All subjects were experimentally naive, and were non-psychology majors. Subjects were recruited through faculty notice-board advertisements and were randomly assigned to one of two conditions. Experimental sessions were arranged so that subjects would not come into contact with each other in the vicinity of the laboratory, and they were instructed not to discuss their participation with anyone.

Procedure

In Experiment 6, Condition 1 was identical to Experiment 1. Thus subjects received one-to-many training and testing. Condition 2 was identical to Experiment 2, thus subjects received one-to-many training and a modified matching-to-sample test. During the matching-to-sample test the contiguously paired stimuli (B1-B2, C1-C2) were included in the matching-to-sample test.

Results and Discussion

Condition 1

Number of correct responses on symmetry and equivalence tests are presented in Table 6. All 8 subjects required one block of training trials in Steps 1A, 1B, and 1C to establish the A-B conditional relations and they maintained this performance throughout the experiment. Similarly, all subjects required one block of training trials in Steps 2A, 2B, and 2C to establish the A-

C conditional relations, and they also maintained this performance throughout the experiment. In Step 3, all subjects produced 16/16 correct responses on the B-A and C-A test trials on their first exposure. Similarly in Step 4, all 8 subjects successfully matched the B-C and C-B stimuli on their first exposure. This condition demonstrated that the adults, like the children, had no difficulty in demonstrating equivalence responding given a one-to-many protocol.

Condition 2

Number of correct responses on symmetry and equivalence tests are presented in Table 7. All eight subjects in Condition 2 required one block of training trials in Steps 1A, 1B, and 1C to establish the A-B conditional relations and they maintained this performance throughout the experiment. Similarly in Step 2 all subjects reached criterion performance after one block of A-C conditional relations and also maintained this performance throughout the condition. In Step 3, all subjects reached criterion after one exposure to the test. In Step 4, all eight subjects responded in accordance with the trained relations on their first exposure to the test. This experiment clearly demonstrated that the adults, unlike the children, were not susceptible to the effects of B1-B2 and C1-C2 contiguity and responded in accordance with the trained conditional relations.

General Discussion

This study demonstrated that comparison contiguity may be an important determinant of equivalence class formation in a population of five year old children, but this effect was not evident with human adults.

In Experiment 1, all eight subjects were successful on all tests, thus demonstrating that five year old children readily match both directly and indirectly paired stimuli using a one-to-many protocol.

Table 6

Number of correct responses on symmetry and equivalence tests for each subject in Experiment 6, Condition 1.

Subject	Step 3		Step 4	
	B-A	C-A	B-C	C-B
S41	8	8	8	8
S42	8	8	8	8
S43	8	8	8	8
S44	8	8	8	8
S45	8	8	8	8
S46	8	8	8	8
S47	8	8	8	8
S48	8	8	8	8

In Experiment 2, subjects were given a modified equivalence test. Rather than presenting, for example, B1 as a sample and C1 and C2 as comparisons, subjects were presented with B1 as a sample with B2 and C1 as comparisons. Therefore subjects could respond in accordance with the trained conditional relations (choose C1 in the presence of B1) or contiguity (choose B2 in presence of B1).

Under these conditions, 6 subjects responded in accordance with contiguity and 2 subjects responded in accordance with the trained conditional relations. This result indicates that young children appear to partition stimuli more readily into classes based on contiguity than on differentially reinforced conditional discriminations.

Table 7

Number of correct responses on symmetry and equivalence tests for each subject in Experiment 6, Condition 2.

Subject	Step 3		Step 4			
	B-A	C-A	B-C	B-B	C-B	C-C
S49	8	8	8		8	
S50	8	8	8		8	
S51	8	8	8		8	
S52	8	8	8		8	
S53	8	8	8		8	
S54	8	8	8		8	
S55	8	8	8		8	
S56	8	8	8		8	

In Experiment 3, subjects were trained using a many-to-one preparation. During training, the contiguously paired stimuli B1-B2 and C1-C2 were never seen together -- subjects only observed them during the symmetry probes of Step 3. All subjects responded in accordance with the trained conditional relations, thus indicating that contiguity was the key variable involved in the different performances obtained between Experiment 1 and 2, because in its absence (in Experiment 3) "normal" equivalence responding emerged.

An issue that arose at this point in our research was the possibility of an interaction between contiguity and conditional discrimination training. In Experiment 2, subjects were trained using a one-to-many preparation during which they observed the contiguously paired stimuli, B1-B2 and C1-C2,

maximum of 132 times, and then during the test phase, 6 of the 8 subjects responded in accordance with contiguity rather than the trained relations. In Experiment 3, B1-B2 and C1-C2 contiguity was not present when subjects were trained on a many-to-one preparation, but contiguity between these pairs was present during the 16 symmetry probes of Step 3. Under these conditions normal equivalence responding emerged, indicating the presence of contiguity during symmetry testing was not effective in disrupting emergent conditional discriminations. Consequently, we asked whether the absence of the effect was due simply to the low level of contiguity or to the absence of contiguity during training trials. Experiment 4 was identical to Experiment 3, except that subjects were exposed to 116 identity test probes before the equivalence test. Under these conditions, 7 subjects responded in accordance with contiguity and 1 subject responded in accordance with the trained relations. These results clearly demonstrated that the effects of contiguity was not a function of conditional discrimination training alone, but may also emerge when contiguity is present during testing. Experiment 5 was identical to Experiment 4 except that subjects were administered symmetry test probes instead of identity probes. In this condition all eight subjects responded in accordance with contiguity, demonstrating again that the effects of contiguity were not dependent on conditional discrimination training alone.

In Experiment 6, we sought to determine whether normal functioning adults would respond in a similar manner to children and thus partition stimuli into classes based on comparison contiguity. Conditions 1 and 2 of Experiment 6 were identical to Experiments 1 and 2, respectively. All 16 adults across both conditions responded in accordance with the trained conditional discriminations, thereby indicating that contiguity had virtually no effect on the adult test performances.

The current study apparently identified two sources of stimulus control over equivalence test performances; the conditional discriminations established

during matching-to-sample training, and spatial contiguity between the correct and incorrect comparisons. Which of these sources of control predominates during a test performance may depend upon the amount of “behavioural effort” required to respond in a consistent way (Novak, 1996). The data appear to indicate that, for the children, responding in accordance with contiguity was in some sense less effortful than responding in accordance with derived conditional relations (see also the final chapter of the current thesis). This conclusion is based on the fact that most of the children responded in accordance with contiguity when the test tasks permitted them to do so (Experiments 2, 4, & 5), but this pattern did not emerge when the test tasks did not allow for control by contiguity (Experiments 1 & 3). Based on this line of reasoning, it would be interesting to determine whether adults would show a similar effect if greater behavioural effort was required to respond in accordance with derived conditional relations (e.g., by increasing the number and size of the classes).

The foregoing interpretation would also help to explain a conceptual problem arising from the results of Experiment 3. In this experiment, subjects were presented with A1 and A2 as comparisons during the training (i.e., many-to-one training), but responded in accordance with derived conditional relations during the test phases. Based on contiguity, A1 and A2 should have entered into one class, and thus all of the stimuli in the experiment should have collapsed into a single class. Why did this not occur? (i.e., all subjects passed the equivalence test). If the “two-process/least effort” analysis suggested above is correct, then the data of Experiment 3 are predictable. Responding in accordance with contiguity during the test was simply not possible (i.e., based on contiguity choosing both comparisons was always correct, and the nature of the task did not permit this to occur), and thus subjects’ responding came under the control of the more effortful form of stimulus control (i.e., derived conditional responding).

In fact, this issue may be related to previous data reported by Smeets, Barnes, Schenk, & Darcheville (1996), and Smeets and Barnes (1997). In the Smeets et al. (1996) study, 24 five year old children, 4 high functioning adults with mental retardation and 4 normal functioning adults were trained on a simple A discrimination task (A1+/A2-). Subjects then received simple discrimination probes, first with AB compounds (A1B1 vs A2B2) and then with B stimuli (B1 vs B2). At this point in the study all subjects received A-B and B-A matching probes. All subjects subsequently showed transfer from A to B stimuli (A1B1+A2B2-, B1+/B2-). However, only 6 out 24 children and 1 out 4 mentally retarded adults, responded accurately on A-B and B-A matching probes (A1-B1, A2-B2). All normal functioning adults, responded accurately on these tests. Subjects then received additional simple discrimination probes; B1C1 vs B2C2 and C1vs C2. Again all subjects showed the designated transfer of stimuli but only normal functioning adults demonstrated accurate responding on the B-C, C-B, A-C and C-A test probes. In the Smeets and Barnes (1997) study, 5 year old children and normal functioning adults were trained two simple discrimination tasks (A1+/A2- and B1+/B2-). Subjects then received simple discrimination probes which tested A3+/A2- and B3+/B2- followed by the matching probes A2-A1, B2-B1, A2-A3, B2-B3, A3-A1 and B3-B1. The majority of children matched the directly paired stimuli with each other (e.g., A2-A2, B1-B2) but failed to match the indirectly paired stimuli with each other (e.g., A1-A3, B1-B3). All normal functioning adults responded accurately on all test trials. Both these studies demonstrated that adults relative to children are superior at forming relations between directly and indirectly paired stimuli. It should be noted that in these 2 studies, stimulus relations could only be formed on the basis of contiguity. Experiments 2, 4 and 5 of the present chapter allowed subjects to form stimulus relations on the basis of comparison contiguity or with the trained conditional relations. In effect adults may be superior at forming relations on the basis of contiguity, but

they will revert to forming relations on the basis of the trained conditional relations when given the opportunity to do so. Children on the other hand tend to continue responding in accordance with contiguity “or hold on to contiguity”, even when it is possible to respond in accordance with the trained conditional relations.

The current research shows that even relatively subtle differences in the configuration of the training and testing tasks during studies of stimulus equivalence can have a major impact on the subjects' test performances. Perhaps the most remarkable finding in the current study was the findings of Experiments 4 and 5, in which it was shown that prior exposure to reflexivity and symmetry tests was followed by failure on subsequent equivalence tests. These data indicate that in some contexts, exposing subjects to probes that test for individual components of the equivalence relation (i.e., reflexivity and symmetry) may sometimes work against the full emergence of that relation (i.e., combined symmetry and transitivity). This is certainly a counterintuitive result, and one that will require considerable scrutiny in future research. Furthermore, these data also supplement recent work suggesting that equivalence class formation is not an unanalysable primitive and may itself be composed of simpler behavioural units (see, for example, Pilgrim & Galizio, 1990, 1996; Wilson & Hayes, 1996; Roche, Barnes, & Smeets, 1997).

In summary, this is the first study that has systematically examined the effects of comparison contiguity on equivalence responding. The results of the study may be seen as counterintuitive in that it was shown that certain types of reflexivity or symmetry tests may actually hinder the emergence of combined symmetry and transitivity responding. Furthermore, the effects of comparison contiguity were found to be particularly strong for the young children, but virtually non-existent for the adults.

Figure 1:
Symbols Used as Stimuli

A1 A2 B1 B2

@ # % £

C1 C2

& \$

Chapter 6:

The Respondent-type Training Procedure and Young Children

Having identified a new procedure that reliably produces equivalence responding in adult human subjects (Chapters 2 and 3), the issue of comparison-contiguity arose in Chapter 4. This variable was systematically examined in Chapter 5, within the context of the MTS procedure, using both adults and children as subjects. At this point in my research program, however, I had not used the respondent procedure with children. Obviously, if the general effectiveness of this procedure was to be explored adequately within the current research program, then it would have to be shown to be effective with this younger subject population.

In a study conducted outside of my doctoral research, Smeets, Leader, and Barnes, (1997) investigated whether the respondent procedure would produce symmetry and equivalence formation in 5 year old normal functioning children. During respondent training subjects were trained on either a linear, one-to-many or many-to-one training protocol. During a respondent training trial the experimenter showed the subject both sides of an observation card. The experimenter showed the front side first (e.g., showing A1) for 1-s (the experimenter silently counted “twenty-one”) and then the back side (showing B1) for 1-s. In Experiment 2 the vast majority of subjects failed the equivalence test when trained on a simultaneous training design (observe A->B, B->C and then test B-A, C-B, A-C and C-A in a single block). In Experiments 3 and 4 of this study, when a simple-to-complex training design was employed, 87.5% of subjects matched all directly paired stimuli (B-A and C-B) and 76.2% of subjects matched all indirectly paired stimuli (C-A). In Experiment 3 subjects were trained A->B and tested A-B, B-A, trained B->C and tested B-C, C-B and tested A-C, C-A. Experiment 4 was identical to

Experiment 3 except that only symmetry and equivalence relations were tested. This study found that the respondent training procedure is an effective means of producing equivalence with this population when subjects are trained using a simple-to-complex training design. This study did not show an effect across training protocols (i.e., no difference was found between linear, one-to-many and many-to-one)

One possible criticism of the Smeets et al., study, however, was that stimulus pairs (i.e., $A \rightarrow B$, $B \rightarrow C$) were presented on opposite sides of the same observation card. The authors argued that this use of spatial contiguity (displaying a stimulus pair on the same observation card) may have facilitated the emergence of equivalence relations, and thus it cannot be determined to what extent the temporal relations among stimulus pairs, per se, were responsible for the formation of equivalence classes. To establish the relative effectiveness of the respondent procedure for young children, therefore, the confounding variable of spatial contiguity will have to be removed from the procedure. To address this issue in the current study, stimulus pairs were presented on separate observation cards.

A second issue that arose from the Smeets et al. (1997) study was that the majority of subjects passed the equivalence test only when a simple-to-complex training design was employed. That is, in Experiment 3 subjects were trained $A \rightarrow B$ and tested $A-B$, $B-A$, trained $B \rightarrow C$ and tested $B-C$, $C-B$ and tested $A-C$, $C-A$. When a simultaneous training design was used the vast majority of subjects failed the equivalence test. In Experiment 2, for example, subjects were trained $A \rightarrow B$, $B \rightarrow C$, and were then tested for $B-A$, $C-B$, $A-C$ and $C-A$ in a single block. One question that arises from this finding is whether some form of procedural modification would allow the respondent procedure to generate equivalence relations without first testing for symmetry. Previous research has shown that once an equivalence class has been established, additional members may be added to the class with less training and testing than was needed to

establish the initial class (Saunders, Saunders, Kirby, & Spradlin, 1988). Perhaps, therefore, it may be possible to establish equivalence relations using the respondent procedure and young children, without first testing for symmetry, if an initial class was first established and then an additional member was added to that class. To test this suggestion in the current study we trained two three member equivalence classes using a simple-to-complex training design (as in Experiment 4 of Smeets et al. 1997), and then added another stimulus to each of the existing classes, (i.e., train C->D). We then investigated whether equivalence would emerge (i.e., test D-B and D-A), without testing for symmetry (i.e., D-C).

Finally, we examined variables which have been found to either suppress or facilitate equivalence responding in human subjects. Studies by Spradlin and Saunders (1986), found that multiple sample, single comparison, conditional relational training (many-to-one) appears to facilitate equivalence responding more readily than single-sample multiple comparison training (one-to-many). Furthermore, recent studies have also found that many-to-one training (relative to one-to-many) facilitates derived performances in non human subjects such as pigeons (see Urcuioli and Zentall, 1993, and Zentall and Urcioli, 1993). The data obtained in Condition 1 of Smeets et al, (1997) together with Condition 2 (linear) of Leader et al, (1996), provided tentative evidence that many-to-one was superior to one-to-many which was in turn was superior to the linear protocol with an adult population. However with a population of normal functioning five year old children in the Smeets et al, (1997) a superiority effect was not found in favour of any of the three protocols. The current study explored further this question. In Experiment 1, subjects were exposed to the respondent procedure using a linear protocol, in Experiment 2 using a one-to-many protocol, and in Experiment 3 using a many-to-one protocol.

General Method

Subjects

Fifteen normal functioning five year old Dutch pre-school children served as subjects. The children were randomly assigned to one of three experiments. Age (years and months) and sex of subjects is shown in Table 1, 2 and 3.

Apparatus

The stimuli (3.0 x 3.0 cm) consisted of 12 black symbols (see Figure 1). The stimuli are indicated by alphanumerical codes (e.g., X1, A1). The stimuli were presented on white cards (14.5 x 20.0 cm) covered with plastic to prevent staining. Observation cards displayed one stimulus (e.g., B2) positioned at the centre of the card. Matching cards displayed three stimuli, two horizontally aligned (e.g., B1 and B2) 9 cm apart, and one centred 3 cm below (e.g., A2). Additional materials were a tray with beads and a standing transparent glass tube which displayed a mark. Filling the tube to the mark required 50 beads.

Sessions and Settings

Sessions were conducted in a quiet room in the school building, once a day, 5 days a week, typically for a duration of 10 to 15 mins. Three adults participated in the study, an experimenter and two reliability observers. The experimenter and subject were seated at a table facing each other. The reliability observer (one at a time) was present in the same room but situated so that she could clearly observe the stimuli and the subjects response but not the experimenters data sheet.

Trials, Responses recordings and Contingencies

Three types of trials were used: respondent training trials, matching-to-sample training trials, and matching-to-sample test trials. During a respondent training trial the experimenter showed the child an observation card (e.g., A1) for 1-s (the experimenter silently counted "21") followed by another observation card (e.g., B1) for 1-s. The experimenter then recorded whether the subject had looked at both observation cards and without delivering any programmed consequences initiated the next training trial (i.e., there was a 3-s delay between the presentation of one stimulus pair and the next). If after every fifth training trial the subject had observed all stimulus presentations, the experimenter praised the subject . "Good girl/boy, you are doing well, take a bead."

Two types of matching-to-sample training trials were used: demonstration and no help trials. A demonstration trial begun with the experimenter presenting a matching card and pointing to the sample and designated correct comparison saying, "If you see this, point to that". The experimenter then requested the subject to point to the sample and correct comparison. During the matching-to-sample no help trials, the subject did not receive instruction or modelling, the experimenter silently presented the matching card. Responses on the matching-to-sample training trials were scored as correct, incorrect, or invalid. Correct or incorrect responses were defined as pointing to the correct or incorrect comparison while invalid responses were recorded when the subject pointed, for example, to the sample, to both comparisons, or when the subject pointed to the comparison without looking at the sample. Correct responses were followed by verbal praise and the delivery of a token ("Good, take a bead"). Incorrect responses were followed by verbal disapproval ("Wrong, no bead), while invalid responses were followed by corrective feedback.(e.g., "look at the pictures when pointing").

The matching-to-sample test trials were the same as the no help trials (silent presentation of matching cards) except that (a) responses consistent with the respondent and matching-to-sample training were recorded and (b) no programmed consequences were used. In addition to the nonverbal responses (looking at cards, pointing), the experimenter also recorded the subjects verbal comments on the respondent training trials and on matching-to-sample test trials involving stimuli that were used in respondent training.

Experiment 1

Procedure

A linear preparation was used during respondent training. In Step 1 and 2 of this experiment two unrelated matching-to-sample tasks were pretrained so that any failure in the matching-to-sample test could be not attributed to a lack of familiarity with the matching-to-sample task per se.

Step 1A: Pretraining X-Y. One block of 18 matching-to-sample training trials were used. The step begun with two demonstration trials in which X1 and X2 served as samples and Y1 and Y2 as comparisons. This was followed by 16 no-help trials. In this step the Y1 and Y2 comparison were always placed in the same position (i.e., Y1 to the left and Y2 to the right). A stability criterion of 15 out of 16 correct responses on the no-help trials was required. If the subject failed to reach this criterion then he or she was re-exposed to this step. If the subject was not successful at this point he or she was dropped from the study.

Step 1B: This step consisted of 16 no help trials. The step was identical to Step 1A except that no demonstration trials were used and the position of the comparison stimuli was reversed. (i.e., Y2 to the left and Y1 to the right).

Step 1C: In this step 16 no help trials were used. The position of the comparison stimuli was randomised (i.e., 8 trials with Y1 to the left and Y2 to

the right quasi-randomly mixed with 8 trials with Y2 to the left and Y1 to the right).

Step 2: Testing X-Y and Y-X. This step examined whether the subjects continued the X-Y performance accurately (a) without programmed consequences and (b) when the sample-comparison functions of the X and Y stimuli were reversed. The step consisted of two blocks of test trials (Blocks 1 & 3) and two blocks of training trials (Blocks 2 & 4). Each training block consisted of 6 X-Y training trials and each test block consisted of 8 X-Y test trials quasi-randomly mixed with 8 Y-X test trials.

Prior to the commencement of a test block the experimenter removed the tray of beads and glass tube and said “Now we are going to play the game without me telling you whether you are right or wrong. You won't get any beads. Later on we will play the game with beads. Do your best.” The experimenter then proceeded with the test trial and refrained from any communication with the subject. Prior to the commencement of the training block the experimenter placed the tray of beads and the glass tube on the table and said, “now you can earn beads again.” When the subject succeeded in filling the glass tube to the mark (50 beads) during this stage or any other stage of the experiment, the subject was allowed to exchange the beads for a preselected card (cartoon character, soccer player, animal). A stability criterion of (a) 7/8 correct responses X-Y test trials, (b) 7/8 correct responses on the Y-X test trials and (c) 11/12 correct responses on the X-Y training trials was required to proceed to Step 3. If a subject did not reach the criterion the subject was re-exposed to Step 2 and at this point if the subject was not successful his or her participation in the study was terminated.

Step 3: In this step subjects received respondent training where they observed the stimuli A->B s in a fixed temporal order. This was followed directly by the conditional discrimination probes B-A. The step consisted of six blocks. In the first block subjects received 10 respondent training trials.

Block 2 consisted of 1 X-Y and 1 Y-X matching-to-sample test trial followed by 8 B-A conditional discrimination probes. Block 3 consisted of 6 X-Y training trials. Blocks 4, 5, & 6 were identical to Blocks 1, 2, & 3 respectively. Subjects reached the criterion if they observed the A->B stimulus presentation 18/20 times during the respondent training trials (Blocks 1&4), produced 14/16 correct responses on the B-A test trials, 3/4 correct response on the X-Y and Y-X test trials (Blocks 2&5) and 11/12 correct responses on the X-Y training trials (Blocks 3 &6). Two exposures to the step were allowed.

Step 4: Step 4 was identical to Step 3 except that (a) each respondent training block consisted of 10 B->C respondent training trials and (b) Blocks 2 and 4 consisted of 1 X-Y, 1 Y-X, 8 C-B and 2 B-A test trials.

Step 5: This step examined whether the subject matched both directly and indirectly paired stimuli. This step consisted of six blocks. Block 1 consisted of 1 X-Y, 1 Y-X and 4 B-A quasi-randomly mixed with 4 C-B test trials. Block 2 consisted of 8 C-A test trials. Block 3 consisted of 6 X-Y training trials. Blocks 4, 5, and 6 were identical to blocks 1, 2, and 3 respectively. Subjects were allowed to proceed to Stage 6 if they (a) produced 3/4 correct responses on the X-Y and Y-X test probes, 7/8 correct responses on the B-A test probes and 7/8 correct responses on the C-B test probes (Blocks 1 and 4). (b) produced 14/16 correct responses on the C-A test trials (Blocks 2 & 4) and produced 11/12 correct responses on the X-Y training (Blocks 3 & 6). Two exposures to the experimental sequence were allowed.

Step 6: There were eight blocks in this stage. Block 1 consisted of 2 B-A, 2 C-B and 2 C-A test trials. Blocks 2 consisted of 10 C->D respondent training trials. Block 3 consisted of 8 D-B test trials and Blocks 4 consisted of 6 X-Y training trials. Blocks 5, 6, 7 and 8 were identical to Blocks 1, 2, 3, and 4 respectively. Subjects were allowed to proceed to Step 7 if they (a) produced 10/12 correct responses on Blocks 1 and 5, (b) observed both stimuli 18/20 times in Blocks 2 and 6, (c) produced 14/16 correct responses in Blocks 3 and

7 and (d) produced 11/12 correct responses in Blocks 4 and 8. Two exposures to the experimental sequence were allowed.

Step 7: Step 7 consisted of six blocks. Blocks 1 consisted of 2 B-A, 2 C-B, 2 C-A and 2 D-B test trials. Blocks 2 consisted of 8 D-A test trials and Blocks 3 consisted of 6 X-Y training trials. Blocks 4, 5 and 6 were identical to Blocks 1, 2 and 3 respectively. Subjects reached the criterion if they (a) produced 14/16 correct responses in Blocks 1 and 4, (b) produced 14/16 correct responses in Blocks 2 and 4, and (c) produced 11/12 correct responses in Blocks 3 and 6. Subjects were allowed two exposures.

Results and Discussion

Correct responses on symmetry and equivalence tests are presented in Table 1. All five subjects in Experiment 1 required one block of training trials in Step 1A, 1B, and 1C to establish the pretrained X-Y conditional relations and they maintained this performance throughout the experiment. In Step 2 all subjects reached criterion performance after one block of X-Y and Y-X test trials. All five subjects observed all stimulus pairs during respondent training and did not make any task related comments throughout the experiment. Subjects 1, 2, 3, and 5 produced 16/16 correct responses on the first exposure to the B-A test probes while Subject 4 produced 14/16 correct responses on the first exposure. In Step 4, Subjects 2 and 3 produced 15/16 correct responses on the C-B test probes while Subjects 1, 4, and 5 produced 16/16 correct responses. All subjects were successful on the B-A test probes. In Step 5 all subjects were successful on the C-A equivalence test after one exposure and proceeded to Step 6. In this step all subjects were successful on the D-B equivalence test.

Table 1

Sex, Age, and Number of Correct Conditional Discrimination Responses for each Subject during Steps 3-7 of Experiment 1.

Subject	Step 3	Step 4	Step 5	Step 6	Step 7
Sex	B-A	C-B	C-A	D-B	D-A
Age					
S1 F 5.0	16	16	16	16	16
S2 F 5.2	16	15	14	16	16
S3 M 5.7	16	15	14	15	10 12
S4 M 5.4	14	16	16	16	10 12
S5 M 5.3	16	16	16	16	16

In Step 7, three subjects were successful on the D-A equivalence test while Subject 3 and 4 scored 12/16 on the second exposure. None of the subjects provided the experimenter with any helpful verbal reports when questioned about their performance (e.g., "Just because", "don't know", shrugged shoulders).

Reliability checks were made on 30% of all respondent training and matching-to-sample training and test trials. Experimenter and reliability observer disagreed on one matching-to-sample test trial. This experiment clearly showed that respondent training is an effective means of producing conditional relations and stimulus classes in a population of five year old children. Furthermore, when a stimulus class has been established it is possible to extend this class with this population.

Experiment 2

This study, as did Smeets et al. (1997), employed a linear protocol. Smeets et al. (1997) also investigated the effectiveness of a one-to-many and a many-to-one protocol. No difference was found between the three training procedures. However, as stated in the introduction stimulus pairs were presented on the same observation card (A1 on the front and B1 on the back). In the present study, stimulus pairs were presented on separate observation cards. Smeets et al. (1997) examined a three-member class whereas in this study the three-member class has been extended. Experiments 2 and 3 were designed to investigate whether there would be any difference between the three protocols under these conditions.

Procedure

This experiment was identical to Experiment 1 except that during respondent training a one-to-many protocol was used rather than a linear protocol (i.e., B-A respondent training in Step 3, B-C training in Step 4 and B-D training in Step 6).

Results and Discussion

Correct responses on symmetry and equivalence test probes are presented in Table 2. Subjects 6-10 reached the stability criterion on Steps 1A, 1B and 1C after one block of training and maintained this performance throughout the experiment. In Step 2, all subjects were successful on the X-Y and Y-X test probe. Subjects remained silent and observed all stimulus pairs during respondent training and did not make any comments during the testing phases. In Step 3, Subjects 6, 8, and 9 produced 16/16 correct responses on their second exposures to the step. In Step 4, Subjects 7, 9, and 10 were successful on their first exposure, while Subjects 6 and 8 reached criterion on their second

Table 2

Sex, Age, and Number of Correct Conditional Discrimination Responses for each Subject during Steps 3-7 of Experiment 2

Subject	Step 3	Step 4	Step 5	Step 6	Step 7
Sex	A-B	C-B	C-A	D-C	D-A
Age					
S6 M 5.6	12 16	12 16	11 16	16	16
S7 F 5.7	15	16	16	16	16
S8 M 5.8	10 16	11 16	14	8 14	16
S9 F 5.1	10 16	15	14	9 15	8 11
S10 F 5.0	16	16	16	16	16

exposures. In Step 5, all subjects passed the equivalence test. In Step 6, all subjects were successful on the D-C equivalence test with Subjects 8 and 9 needing two exposures to the test. In Step 7, Subjects 6, 7, 8 and 10 were successful on the D-A equivalence test with Subject 9 failing to reach criterion.

Reliability checks were made on 30% of all respondent training and matching-to-sample training and test trials. Experimenter and reliability observer always agreed.

As in Experiment 1, subjects did not provide the experimenter with any "insightful" reports to explain their performance.

This study demonstrated that a one-to-many protocol can also be effectively applied to respondent conditioning to produce equivalence. In fact, the performance of subjects in this experiment were slightly better than subjects in Experiment 1 (i.e., on the D-A test 3 out 5 passed using the linear protocol, whereas 4 out of 5 passed using the one-to-many protocol).

Experiment 3

Procedure

This experiment was identical to Experiments 1 and 2 except that a many-to-one protocol was used (i.e., A-B respondent training in Step 3, C-B training in Step 4, and D-B training in Step 6).

Results and Discussion

Correct responses on symmetry and equivalence test probes are presented in Table 3. Subjects 11-15 learned the X-Y task of Step 1 in one training block and continued to respond accurately to it and its symmetrical form Y-X under the test conditions of Step 2.

Subjects observed all stimuli and remained silent during respondent training. All subjects responded successfully to the B-A test probes of Step 3. In Step 4, all subjects reached the criterion after one test block. In Step 5, all subjects scored 16/16 correct responses to the C-A equivalence probe. All subjects were successful on the D-C test probe of Stage 6, with Subjects 12 and 14 needing two exposures. In Step 7 all subjects scored 16/16 correct responses in the D-A equivalence probe with Subject 14 needing two exposures. Reliability checks were made on 40% of all respondent training and matching-to-sample training and testing. Experimenter and reliability observer always agreed. As in Experiments 1 and 2 none of the subjects provided the experimenter with any helpful verbal reports when questioned about their performance. The many-to-one protocol of this experiment proved to be the most effective, in that subjects were 100% successful on all equivalence tasks.

Table 3

Sex, age, and Number of correct conditional discrimination responses for each subject during steps 3-7 of Experiment 3

Subject	Step 3	Step 4	Step 5	Step 6	Step 7
Sex	B-A	B-C	C-A	D-C	D-A
Age					
S11 F 5.4	16	16	16	16	16
S12F 5.7	16	16	16	13 16	16
S13M 5.2	16	14	16	16	16
S14M 5.1	16	16	16	13 16	12 16
S15 F 5.0	16	16	16	16	16

General Discussion

This study clearly demonstrates that respondent training is an effective and powerful means of generating equivalence relations with young children. In Experiments 1, 2, and 3 all fifteen subjects matched all directly paired stimuli with each other. This compares favourably with the 87.5% success rate obtained in Experiments 3 and 4 of the Smeets et al. (1997) study. In the present study, all subjects successfully matched the indirectly paired stimuli, C and A, with each other, and again this compare well with the 76.2% success rate reported by Smeets et al. (1997). The current success rates are particularly impressive, give the following point made by Smeets et al; “The efficiency of respondent training with these youngsters is particularly noteworthy in view of the repeated negative attempts to establish conditional discriminations and

stimulus classes with this age group through other nonmatch-to sample tasks (Smeets, et al., 1997, p. 302).

An issue that arose from the Smeets et al. (1997), study was that subjects only succeeded in passing the equivalence test when a simple-to-complex training design was used (i.e., subjects were exposed to a symmetry test before testing for transitive/equivalence relations). Perhaps, therefore, the respondent training procedure is only effective in producing equivalence classes if subjects are first tested for symmetry. To determine if this is always the case we trained two three member equivalence classes using a simple-to-complex training design and then added another stimulus to each of the classes (C-D in Experiment 1, D-B in Experiment 2 and B-D in Experiments 3). Equivalence relations were then tested without a prior symmetry test (D-B and D-A in Experiment 1, and D-C and D-A in Experiments 2 and 3). In Experiment 1, where a linear training design was used, all five subjects were successful on the D-B equivalence test and three of these subject were successful on the D-A equivalence test. In Experiment 2, the one-to-many condition, all five subjects were successful on the D-C equivalence test and four out of five subjects were successful on the D-A test. Finally, in Experiment 3, the many-to-one condition, all five subjects were successful on the D-C equivalence test and all five subjects were successful on the D-A equivalence test. This extends the findings of the Smeets et al. (1997) study in that it demonstrates that it is possible to extend an equivalence class without testing for the "mediating" symmetry relations. It is worth noting that subjects were 100% successful on the second equivalence test (D-B in Experiment 1, D-C in Experiments 2 and 3) and it was only when the third equivalence test was introduced (D-A) that some negative results were obtained. These results are consistent with previous research that has found that success on a test for equivalence responding is a negative function of the number of nodes separating the stimuli within the test (e.g., a subject is more likely to pass an

A-C test than an A-D test following A-B-C-D training).

In the present series of experiments additional conditional discrimination probes were introduced. Specifically in Step 4 two additional B-A probes were interspersed with the C-B test probes. Similarly in Step 5 the subject received 4 B-A and 4 B-C test probes prior to the C-A equivalence test. In Step 6 the subject received 2 B-A, 2 C-B and 2 C-A test probes prior to the D-B equivalence test and in Step 7 the subject first received 2 B-A, 2 C-B, 2 C-A and 2 D-B test probes prior to the equivalence test. These additional test probes may have contributed to the high success rates in present study.

One criticism of the Smeets et al. (1997), study was that stimuli were presented on opposite sides of the same observation card (p. 303). Thus it could not be determined whether equivalence formation was a sole function of the temporal relations between the stimulus pairs, or the spatial contiguity of stimulus pairs. In the present series of experiments when stimulus pairs were presented on separate observation cards there was a marked improvement on the rate of equivalence responding over that reported by Smeets et al. It appears, therefore, that removing the confounding variable of spatial contiguity from the current study brought about an increase in levels of equivalence responding. In effect, rather than aiding equivalence responding, spatial contiguity apparently “interfered” with equivalence formation in the Smeets et al. (1997) study. At the present time, this (perhaps) counterintuitive result remains unexplained, and further research will be needed to address this issue. Certainly, a future study should conduct a systematic within subjects comparison of the effects of the two types of contiguity (spatial and temporal) on equivalence class formation in children.

During the last decade a considerable amount of research has investigated the effects of training protocols on equivalence. Research suggests that the many-to-one protocol may facilitate equivalence more readily than one-to-many in both human and non-human populations. (e.g. Saunders et al.,



1988; Spradlin & Saunders 1986; Urcioli & Zentall 1992). Data obtained in Condition 1 of Smeets et al. (1997) together with the results of Conditions 2, 8, and 9 in Chapter 2, provided tentative evidence that many-to-one was superior to one-to-many, which in turn which was superior to the linear protocol in an adult population. However, in the Smeets et al (1997) study, five year old children did not show a performance biases across the three protocols. The present research seems to provide some support for the earlier research (i.e., many-to-one was superior to one-to-many which in turn was superior to the linear protocol). However, one must be cautious when making such an inference. The final D-A equivalence test of Experiment 1 (linear protocol), involved a distance of two nodes (D-C, C-B, B-A), but in Experiments 2 and 3 (one-to-many and many-to-one) there was a distance of one node (D-C, C-A). Furthermore, one of the problems with the current data is that subjects performed so well it is difficult to determine clearly the superiority of any one protocol over another (i.e., in the linear condition subjects were successful on 90% of the equivalence tests, in the one-to-many condition subjects were successful on 95% of the equivalence tests, and in the many-to-one condition subjects were successful on 100% of the equivalence tests). One solution to this problem might be to increase the number of stimuli within the equivalence classes; recent evidence suggests that clear differences across protocols can be demonstrated when seven-member classes are used, at least with adults subjects (Fields, personal communication).

In light of the current data we can be reasonably confident that the respondent-type training procedure is capable of producing equivalence responding in both adults and children as young as five years old. That is, when stimulus events are discriminated as correlated in space and/ or time the formation of equivalence relations become likely. As will be argued in the final Chapter, this effect can be interpreted from the relational frame view of equivalence responding (see also Barnes 1994; Hayes 1992).

Figure 1:
Symbols used as stimuli

X1	X2	Y1	Y2		
@	#	%	£		
A1	A2	B1	B2	C1	C2
&	?	¢	!	*	\$
		D1	D2		
		±	¶		

Chapter 7:

Applying the Respondent-type Training Procedure to an Educational Context

Given the successful use of the respondent procedure in establishing equivalence classes with both adults and young children, in this final stage of my research program I aimed to extend my work into a more applied domain. This was deemed important, given that the study of stimulus equivalence originally emerged from applied research, and in more recent times there is some evidence of a return to applied concerns by equivalence researchers.

In one of the earliest equivalence studies, Sidman and Cresson (1973) worked with a retarded youth who could match spoken words to pictures, and could vocally name the pictures, but was unable to match the printed words to the dictated names. However, after the youth was trained to match the printed words to the pictures, he was able to select any set of 20 pictures or picture names conditionally upon a dictated name. Furthermore, given a printed name sample he could select the corresponding picture and given a picture sample, he could select its printed name. The boy's emergent ability to perform two new sets of matching tasks demonstrated that the matching-to-sample training and test procedure had created 20, 3 member classes of equivalent stimuli.

Research on stimulus equivalence has provided researchers with a valuable means of training academic skills such as reading (e.g., Mackay, 1985, Sidman, 1971) and spelling (e.g., Stromer, Mackay, & Stoddard, 1992). For example, Mackay and Sidman (1984) and Mackay (1985) found that equivalence classes involving printed words could be established by teaching subjects to construct the printed words with movable letters. In their studies, Makay and Sidman (1984) taught students who were mentally retarded to name colour patches and construct the colour names using movable letters. Students

subsequently matched printed-word comparisons to colour patches and colour comparisons to printed-word samples, and also named printed words.

Although the applied potential of stimulus equivalence research has been noted, the actual use of equivalence research in the applied setting has been very limited (see Mace, 1994; Sidman, 1994), although there are some recent exceptions. In one study, for example, Lynch and Cuvo (1991) used the matching-to-sample training procedure to teach fraction and decimal equivalence to 7 fifth and sixth grade students (aged between 11 to 13 years old), who were identified by their math teachers as having difficulty on these tasks despite formal instruction. The students were taught to match pictorial representations of fractions (B comparison stimuli) to printed counterpart fraction ratios (A sample stimuli), and to match printed decimals (C comparison stimuli) to pictorial representations of fractions (B sample stimuli). For example, the three stimuli in a class may have been as follows; $1/5$ (A), pictorial analogue of $1/5$ (B), 0.20 (C). Post-test performance by all subjects indicated the emergence of equivalence relations between stimuli, but subjects only showed low levels of generalisation. Generalisation tests involved printed fraction-fraction decimal and printed decimal-printed fraction relations to novel sample and comparison quantities following training and post-test trials.

The purpose of the present study was to determine whether the respondent-type training procedure could be used to establish fraction and decimal equivalencies in 5-year old children. Furthermore, this study sought to investigate emergent generalisation based on physical similarity (Barnes & Keenan 1993), rather than mathematical generalisation (as used by Lynch & Cuvo 1991). Generalisation tests involved presenting subjects with stimuli seen in training as samples and a series of shapes that are physically similar (but different from those seen in training) as comparisons. The intention was not to replicate the study of Lynch and Cuvo but to investigate generalisation on the basis of physical similarity. This was deemed important

because, the expansion of equivalence classes based on physical similarity has not yet been shown in young children. Furthermore, it seems likely that responding based on physical quantities is a pre-requisite to mathematical understanding (Grundt, in press), and thus a thorough analysis of equivalence class expansion based on stimulus generalisation in young children seems important. The current study consisted of 3 Experiments. In Experiment 1 subjects were given conditional discrimination training using fractions and decimals as stimuli and were then tested for the emergence of equivalence classes. Experiment 2 was identical to Experiment 1, except that subjects were also administered three generalisation that examined generalisation between mathematically equivalent stimuli and physically similar stimuli. Experiment 3 was identical to Experiment 2, except that subjects were given an additional generalisation test.

General Method

Subjects

Twenty four normal functioning five year old Dutch pre-school children served as subjects. The children were randomly assigned to each of the three experiments (8 in each experiment). Age (years and months) and sex of subjects are shown in Tables 1, 2, and 3.

Apparatus

The stimuli (3.0 x 3.0 cm) consisted of squares, circles, decimals, and fractions (see Figure 1), and are indicated by alphanumerical codes (e.g., X1, A1). The stimuli were presented on white cards (14.5 x 20.0 cm) covered with plastic to prevent staining. Observation cards displayed one stimulus (e.g., B1) positioned at the centre of the card. Matching cards displayed three stimuli, two horizontally aligned (e.g., C1 and C2) 9 cm apart, and one stimulus centred 3 cm below (e.g., A2). Additional materials were a tray with beads and a

standing transparent glass tube displaying a mark. Filling the tube to the mark required 50 beads.

Sessions and Setting

Sessions were conducted in a quiet room in the childrens' school building, once a day, 5 days a week, typically for a duration of 10 to 15 mins. Three adults participated in the study, one as experimenter, and two as reliability observers. One of two reliability observers were present in the same room but were situated so that s/he could clearly observe the stimuli and the subjects responses, but not the experimenter's data sheet.

Trials, Responses, Recordings, and Contingencies.

Three types of trials were used: respondent training trials, matching-to-sample training trials, and matching-to-sample test trials. During a respondent training trial the experimenter showed the child an observation card (e.g., A1) for 1 s (the experimenter silently counted "21") followed by another card (e.g., C1) for 1 s. The experimenter then recorded whether the subject had looked at both observation cards and without delivering any programmed consequences initiated a 3 s interval before commencing the next training trial (i.e., there was a 3 s delay between the presentation of one stimulus pair and the next). If after every fifth training trial the subject had observed all stimulus presentations, the experimenter praised the subject (i.e., "Good girl/boy, you are doing well, take a bead.").

Two types of matching-to-sample training trials were used: demonstration and no help trials. A demonstration trial began with the experimenter presenting a matching card and pointing to the sample and designated correct comparison saying, "If you see this, point to that." the experimenter then requested the subject to point to the sample and correct comparison. During the matching-to-sample no help trials, the subject did not

receive instruction or modelling -- the experimenter simply presented the matching card to the subject without any comment. Responses on the matching-to-sample training trials were scored as correct, incorrect, or invalid. Correct or incorrect responses were defined as pointing to the correct or incorrect comparison, while invalid responses were recorded when the subject pointed, for example, to the comparison without looking at the sample. Correct responses were followed by verbal praise and the delivery of a token ("Good take a bead"). Incorrect responses were followed by verbal disapproval ("wrong, no bead"), while invalid responses were followed by corrective feedback (e.g., "look at the picture when pointing").

Matching-to-sample test trials were the same as the no help trials (silent presentation of matching cards) except that, responses consistent with the matching-to-sample training were simply recorded and no programmed consequences were delivered. In addition to the nonverbal responses (pointing to the comparison stimuli), the experimenter also recorded the subjects' verbal comments on the respondent training and matching-to-sample training and test trials.

Experiment 1

Procedure

Step 1A: Pretraining X-Y. This step was designed to establish an unrelated conditional discrimination with abstract X and Y stimuli (see Figure 1), so that any "failures" on the matching-to-sample test with decimal and fraction stimuli could not be attributed to unfamiliarity with the task. One block of 18 matching-to-sample training trials was used. The step began with two demonstration trials in which X1 and X2 served as samples and Y1 and Y2 as comparisons. This was followed by 16 no-help trials. In this step the Y1 and Y2 comparisons were always placed in the same position (i.e., Y1 to the left and Y2 to the right). A stability criterion of 15 out of 16 correct responses

on the no-help trials was required. If the subject failed to reach this criterion then s/he was re-exposed to this step. If the subject was not successful at this point he or she was dropped from the study.

Step 1B: This step consisted of 16 no help trials. The step was identical to Step 1A, except that no demonstration trials were used and the position of the comparison stimuli was reversed (i.e., Y1 to the right and Y2 to the left).

Step 1C: In this step 16 no help trials were used. The position of the comparisons was randomized. That is, 8 trials with Y1 to the right and Y2 to the left quasi-randomly mixed with 8 trials during which the stimulus positions were reversed.

Step 2: Testing X-Y and Y-X. This step examined whether the subjects continued the X-Y performance accurately: (a) without programmed consequences, and (b) when the sample-comparison functions of the X and Y stimuli were reversed. The step consisted of two blocks of test trials (Blocks 1 & 3) and two blocks of training trials (Blocks 2 & 4). Each training block consisted of 6 X-Y training trials and each test block consisted of 8 X-Y trials quasi-randomly mixed with 8 Y-X trials.

Prior to the commencement of a test block the experimenter removed the tray of beads and glass tube and said, "Now we are going to play the game without me telling you whether you are right or wrong. You won't get any beads. Later on we will play the game with beads. Do your best." The experimenter then proceeded with the test trial and refrained from any communication with the subject. Prior to the commencement of a training block the experimenter placed the tray of beads and the glass tube on the table and said "Now you can earn beads again." When the subject succeeded in filling the glass tube to the mark (50 beads) during this stage or any other stage of the experiment, the subject was allowed to exchange the beads for a preselected card (cartoon character, soccer player, animal). A stability criterion of; (a) 7/8 correct responses on X-Y test trials, (b) 7/8 correct

responses on the Y-X test trials, and (c) 11/12 correct responses on the X-Y training trials was required to proceed to the next stage of the experiment. If a subject did not reach the criterion the subject was re-exposed to Step 2 and at this point if the subject was not successful his/her participation in the study was terminated.

Step 3: Train A-B, Test B-A. In this step subjects received respondent training during which they observed the stimuli A->B in a fixed temporal order. This was followed directly by the conditional discrimination probes B-A. During A1->B1 respondent training trials subjects were presented with 1/4 (A1) followed by a circle divided into four quarters with the upper left quarter shaded (B1). During A2->B2 respondent training trials subjects were presented with 2/4 (A2) followed by a circle divided into four quarters with the upper two quarters shaded (B2), (see Figure 1).

Step 3 consisted of six blocks. In the first block subjects received 10 A->B respondent training trials. Block 2 consisted of 1 X-Y and 1 Y-X matching-to-sample test trial followed by 8 B-A conditional discrimination probes. Block 3 consisted of 6 X-Y training trials. Blocks 4, 5, & 6 were identical to Blocks 1, 2, & 3 respectively. Subjects reached the mastery criterion if they observed the A->B stimulus presentation 18/20 times during the respondent training trials (Blocks 1& 4), produced 14/16 correct responses on the B->A test trials, produced 3/4 correct responses on the X-Y and Y-X test trials (Blocks 2 & 5), and produced 11/12 correct responses on the X-Y training trials (Blocks 3 & 6). If a subject did not reach the criterion s/he was re-exposed to Step 3, and at this point if the subject was not successful his or her participation in the study was terminated.

Step 4: Train C-B, Test B-C. This step was identical to Step 3 except that; (a) each respondent training block consisted of 10 C->B respondent training trials, and (b) Blocks 2 and 4 consisted of 1 X-Y, 1 Y-X, 8 B-C, and 2 B-A test trials. During C1->B1 respondent training trials subjects were

presented with 0.25 (C1) followed by a circle divided into four quarters with the upper left quarter shaded (B1). During C2->B2 respondent training trials subjects were presented with 0.50 (C2) followed by a circle divided into four quarters with the upper two quarters shaded (B2), (see Figure 1).

Step 5: Test A-C and C-A: This step determined whether subjects matched both directly and indirectly paired stimuli. This step consisted of six blocks. Block 1 consisted of 1 X-Y, 1 Y-X and 4 B-A test trials quasi-randomly mixed with 4 B-C test trials. Block 2 consisted of 4 A-C test trials quasi-randomly mixed with 4 C-A test trials. Block 3 consisted of 6 X-Y training trials. Blocks 4, 5, and 6 were identical to Blocks 1, 2, and 3 respectively. Subjects reached the mastery criterion if they; (a) produced 3/4 correct responses on the X-Y and Y-X test probes, 7/8 correct responses on the B-A test probes, and 7/8 correct responses on the B-C test probes (Blocks 1 and 4), and (b) produced 14/16 correct responses on the A-C and C-A test trials (Blocks 2 & 4) and produced 11/12 correct responses on the X-Y training trials (Blocks 3 & 6). Two exposures to Step 5 were allowed (i.e., a total of 12 blocks).

Results and Discussion

Correct responses on symmetry and equivalence tests are presented in Table 1. All eight subjects in Experiment 1 required one block of training trials in Steps 1A, 1B, and 1C to establish the pretrained X-Y conditional relations, and they maintained this performance throughout the experiment. In Step 2 all subjects reached criterion performance after one block of X-Y and Y-X test trials. All eight subjects observed all stimulus pairs during respondent training. Subjects 1, 2, 3, 4, 5, and 6 produced 16/16 correct responses on the first exposure to the B-A test probes while Subjects 7 and 8 and produced 14/16 correct responses on the first exposure. In Step 4, Subjects 2 and 3

Table 1

Sex, Age and number of correct conditional discrimination responses for each subject in Experiment 1.

Subject	Step 3	Step 4	Step 5	
Sex	B-A	B-C	A-C	C-A
Age				
S1 F 5.2	16	16	8	8
S2 M 5.4	16	15	8	8
S3 M 5.6	16	15	8	8
S4 M 5.5	16	16	8	8
S5 F 5.7	16	16	8	8
S6 M 5.4	16	16	8	8
S7 F 5.3	14	16	8	8
S8 F 5.1	14	16	8	8

produced 15/16 correct responses on the B-C test probes, while Subjects 1, 4, 5, 6, 7, and 8 produced 16/16 correct responses. All subjects were successful on the B-A test probes. In Step 5 all subjects were successful on the A-C and C-A test probes after one exposure. Reliability checks were made on 30% of all respondent training and matching-to-sample training and test trials.

Experimenter and reliability observer always agreed.

This experiment demonstrated that five year old children are capable of forming equivalence classes using fractions, decimals and pictorial representations as stimuli. Experiment 2 was designed to determine whether these findings could be replicated, and to establish whether subjects would show generalisation with 1/4, 2/4, 0.25, and 0.50 as samples and novel shapes as comparisons.

Experiment 2

Procedure

Steps 1-5 were identical to Experiment 1.

Generalisation Test No.1: The stimuli A1, A2, C1, and C2 (i.e., 1/4, 2/4, 0.25 and 0.50) served as samples. Shapes not seen in training, but with the same shaded areas, served as comparison stimuli. That is, when subjects were presented with B1' they observed a square divided into four quarters with the upper left quarter shaded, and when B2' was presented, they observed a square divided into four quarters with the upper two quarters shaded (see Figure 1). This Generalisation test consisted of four blocks. Block 1 consisted of 4 B1'-A1, 4 B2'-A2, 4 B1'-C1, and 4 B2'-C2 trials quasi-randomly mixed. Block 2 consisted of 6 X-Y training trials. Blocks 3 and 4 were identical to Blocks 1 and 2 respectively. The mastery criterion consisted of a minimum of 30/32 correct responses across the two test blocks (Blocks 1 and 3) and 11/12 correct responses on the training trials (Blocks 2 and 4). Subjects were allowed two exposures to the step (i.e., a total of 8 test blocks).

Generalisation No. 2: Generalisation Test No.2 was identical to the previous one, except that the comparison stimuli were altered, in that a different area of the shapes was shaded (i.e., B1'' consisted of a square divided into four quarters with the lower right quarter shaded, and B2'' consisted of a square divided into four quarters with the upper and lower right quarters shaded (see Figure 1).

Generalisation Test No.3: This generalisation test was identical to the previous two tests, except that the comparison stimuli were altered once again in that the number of shaded and unshaded areas was increased. That is, B1''' consisted of a square divided into sixteen segments with segments 1, 8, 10, and

16 shaded, and B2''' consisted of a square divided into sixteen segments with segments 1, 3, 6, 10, 12, 13, 15 and 16 shaded (see Figure 2).

Results and Discussion

Correct responses on symmetry, equivalence, and generalisation tests are presented in Table 2. All eight subjects in Experiment 2 required one block of training trials in Steps 1A, 1B, and 1C to establish the pretrained X-Y conditional relations, and all subjects maintained this performance throughout the experiment. In Step 2, all subjects reached criterion performance after one block of X-Y and Y-X test trials. All eight subjects observed all stimulus pairs during the respondent training. All eight subjects in Step 3 produced 16/16 correct responses on the B-A test probes. In Step 4, Subjects 9 and 10 produced 15/16 correct responses on the B-C test probes, while Subjects 11, 12, 13, 14, 15, and 16 produced 16/16 correct responses on their first exposure to the test. All subjects were successful on the B-A test probes. In Step 5, all subjects were successful on the A-C and C-A test probes on their first exposure to the test. All eight subjects were successful on Generalisation Tests 1 and 2, after one exposure. Subjects 9, 10, 11, and 12 were successful on Generalisation Test 3 after one exposure, whereas Subjects 13, 14, 15, and 16 failed to reach the mastery criterion across two exposures. Reliability checks were made on 35% of respondent training and matching-to-sample training and test trials. Experimenter and reliability observer always agreed. This experiment demonstrated, as did Experiment 1, that young children show the emergence of equivalence relations between fractions, decimals, and pictorial representations. However, only 50% of subjects passed all three generalisation tests. Experiment 3 was designed to determine whether administering an extra generalisation test would improve performance on Generalisation Test 3.

Table 2

Sex, Age and number of correct conditional discrimination responses for each subject in Experiment 2.

Subject	Step 3	Step 4	Step 5		Generalisation Tests		
Sex	B-A	B-C	A-C	A-C	No.1	No.2	No.3
Age							
S9 M 5.3	16	15	8	8	32	32	32
S10 M 5.4	16	15	8	8	32	32	32
S11 M 5.1	16	16	8	8	32	32	32
S12 F 5.1	16	16	8	8	32	32	32
S13 F 5.6	16	16	8	8	32	32	25 28
S14 F 5.0	16	16	8	8	32	32	20 25
S15 F 5.0	16	16	8	8	32	32	21 20
S16 F 5.0	16	16	8	8	32	32	15 20

Experiment 3

Procedure

Training and testing of Steps 1-5 and Generalisation Tests 1 and 2 were identical to Experiment 2.

Generalisation Test No. 3: Generalisation Test No.3 was identical to Test 3 from the previous experiment, except that the shaded segments were contiguous with one another. That is, the B1''' stimulus consisted of a square divided into sixteen segments with the upper left four segments shaded, and B2''' consisted of a square divided into sixteen segments with the upper eight segments shaded (see Figure 2).

Generalisation Test No. 4 : Generalisation test No. 4 was identical to Generalisation test No. 3 of Experiment 2.

Results and Discussion

Correct responses on symmetry, equivalence and generalisation tests are presented in Table 3. All eight subjects in Experiment 3 required one block of training trials in steps 1A, 1B, and 1C to establish the pretrained X-Y conditional relations, all subjects and maintained this performance throughout the experiment. In Step 2, all subjects reached the criterion performance after one block of X-Y and Y-X test trials. All eight subjects observed all stimulus pairs during respondent training. All eight subjects in Step 3 were successful on all B-A test probes on their first exposure. Similarly, all eight subjects were successful on all B-C and B-A test probes on their first exposure. In Step 5, all subjects produced 16/16 correct responses on all A-C and C-A test probes on their first exposure to the test. Finally, all subjects were successful across all four generalisation tests on their first exposures. Reliability checks were made on 30% of all respondent training and matching-to-sample training and testing. Experimenter and reliability observer always agreed.

General Discussion

This study successfully used the respondent-type training procedure to establish equivalence relations among fractions, decimals, and pictorial representations of these numerical properties, with five year old children in an educational setting. In Experiment 1, all subjects successfully matched fractions to counterpart decimal ratios (A-C), and decimals to equivalent fraction ratios (C-A) in accordance equivalence relations. This experiment clearly demonstrated that children of this young age, are capable of forming equivalence classes using fractions, decimals and pictorial representations as stimuli

Table 3

Sex, Age and number of correct conditional discrimination responses for each subject in Experiment 3.

Subject	Step 3	Step 4	Step 5		Generalisation Tests			
Sex	B-A	B-C	A-C	A-C	No.1	No.2	No.3	No.4
Age								
S9 M 5.3	16	15	8	8	32	32	32	32
S10 M 5.4	16	15	8	8	32	32	32	32
S11 M 5.1	16	16	8	8	32	32	32	32
S12 M 5.1	16	16	8	8	32	32	32	32
S13 F 5.6	16	16	8	8	32	32	32	32
S14 F 5.8	16	16	8	8	32	32	32	32
S15 F 5.0	16	16	8	8	32	32	32	32
S16 F 5.0	16	16	8	8	32	32	32	32

The purpose of Experiment 2 was to replicate the findings of Experiment 1 and test for emergent generalisation to novel pictorial representations of the fraction/decimal stimuli. As in Experiment 1, subjects reliably formed decimal and fraction equivalence relations. During generalisation tests subjects were presented with $1/4$, $2/4$, 0.25 and 0.50 as samples and novel pictorial representations as comparisons. The purpose of these tests was to assess each subject's ability to match a stimulus seen in training (e.g., $1/4$, 0.25) to a novel pictorial comparison not seen in training. This additional test allowed us to determine whether the equivalence classes could be expanded to include novel pictorial representations that were

mathematically equivalent to the previously trained pictures. In Generalisation Tests 1 and 2, all subjects reached the mastery criterion. During Generalisation Test 1, subjects were presented with a shape not seen in training but the shaded areas remained the same. In Generalisation Test 2, subjects were presented with a shape not seen in training and the shaded areas were altered. In Generalisation Test 3, subjects were presented with a shape not seen in training, and the number of shaded and unshaded segments was increased, and the position of the shaded areas was randomised. All subjects passed the first two generalisation tests, but only four of the eight subjects were successful on Generalisation Test 3.

In Experiment 3, subjects were administered an extra generalisation test (B1'''& B2''') to determine whether this would improve performance on Generalisation Test 4 (Test 3 from Experiment 2). This test was identical to the Test 3 in Experiment 2, but the position of the shaded areas was consistent with the training. All subjects passed this test, and then successfully passed the final test in which the position of the shaded areas was randomised. In effect, performance on Generalisation Test 4 was dramatically improved when subjects were presented with a series of generalisation tests that involved a gradual (rather than abrupt) progression from stimuli seen in training to novel stimuli presented during the generalisation tests.

The results of Experiment 3 demonstrated that children of a young age are capable of not only demonstrating equivalence between fraction and decimal stimuli, but also of showing stimulus generalisation involving novel pictorial representations that are physically similar. This is an apparently important behavioural effect because it may be critical for the subsequent demonstration of mathematical responding involving mathematically equivalent, but perceptually different stimuli, like those employed by Lynch and Cuvo (1991). Indeed, it could be argued that until subjects pass generalisation tests like those employed by Lynch and Cuvo, the experimental

equivalence classes generated in such studies do not possess mathematical properties beyond the basic equivalence relations, thereby failing to provide evidence for "genuine" mathematical behaviour (see Baroody & Hume, 1991; Bell, 1991). In taking this position, however, the question then arises as to how one might generate such "genuine" mathematical properties. In addressing this question, the systematic analysis of the interaction between equivalence classes and primary stimulus generalisation would seem to be an important starting point. Now that this basic interaction has been demonstrated in the current study, future research might examine how to establish appropriate responding to the proportional relations between elements of fractions and pictorial representations of those fractions (e.g., to what extent is equivalence and stimulus generalisation involved in relating $1/4$ and $2/8$ to a square frame containing 4 small black squares out of a total of a total of 16 white squares). Clearly, this is an important question for the teaching of complex and advanced mathematically skills.

One criticism of the current study might be that the mathematical stimuli employed allowed the subjects to respond to specific elements of the stimuli. For example, subjects may have discriminated the two fractions, based on the numerators, 1 and 2. The same criticism may be made regarding the decimals (0.25, 0.50) with 2 and 5 being the discriminative elements. Even the generalisation tests could be criticised on the basis that subjects discriminated physical similarity based on "more or less black". An important follow-up study, therefore, would involve using $1/4$, $2/4$, $4/1$, $4/2$ and their corresponding decimal and pictorial representations. This study would allow one to determine whether subjects discriminated stimuli on the basis of complex stimuli with discriminative elements or on the basis of "genuine" mathematical comprehension.

The respondent-type training procedure is a relatively new non-matching-to-sample training procedure. This study represents an important

advance in that it demonstrated the effectiveness of a new procedure in the applied setting. Given these findings it may now be possible to use the respondent procedure in other areas of research in the applied domain. One possible avenue for future research would be to replicate the Lynch and Cuvo study, but use the respondent training procedure. This would allow us to determine whether the alternative methodology improves older subjects' fraction-decimal equivalence class formation, and whether it has any effect on the generalisation test performances. A related issue is that the current subjects were successful across all generalisation tests after the difference from one test to the next involved a gradual shift along the dimension towards more novel pictorial stimuli. It would be interesting to see if a similar strategy applied to a replication of Lynch and Cuvo's study would lead to better generalisation data.

In conclusion, the respondent training procedure was clearly an effective means of teaching new decimal and fraction relations via the equivalence paradigm. In the class-room setting, however, difficulties may arise in maintaining the students attention. Obviously, the materials used in this experimental study would have to be modified to accommodate such difficulties. Nevertheless, the basic procedure is effective, and thus warrants further attention within the applied domain.

Figure 1: Fractions, Decimals and Shapes used as Stimuli.

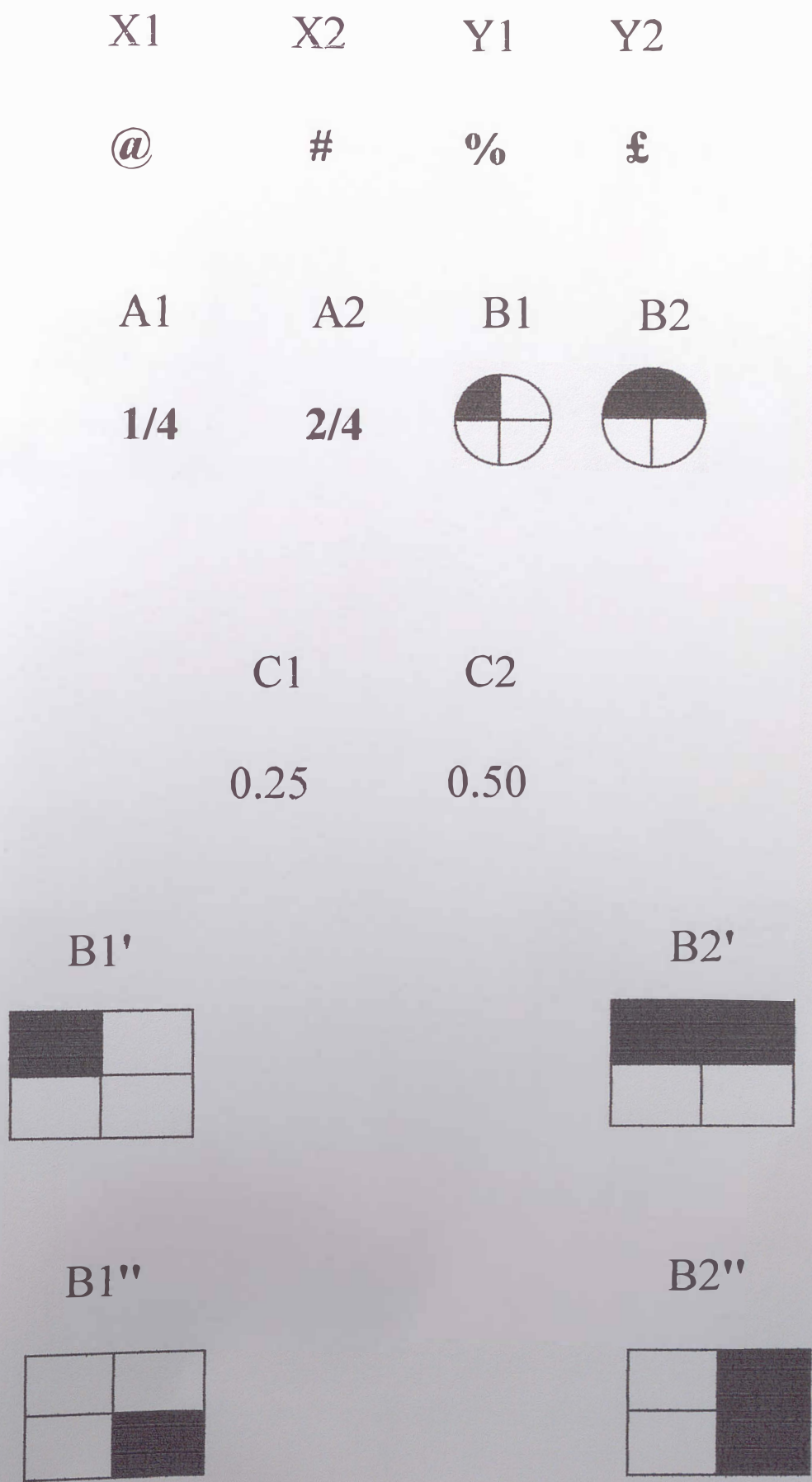
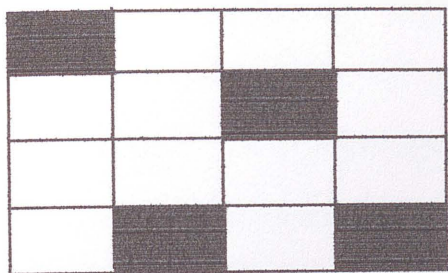
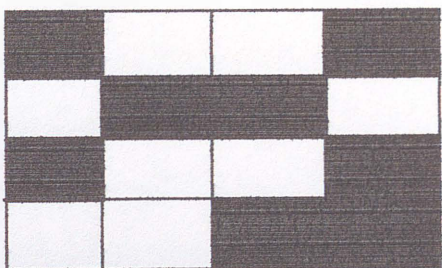


Figure 2: Fractions, Decimals and Shapes used as Stimuli

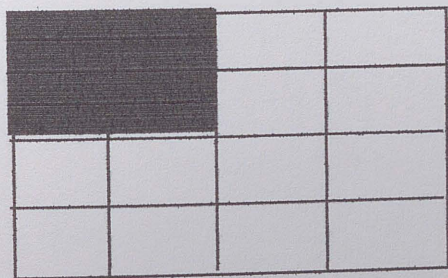
B1'''



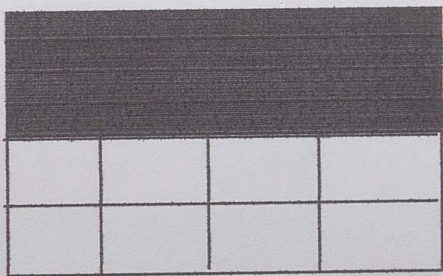
B2'''



B1''''



B2''''



Chapter 8:

Respondent-type Training: A Theoretical Analysis

The current thesis has focused almost exclusively on the development of a new training procedure for establishing equivalence classes in both adults and children. Thus far, I have not addressed any of the theoretical concerns arising out of the use of the respondent procedure. In this final chapter, I will outline one possible theoretical interpretation of the data reported in the current thesis. To do so, I will draw upon a recent but well developed behavioral approach to language and cognition, known as Relational Frame Theory (RFT) (see Hayes, in press). First, however, I will need to provide a general summary of this theory.

Relational Frame Theory

The relational frame account of stimulus equivalence was developed by Steven Hayes (1991, 1992). One of the driving forces behind the development of this theory is to provide a set of conceptual terms which accurately describe the specific types of behaviour-environment interaction responsible for equivalence responding, and other forms of human behaviour more generally (e.g., Hayes, 1991; Hayes & Hayes, 1989).

This account of stimulus equivalence views it not as a basic stimulus function (see Sidman, 1994), but the result of prolonged exposure to the contingencies of reinforcement operating in the verbal community. Relational frame theory does allow for the possibility that humans have evolved a particularly strong behavioural predisposition for equivalence, given sufficient exposure to the appropriate reinforcement contingencies (Hayes, 1989). In the final analysis, however, equivalence responding and related phenomena require

some form of prior learning, and it is the nature of this learning upon which RFT focuses most attention.

Relational frame theory accounts for equivalence on the basis of arbitrarily applicable relational responding brought to bear on the matching-to-sample task (see Barnes & Holmes 1991; Hayes & Hayes 1992; Hayes & Hayes, 1989). The basic idea is as follows. All animals that show complex types of learning are capable of learning to respond to nonarbitrary relations between stimuli (e.g., bigger than, darker than; see Reese 1968). Verbally-able humans also have a history of learning to respond to the relations among stimuli where these relations are not defined by the physical form of the stimuli, but by additional contextual cues. These stimulus relations are arbitrarily applicable, in that they can be brought to bear on any set of stimuli, irrespective of physical appearance, given only a suitable context to do so.

Learning to name objects is one of the earliest, and most important forms of arbitrarily applicable relational responding. More specifically, young children are repeatedly presented with various objects and are then asked to repeat the name of the object (e.g., a parent holding a book might say "what is this? Its a book". Once the child repeats the word "book", the response is reinforced. This could be described as see object A, hear name B, say name B. When the child points (to a book) in response to "where is the book", the child is similarly rewarded (i.e., hear name B then see object A). Initially each relation may be specifically trained, but after a large number of Object-Word and Word-Object relations are learned, this is no longer necessary. A history of such naming, coupled with the contextual cues such as the word is¹ and the naming context in general, predict that if an object is a "book" (object A -> name B) a "book" is the object (name B -> object A).

¹ One of the contextual cues that are often present when a child learns to respond in accordance with the relational frame of coordination, is the matching-to-sample format itself. Consider, for example, the number of pre-school exercises that involve asking a child which picture "is the same as" or "goes with" another picture. Thus the matching-to-sample format alone may be able to involve relational responding in accordance with coordination (see Hayes and Hayes, 1989, p176)

Arbitrarily applicable relational responding may be brought to bear on any stimuli, given appropriate contextual cues. Relational frame theory therefore explains equivalence responding in terms of a training history applicable to a given situation. In effect, when a young child is taught a number name-object and object-name relations and is then exposed to a matching-to-sample procedure, contextual cues provided by this procedure may be discriminative for equivalence responding. In fact, the matching-to-sample format itself may be a particularly powerful contextual cue for equivalence responding insofar as it is often used in preschool education exercises to teach picture-to-word equivalencies (see Barnes, 1994, and Barnes & Roche, 1996, for detailed discussions).

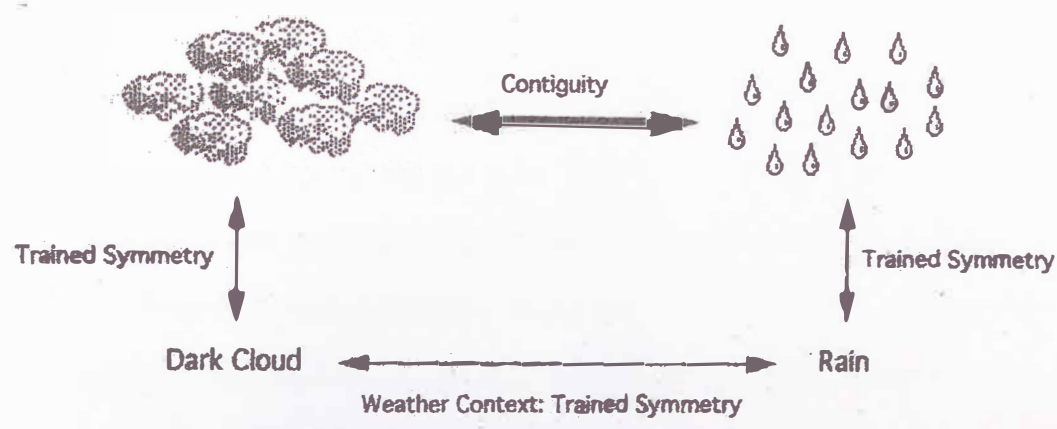
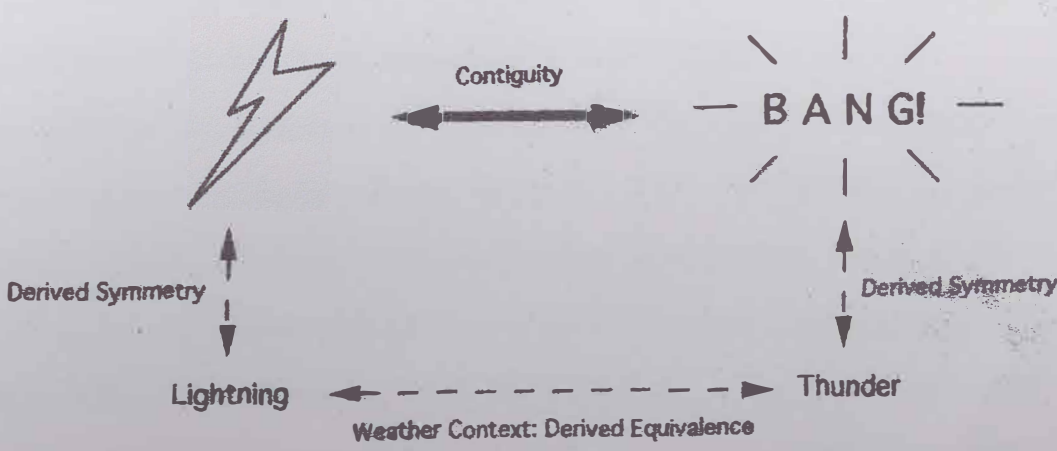
A Relational Frame Interpretation

How might RFT account for the effectiveness of the respondent training procedure? To answer this question, consider the following. In addition to naming, children are normally taught that events that are correlated in time and/or space often "go together" (i.e., participate in equivalence relations). In a typical early education exercise, for example, a child might learn that a picture of a dark cloud and the words "dark cloud" should be matched to a picture of rain and to the word "rain". In effect, the temporal and spatial correlation of actual dark clouds and rain is used to establish, in certain contexts, an equivalence relation between these events and the arbitrary stimuli "dark cloud" and "rain". After sufficient training of this type, a child might respond, in certain contexts, to other correlated events as participating in equivalence relations without explicit reinforcement for doing so. For example, having established an equivalence relation between actual lightening and the word "lightening" and another equivalence relation between actual thunder and the word "thunder", given an appropriate context (e.g., when asked by a teacher about different types of weather), the child might say "thunder and lightening

go together" (see Figure 1). In effect, the correlation between lightening and thunder in the natural environment is sufficient to establish an equivalence relation between these events and their descriptors if; (a) the child has an appropriate history of arbitrarily applicable relational responding, and (b) is provided with an appropriate context (i.e., a question about types of weather from a teacher).

From the RFT perspective, therefore, the temporal correlations that occurred among the stimuli during the respondent training produced equivalence responding in the current study, in part, because; (a) the subjects all possessed the appropriate histories of arbitrarily applicable relational responding, and (b) these histories were brought to bear by various contextual cues provided by the experimental setting and procedure. This interpretation readily incorporates the finding that using relatively long delays does not hinder the effectiveness of the respondent training procedure. The length of the delays are not critical -- what matters are the relative correlations that function as contextual cues for establishing the appropriate equivalence classes. At the present time, of course, it is not possible to identify exactly what properties of the experimental environment functioned as contextual cues, but a likely source of contextual control for equivalence responding in the current study was the matching-to-sample format of the equivalence test itself (see two paragraphs above, and see Barnes, 1994; Barnes & Roche, 1996). More informally, exposure to the matching-to-sample tasks may have helped subjects to discriminate that the respondent training was being used to "tell them which stimuli go together", and that the matching-to-sample tasks were being used to determine whether they had "learned which stimuli go together". This RFT interpretation would certainly explain why almost all of the subjects required at least two exposures to the training and testing before demonstrating equivalence. That is, only after a subject had been exposed to the matching-to-sample test did the respondent training then begin to function as the baseline

Figure 1: Diagrammatic Representation of an Early Education Exercise



training for equivalence responding. The foregoing RFT interpretation addresses the data from those studies that explored various features of the respondent procedure using both adults and children. However, what does RFT have to say with regard to the data reported in Chapter 5? In this chapter, various types of matching-to-sample arrangements were used that inadvertently promoted instances of contiguity between the positive and negative comparisons that either facilitated or competed against the formation of equivalence classes in young children and adults. A key finding in Chapter 5 was the differential effect of comparison contiguity across the children and adult populations -- the children appeared to respond far more readily in accordance with contiguity than the adults, who responded in accordance with the conditional relations between samples and comparisons. According to Relational Frame Theory, there are two main behavioural processes by which it is possible to form stimulus relations. The first of these is through direct stimulus pairing (including the effects of mediated generalisation), and the other is via the generalised operant of relational framing (see Barnes, 1994; Barnes & Roche, 1996). The effects of direct stimulus pairing are dependent upon the relatively basic behavioural process of respondent conditioning. This process is basic in that the process itself does not have to be learned. Relational framing, however, is a behavioural process that is established through multiple-exemplar training via interactions with a verbal community. In effect, relational framing, unlike respondent conditioning, is not present from birth (Healy, Barnes, Vaughan, Leader & Dymond, in press; Hayes & Hayes, 1989). From this perspective, the fact that the effects of comparison contiguity were restricted to the young children comes as no surprise. The relational framing repertoire of this young population was relatively underdeveloped in comparison to the adult population who had many more years of verbal interactions in their behavioural histories. Consequently, when presented with a task that could be responded to based on the basic behavioural

process of respondent conditioning, or the less well developed process of relational framing, the children "defaulted" to the basic process. The adults, however, came to the study with relatively protracted histories of relational framing, and given the context of a "problem-solving" psychology experiment, the repertoire of relational framing (which they would have learned to use for solving educational-type problems) was brought to bear. This is not to say that adult subjects are not readily controlled by contiguity (this was clearly the case in Chapter 4). However, in the studies reported in Chapter 5 another source of control was embedded within the task (i.e., sample-comparison conditional responding). Given the adults' extended "problem-solving" histories of responding consistently within particular contexts, these subjects continued to respond conditionally during the test trials, although an alternative, but inconsistent, form of stimulus control was possible (i.e., inconsistent in the sense that subjects had to respond conditionally to the samples and comparisons during the training, but could respond based on comparison-contiguity alone during the testing). Relational frame theory can, therefore, readily explain the apparently contradictory finding that adults derived relational responding was readily controlled by contiguity in the studies reported in Chapter 4, but their responding was controlled by sample-comparison conditional relations in the studies reported in Chapter 5. In other words, by focusing on the protracted histories of reinforcement for responding consistently across training and testing tasks, the adult test performances reported in both Chapters 4 and 5 make complete sense from the RFT perspective.

Another finding from the current research that might be seen to contradict the relational frame interpretation was the fact that the subjects in Chapter 6 failed to provide any coherent verbal reports concerning their performances on the equivalence tests. From the relational frame perspective, however, verbal functions are not defined in terms of the topography of

speaking (e.g., for relational frame theory, listening is also verbal behaviour; see Hayes & Hayes, 1989). From this point of view, therefore, there is no requirement that a subject need verbalise the relations involved in a successful test performance for that performance to be considered an example of relational framing. More specifically, there is no reason to expect that all of the functions that transform during the looking and pointing behaviour that occurs during an equivalence test will also accompany the transformation of functions that are required for subjects to verbalise the tested relations in a post-experimental interview. The relational frame interpretation of the current data thus differs quite dramatically from that offered by Horne and Lowe (1996, 1997) who would require that the appropriate verbalisations should accompany (and give rise to) the successful test performances. That said, however, further research is clearly needed to test the relational frame view. For example, it would be interesting to attempt to replicate some of the studies reported in the current thesis with even younger populations (e.g., two year old children), as a way of focusing on the exact nature of the relationship between a subject's prior history of interaction with the verbal community and their performance on equivalence tests following respondent-type training.

Another area that is also relevant to RFT and certainly needs further empirical analysis relates to the issue of training design. In Chapter 2, using the many-to-one protocol, all 5 adult subjects were successful on all tests on either their first or second exposure, whereas in the one-to-many condition, 4 out of 5 subjects were successful on all tests on either their second or third exposure (suggesting a slight superiority effect for many-to-one). However, the data reported in Chapter 3 suggest that we should be cautious in claiming that one training design is more effective than the other. Specifically, when using a linear protocol, equivalence emerged faster with less training and test exposures than the many-to-one or the one-to-many conditions of Chapter 2. However, the within- and between-pair-delays were massively longer in

Chapter 3, and thus a direct between-study comparison cannot be made. Furthermore, in Chapter 6, when 5 year old children were used as subjects, the many-to-one protocol appeared to be more effective than the one-to-many protocol which in turn was more effective than the linear protocol. But again, extreme caution is required here because the linear condition involved a greater number of nodes than the one-to-many or many-to-one conditions. That is, the final equivalence test in Experiment 1 (Chapter 6), which used a linear protocol, involved a distance of 2 nodes, but in Experiments 2 and 3, which employed one-to-many and many-to-one training protocols, respectively, the final equivalence test involved a distance of one node. In summary, therefore, the current thesis presented only very tentative evidence suggesting that the many-to-one procedure is more effective than the one-to-many or linear training designs.

Returning to the issue of RFT, this theory has been used to interpret many-to-one superiority (see Barnes, 1994). Specifically, the relational frame definition of equivalence in terms of a transfer of functions, predicts the superiority of many-to-one training on two grounds. First, the many-to-one procedure will produce specific respondent-type functions that are more likely to act as contextual cues for equivalence responding than those respondent-type functions produced by the one-to-many protocol. Second, many-to-one training may produce a greater number of discriminative functions between class members, and thereby provide a means of deriving equivalence relations not readily given by one-to-many training. However, even in this publication the author admitted that there are so many variables involved that the effect may be reliably observed only in a very tightly controlled experimental context. Clearly more research is needed to clarify these issues.

Conclusion

The foregoing RFT interpretation represents, of course, only one possible theoretical interpretation of the data presented in the current thesis. Nevertheless, the theory appears to provide a coherent framework within which to approach the effectiveness of the respondent training procedure. Of course further research will be needed, and I anticipate that RFT will help guide these future studies. Relational frame theory is not offered, therefore, as a definitive interpretation of the effect of the respondent training procedure, but should be viewed as a stimulus for further empirical and conceptual analyses in the study of derived stimulus relations.

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