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DERIVED RELATIONAL RESPONDING: A COMPARISON OF MATCH-TO-SAMPLE AND THE RELATIONAL COMPLETION PROCEDURE

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Previous research suggests that the Relational Completion Procedure may be an effective alternative procedure for studying derived relational responding. However, the parameters that make it effective, relative to traditional match-to-sample, remain to be determined. The present experiment compared the Relational Completion Procedure and match-to-sample protocols for training and testing Same and Opposite derived stimulus relations. Trials to criterion and overall pass rate (i.e., yield) in both procedures were compared across three variables: presence versus absence of a confirmatory response requirement, three versus five comparison stimuli, and top-to-bottom versus left-to-right presentation format. Findings demonstrated a facilitative effect of the confirmatory response requirement in both procedures. Training trials to criterion were nominally but not significantly lower during the nonarbitrary training phase in the Relational Completion Procedure compared to match-to-sample, and the overall yield on the arbitrary relational test was greater in the former procedure compared to the latter. The present findings support the further development of the Relational Completion Procedure as an efficient alternative procedure for establishing Same and Opposite relations with adult humans, and with potential applicability to other types of derived relations.

Key words: derived relational responding, match-to-sample, Relational Completion Procedure, relational frames, same, opposite, stimulus equivalence, adult humans

In a typical study on derived relational responding, a series of conditional discriminations involving arbitrary, physically dissimilar stimuli are presented in a match-to-sample (MTS) format. For instance, in the presence of sample stimulus A, selecting comparison stimulus B is reinforced (i.e., A–B) and on other trials selecting comparison stimulus C is reinforced (i.e., A–C). Following this history, it is likely that relations will emerge between B–A, C–A (i.e., termed symmetry or mutual entailment), B–C and C–B (i.e., termed combined symmetry and transitivity or combinatorial entailment), in the absence of any further training. When this occurs, the stimuli are said to have formed equivalence relations (Fields, Adams, Verhave, & Newman, 1990; Sidman, 1994) or a relational frame of coordination (Hayes, Barnes-Holmes, & Roche, 2001). This basic effect has been demonstrated in numerous empirical investigations with different stimuli, procedures, and populations.

Equivalence relations are just one example of a number of different forms of derived relational responding. Extensive research on multiple stimulus relations other than equivalence has shown that it is possible for humans to respond in accordance with contextually controlled relations such as Same (i.e., coordination), Opposite, Different, More than/Less than, and Before/After (e.g., Berens & Hayes, 2007; Dougher, Hamilton, Fink & Harrington, 2007; Dymond & Barnes, 1995, 1996; O'Hora, Roche, Barnes-Holmes, &

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Smeets, 2002; Reilly, Whelan, & Barnes-Holmes, 2005; Roche, Barnes-Holmes, Smeets, Barnes-Holmes, & McGeady, 2000; Steele & Hayes, 1991; Whelan & Barnes-Holmes, 2004; Whelan, Barnes-Holmes, & Dymond, 2006; Whelan, Cullinan, O'Donovan, & Rodriguez-Valverde, 2005). Studying multiple stimulus relations with human participants involves first training specific contextual cues using nonarbitrary stimuli related along formal dimensions, and then using these cues to establish arbitrarily applicable relations among stimuli that are not formally related (see Barnes-Holmes, Hayes, Dymond, & O'Hora, 2001).

Consider, for instance, training and testing the multiple stimulus relations of Same (i.e., coordination) and Opposite. In the first training phase, called nonarbitrary relational training, a contextual cue, a sample, and two or more comparison stimuli are presented on each trial. The objective of this phase is to establish contextual functions for each of the two cues. If the cue designated OPPOSITE[1] is presented, choosing a comparison stimulus that is furthest removed from the sample along a specified physical dimension is reinforced. For example, given a large square as sample, choosing the smallest square among three or more squares of different sizes is reinforced. On other trials, a cue designated SAME is presented, and choosing the comparison which is physically identical to the sample is reinforced. Training is conducted in this way, across multiples exemplars of stimuli that differ along various physical dimensions (e.g., big and small circles, thick and thin lines, few and many dots, etc.) until consistent responding occurs to novel samples and comparisons in the presence of the cues, in the absence of explicit differential reinforcement. In the second training phase, referred to as arbitrary relational training, the contextual cues are presented with samples and comparisons, such as nonsense trigrams, that are unrelated to each other along any consistent formal dimension. The purpose of this phase is to employ the contextual functions established during the nonarbitrary phase with arbitrary, physically dissimilar stimuli; that is, participants are trained to respond to nonsense trigrams as if they were 'same' and 'opposite' to one another.

To further understand this approach, consider the procedures reported by Steele and Hayes (1991) who first trained participants to relate same stimuli (e.g., a short line with a short line) in the presence of one contextual cue and opposite stimuli (e.g., a short line with a long line) in the presence of a second contextual cue. Participants were then taught an extensive series of conditional discriminations, with each of the contextual cues used in training. For illustrative purposes, consider the following two training trials: OPPOSITE/A1 [B1-*B2*] and OPPOSITE/A1 [C1-*C2*] in which selecting the italicized comparisons were reinforced. A later test trial was as follows: OPPOSITE/B2 [C1–C2]. If participants were responding in accordance with an equivalence relation or relational frame of coordination (i.e., sameness) they would choose C2, because during training they had selected C2 and B2 when A1 was the sample. Alternatively, if the OPPOSITE stimulus functioned as a conditional discriminative stimulus (i.e., participants ignored the sample), they would select C2, because choosing it had been reinforced in the presence of the OPPOSITE cue. In fact, participants chose C1 indicating that the relational frame of opposition had been brought to bear on the task. An increasing number of studies have replicated and extended this basic effect (e.g., Dymond & Barnes, 1996; Dymond, Roche, Forsyth, Whelan & Rhoden, 2007, 2008; Roche & Barnes, 1997; Whelan & Barnes-Holmes, 2004).

Although it is widely agreed that MTS procedures are not required to demonstrate equivalence relations (e.g., Sidman, 1994), variants of MTS have, over the years, dominated the experimental analysis of derived relational responding. Other, alternative procedures have, however, been developed. These include stimulus pairing (e.g., Barnes, Smeets, & Leader, 1996; Fields, Doran, & Marroquin, 2009; Fields, Reeve, Varelas, Rosen, & Belanich, 1997; Layng & Chase, 2001; Smyth, Barnes-Holmes, & Forsyth, 2006), go/no-go tasks (e.g., Cullinan, Barnes-Holmes, & Smeets, 2001; Debert, Matos, & McIlvane, 2007), multielement, compound stimuli as samples and/or comparisons (e.g., Markham & Dougher, 1993; Pérez-González & Alonso-Álvarez, 2008; Stromer, McIlvane, & Serna, 1993), constructed response protocols (e.g., Stromer & Mackay,

[1] In line with convention, we refer to the actual contextual cues in capitals (i.e., SAME, OPPOSITE), and the relational frames in title-case (i.e., Same and Opposite).

1992; Stromer, Mackay, Howell, McVay, & Flusser, 1996) and variations of simultaneous discrimination (e.g., McIlvane, Kledaras, Callahan, & Dube, 2002; Smeets, Barnes-Holmes, & Cullinan, 2000) and sequencing procedures (e.g., Lazar, 1977; Wirth & Chase, 2002). However, all of these alternative procedures have been devised to study equivalence relations and they each share a reliance on MTS, either to train the initial discriminations or to test for the emergence of the derived relations.

A potential overreliance on the MTS procedure to study all forms of derived relations may hamper the experimental analysis of derived relational responding (Barnes-Holmes et al., 2001; Hayes & Barnes, 1997; Lipkens & Hayes, 2009) and applied research based on this technology. There are several possible reasons for this. First, real world learning of derived relations rarely formally corresponds to MTS, and research based around MTS procedures may, in some respects, be said to be lacking in ecological validity. Second, in MTS the response of picking, touching or pointing to a comparison in the presence of a sample explicitly encourages analyses based on the concept of stimulus class (Barnes-Holmes et al., 2001; Hayes & Barnes, 1997). According to Barnes-Holmes et al., (2001), ''…if this type of responding is always seen as evidence that the two stimuli have entered into a class, it becomes impossible to observe consistent response patterns in a MTS procedure without also concluding that stimulus classes have formed. This methodological characteristic also encourages us to view the most unusual or complex MTS performances in terms of stimulus classes'' (p. 52). Thus, by focusing on this small subset of relational responses, MTS may limit further investigation of multiple stimulus relations other than equivalence (Hayes & Barnes, 1997). Third, some commentators have questioned the extensive training and testing that has been employed in previous MTS research on multiple stimulus relations with adults (e.g., Horne & Lowe, 1997). Because of the implications that research on derived relational responding has for understanding verbal behavior (Dymond & Rehfeldt, 2000; Hayes et al., 2001), it is important that laboratory procedures be continually refined in order to study all types of multiple stimulus relations, as flexibly and as efficiently as possible. Finally, applied practitioners require efficient protocols to train and test for derived relational responding with a majority of participants. An important translational research objective, therefore, is the development of alternatives to MTS that are both flexible and efficient.

An alternative methodology called the Relational Evaluation Procedure (REP) has been employed to study Same and Different (Stewart, Barnes-Holmes & Roche, 2004) and Before and After (Barnes-Holmes et al., 2001; O'Hora, Barnes-Holmes, Roche, & Smeets, 2004) relations (see also Cullinan et al., 2001; Lipkens & Hayes, 2009). The defining feature of the REP is that it allows participants to evaluate, or report on, different stimulus relations. That is, in the REP participants confirm or deny the applicability of particular stimulus relations to other sets of stimulus relations. For example, a participant might be presented with a contextual cue for OPPOSITE and three or more arbitrary stimuli that are specified within that trial as participating in an Opposite relation. The participant is then required to select one of two arbitrary shapes that function as True or False. So, for instance, selecting True in the presence of the OPPOSITE contextual cue, and selecting False in the presence of the SAME contextual cue would be considered correct, reinforced responses. The chief advantage of the REP over MTS alternatives is that once appropriate contextual control is acquired, a potentially infinite number of relational responses may be observed, with obvious applied implications. Despite this, no previous study has examined the REP with Same and Opposite relations, which are two of the most widely studied relational frames (Dymond, May, Munnelly, & Hoon, 2010).

Recently, Dymond et al. (2007, 2008) employed a procedure based on the REP, the *Relational Completion Procedure* (RCP), to train and test Same and Opposite relations. In the RCP, stimuli were presented in sequence from left to right, starting with the sample and followed (1 s later) by a contextual cue, a blank space and up to five comparisons. The participants' task was to ''complete the sentence'' by dragging and dropping one of several comparisons into the blank space and confirming each selection. For example, during nonarbitrary relational training and testing, given a large square as sample, in the

presence of the contextual cue for SAME, dragging a similarly sized large square to the blank space and emitting the confirmatory response was reinforced. On the other hand, given a large square as sample, in the presence of the contextual cue for OPPOSITE, dragging the smallest square among the five squares of different sizes and emitting the confirmatory response was reinforced. During the arbitrary relational training and testing, the response format was identical except for the use of arbitrary stimuli (e.g., trigrams). Also, Dymond et al. (2007) incorporated the evaluative response component from the REP into a confirmatory response requirement that permitted participants to either clear the selected comparison and resume the trial or confirm their selection and proceed to the presentation of feedback and the subsequent intertrial interval.

The RCP was originally developed to provide a functional analytic model of reading and responding to sentence-completion tasks that require participants to attend to real word language sequences differing in terminal clause (e.g., ''*They wanted the hotel to look more like a tropical resort. So along the driveway they planted rows of* …[*palm trees*] versus [*tulips*]''; see Federmeier & Kutas, 1999). This nonarbitrary sequential presentation of stimuli mirrors that seen when reading sentences written in many languages, such as English, which is read from left to right. Dymond et al. (2007, 2008) speculated that the order of stimulus presentation, which overlaps with participants' reading histories, in tandem with other features of the RCP such as the drag-and-drop and confirmatory response requirements, might facilitate performance relative to traditional MTS. Dymond et al. (2007) found that 8 out of 9 participants passed the arbitrary relational test within the predetermined criterion of four test exposures (3 participants on their first exposure, 4 on their second, and 1 on his final exposure). Across two experiments, Dymond et al. (2008) found that 14 out of 16 participants passed the arbitrary relational test within the predetermined criterion (6 on their first exposure, 4 on their second, 2 on their third and 2 on their final exposure). In both studies, participants also required fewer trials to meet criterion during nonarbitrary relational training and testing than is usually found when other MTS-based procedures have been used to study Same and Opposite relations (e.g., Dymond & Barnes, 1996; Roche & Barnes, 1997; Steele & Hayes, 1991; Whelan & Barnes-Holmes, 2004).

These findings indicate that the RCP may hold potential as a novel procedure for studying derived relational responding. The procedure can accommodate all combinations of multiple stimulus relations, which makes it a flexible alternative to MTS (Hayes & Barnes, 1997). Indeed, findings obtained from the cognitive literature on the electrophysiological responses evoked during sentence-completion tasks that resemble the RCP (Federmeier & Kutas, 1999) indicate that it may also be useful in identifying the neural correlates of derived relational responding (e.g., Barnes-Holmes et al., 2005; Yorio, Tabullo, Wainselboim, Barttfeld, & Segura, 2008). The present study, therefore, sought to undertake further empirical analysis of the RCP as a method for training and testing Same and Opposite relations. Across a total of eight conditions, we investigated the influence of the confirmatory response requirement and numbers of comparison stimuli on relational performance in the RCP and MTS, respectively.

METHOD

Participants

Thirty-two students from Swansea University ranging in age from 18 to 35 years participated in return for either partial course credit or £5 (approximately $9). Participants were randomly assigned to one of eight conditions, with a total of 4 participants in each condition (see Table 1). All participants were recruited through announcements made via the electronic participant-panel maintained by the Department of Psychology at Swansea University or personal contacts.

Apparatus and Setting

The experiments were conducted in a small room containing a computer programmed in Visual Basic® 6.0 that controlled all stimulus presentations and recorded all responses. Two stimuli from the Wingdings font were used as contextual cues for Same (i.e., ⌘) and Opposite (i.e., ♍), respectively. Eight nonsense syllables (e.g., CUG, JOM, ZID) were employed as sample and comparisons during arbitrary relational training and testing in Conditions 1 to 4.

Table 1

Overview of each condition. The symbols ''+'' and ''−'' indicate presence and absence of the confirmatory response requirement, respectively. See text for details.

Condition	Procedure	Number of Comparisons	Confirmatory Response
1	MTS	3	+
2	MTS	3	−
3	RCP	3	+
4	RCP	3	−
5	MTS	5	+
6	MTS	5	−
7	RCP	5	+
8	RCP	5	−

These are labeled, for the purposes of clarity, using the alphanumerics A1, B1, C1, B2, C2, N1, X1, and Y1 (participants never saw these labels). In Conditions 5 to 8, five additional stimuli (Y2, Y3, Y4, N2 and N3) were employed.

General Procedure

Participants were trained and tested individually in sessions ranging in length from 30 to 90 min. All participants completed the experiment in one session. Upon arrival at the laboratory, participants signed an informed consent form and were seated comfortably approximately 0.5 m from the computer monitor and keyboard.

There were several phases common to all conditions in both the MTS and RCP. The first two phases consisted of nonarbitrary relational training and testing designed to establish contextual cues for Same and Opposite responding. The third phase involved arbitrary relational training during which participants were trained to relate a series of arbitrary stimuli (i.e., trigrams) in the presence of the SAME and OPPOSITE cues to establish a contextually controlled relational network of arbitrary stimuli. The fourth phase involved arbitrary relational testing and was used to probe for the emergence of derived (i.e., combinatorially entailed; see Hayes et al., 2001) relations among the arbitrary stimuli in the network. The contextual cues were arbitrary symbols, whereas the samples and comparisons were either nonarbitrary (i.e., formally related) or arbitrary (i.e., formally unrelated) stimuli, depending on the specific phase.

Conditions 1 to 4

Conditions 1 to 4 were as follows (see Table 1): 1 (MTS with three comparisons and confirmatory response); 2 (MTS with three comparisons and no confirmatory response; 3 (RCP with three comparisons and confirmatory response); and 4 (RCP with three comparisons and no confirmatory response).

Procedure: Matching-to-sample (MTS)

Before beginning, the following instructions were presented onscreen and read aloud by the experimenter.

> Thank you for agreeing to participate in this study. You will be presented with a series of images or nonsense words on the screen from top to bottom. Your task is to observe the images or words that appear and pick one of the images from the bottom. Sometimes you will receive feedback on your choices, but at other times you will not. Your aim is to get as many tasks correct as possible. It is always possible to get a task correct, even if you are not given feedback. If you have any questions please ask the experimenter now.

Any questions were addressed by referring to the instructions.

During all nonarbitrary and arbitrary relational training and testing phases the computer screen was divided into two areas, the top two thirds was blue, the remainder gray. The sample appeared in the upper center portion of the screen; after 1 s the contextual cue appeared immediately below it, and after a further 1 s three comparison stimuli appeared simultaneously on the lower section of the screen (Figure 1, upper panels). The location of the comparison stimuli across the bottom of the screen was randomized across trials.

The response requirements of the MTS required participants to click on one of the three comparisons with the computer mouse (Figure 1, upper panels). When the comparison was selected, a red border immediately appeared around the comparison and, in conditions where it was programmed (see Table 1), the confirmatory response requirement became operational: Two buttons simultaneously appeared at the bottom of the screen that displayed the captions 'Finish Trial' and 'Start Again', respectively. Hovering the cursor over the Finish Trial button produced a small text box with the caption ''Click here to finish this trial,'' and hovering over the Start Again button produced the caption ''Click here to start again.'' Pressing the Start Again button removed the red border

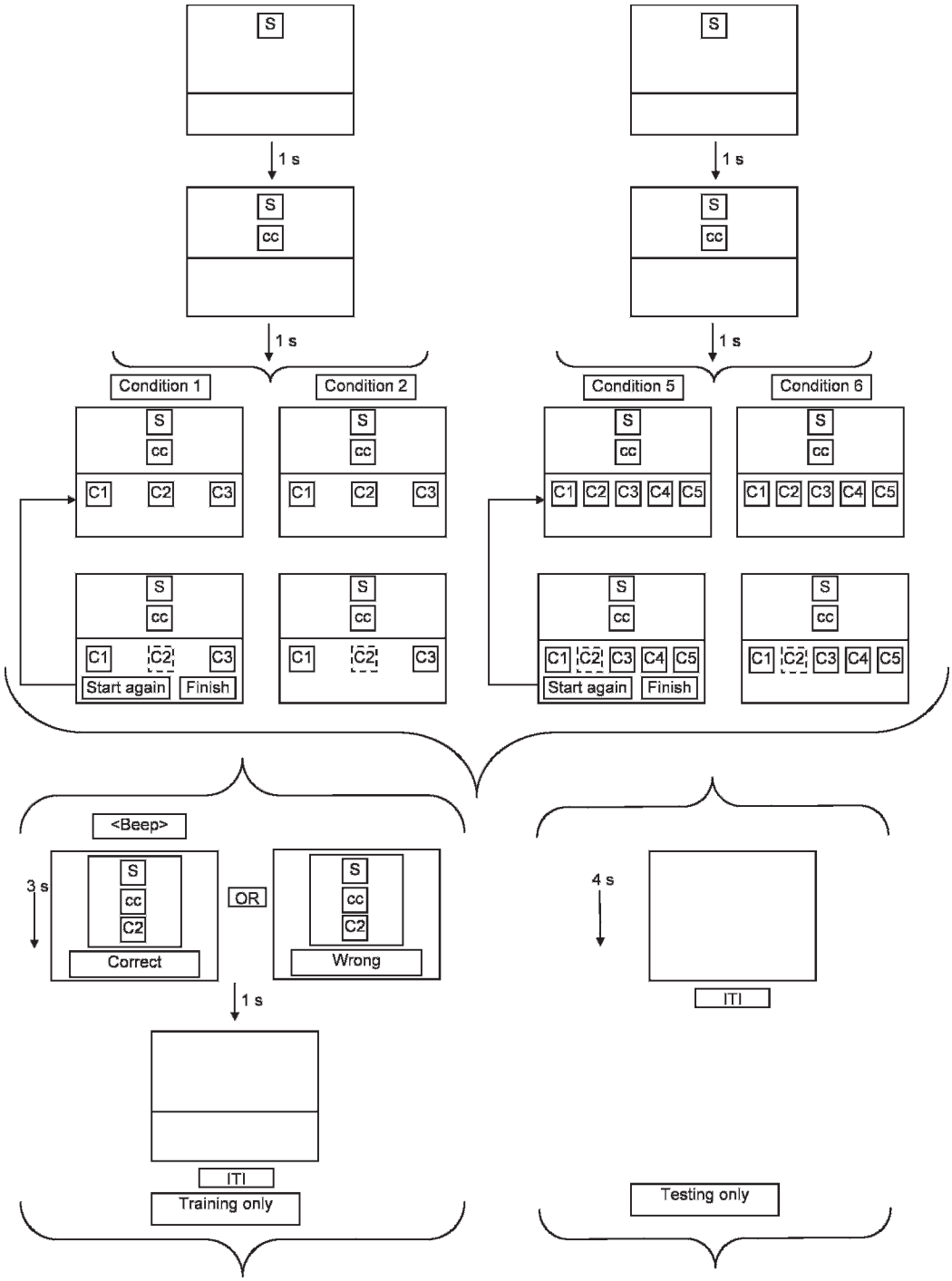

Fig. 1. Schematic diagram of the sequence and format of stimulus presentation during arbitrary relational training and testing in MTS conditions with and without the confirmatory response requirement. *Note*: S = sample, cc = contextual cue, C = comparison, B = blank square, dashed line = ''clicking on'' or having selected a comparison stimulus, 1 = Condition 1 (MTS with three comparisons and confirmatory response), 2 = Condition 2 (MTS with three comparisons and no confirmatory response), 5 = Condition 5 (MTS with five comparisons and confirmatory response), and 6 = Condition 6 (MTS with five comparisons and no confirmatory response). See text for details.

and the two confirmatory buttons (Figure 1, center panels). Pressing the Finish Trial button during the training phases cleared the screen and produced the feedback screen for 3 s followed 1 s later by the intertrial interval (ITI). The feedback screen consisted of the sample, contextual cue and selected comparison from the preceding trial, arranged top-down, along with either ''Correct'' (following correct trials) or ''Wrong'' (following incorrect trials). During the ITI, which was 3 s in duration, all stimuli were cleared from the screen and the background color remained blue. Pressing the Finish Trial button during the test phases was immediately followed by a 4 s ITI (see Figure 1, lower panels).

Phase 1: Nonarbitrary relational training. Phase 1 was designed to establish functions of Same and Opposite for the two contextual cues. During this phase, the contextual cue appeared in the center, top third of the screen. One second later, the sample stimulus appeared in the middle of the screen followed, after a 1-s delay, by three comparison stimuli in a row at the bottom of the screen (see Figure 1, center panels). All stimuli remained on screen until a response was made by clicking on one of the comparison stimuli with the computer mouse. The positions of comparison stimuli on the screen (i.e., left, middle, and right) were randomized across trials. Sample and comparison stimuli were pictures of common objects or shapes, and were always related to each other along a physical dimension (see Table 2). For example, one set of comparison stimuli consisted of a long line, a medium line, and a short line. Thus, given a short line sample stimulus, in the presence of the OPPOSITE contextual cue, choosing the long line comparison stimulus was reinforced. However, given the SAME contextual cue and a short line, choosing the short line comparison was reinforced. The samples and comparisons were pictures of common objects and shapes, and there were a total of six stimulus sets presented in random order. When participants emitted eight consecutively correct responses they were immediately exposed to Phase 2.

Phase 2: Nonarbitrary relational testing. This phase was identical to Phase 1 except for the following important differences: no feedback was presented and four novel stimulus sets were employed. Participants were required to respond correctly across all eight trials in order to immediately proceed to Phase 3; failure to do so resulted in reexposure to Phase 1.

Table 2

The stimulus sets employed during the nonarbitrary relational training (Phase 1) and testing (Phase 2) phases that were used to establish contextual functions of Same and Opposite. ''End 1'' and ''End 2'' refer to the physical endpoints of each stimulus set.

	Physical dimension	
Description	End 1	End 2
Phase 1		
Red disk sections	Thin crescent	Full disk
Lines	Short	Long
Cubes	Small	Big
Smiley faces	Very sad	Very happy
Dots	Few	Many
Trees	Small	Big
Phase 2		
Buildings	Small	Big
Wavy lines	Small amplitude	Big amplitude
Columns	Narrow	Wide
Snowstorm	No snow	White-out
Bowed trees	Straight	Very bowed
Pointed star	Three-points	Twenty-points

Phase 3: Arbitrary relational training. During this phase, the sample and comparison stimuli were all arbitrary stimuli (trigrams). The probes for arbitrary relational training (Phase 3) and testing (i.e., Phase 4) are described using the following convention: The contextual cue is described first in capitals, followed by the sample stimulus, followed by the three comparison stimuli in brackets. The experimenter-designated correct comparison is in italics. For example, the notation SAME/A1 [*B1*-B2-N1] indicates that in the presence of the contextual cue SAME and the sample stimulus A1, selecting B1 was reinforced, whereas selecting B2 or N1 was not. All participants were presented with the following eight training trials: SAME/A1 [*B1*-B2-N1], SAME/A1 [*C1*-C2-N2], OPPOSITE/A1 [B1-*B2*-N1], OPPOSITE/A1 [C1-*C2*-N2], SAME/X1 [*Y1*-B1-N3], SAME/X1 [*Y2*-C1-N3], OPPOSITE/X1 [*Y3*-B2-N3], OPPOSITE/X1 [*Y4*-C2-N3]. Training occurred in blocks of eight trials, with each trial type presented twice per block. Participants were required to choose the correct comparison across eight consecutive trials before being immediately exposed to Phase 4 (see Table 3 for details of the various trial types).

Phase 4: Arbitrary relational testing. The aim of this phase was to determine if appropriate

Table 3

Trial configurations (contextual cue, sample, correct and incorrect comparisons) for Phase 3 (arbitrary relational training) and Phase 4 (arbitrary relational testing) for each condition.

	Contextual Cue	Sample	Correct Comparison	Incorrect Comparisons
Phase 3				
Conditions 1-4				
	SAME	A1	B1	B2 N1
	SAME	A1	C1	C2 N2
	OPPOSITE	A1	B2	B1 N1
	OPPOSITE	A1	C2	C1 N2
	SAME	X1	Y1	B1 N3
	SAME	X1	Y2	C1 N3
	OPPOSITE	X1	Y3	B2 N3
	OPPOSITE	X1	Y4	C2 N3
Conditions 5-8				
	SAME	A1	B1	B2 N1 N2 N3
	SAME	A1	C1	C2 N1 N2 N3
	OPPOSITE	A1	B2	B1 N1 N2 N3
	OPPOSITE	A1	C2	C1 N1 N2 N3
	SAME	X1	Y1	B1 B2 N1 N3
	SAME	X1	Y2	C1 C2 N3 N4
	OPPOSITE	X1	Y3	B1 B2 N3 N4
	OPPOSITE	X1	Y4	C1 C2 N3 N4
Phase 4				
Conditions 1-4				
	SAME	B1	C1	C2 N1
	SAME	C1	B1	B2 N1
	OPPOSITE	B1	C2	C1 N1
	OPPOSITE	C2	B1	B2 N1
	SAME	B2	C2	C1 N1
	SAME	C2	B2	B1 N1
	OPPOSITE	B2	C1	C2 N1
	OPPOSITE	C1	B2	B1 N1
Conditions 5-8				
	SAME	B1	C1	C2 N1 N2 N3
	SAME	C1	B1	B2 N1 N2 N3
	OPPOSITE	B1	C2	C1 N1 N2 N3
	OPPOSITE	C2	B1	B2 N1 N2 N3
	SAME	B2	C2	C1 N1 N2 N3
	SAME	C2	B2	B1 N1 N2 N3
	OPPOSITE	B2	C1	C2 N1 N2 N3
	OPPOSITE	C1	B2	B1 N1 N2 N3

derived relational responding in accordance with the relations of Same and Opposite would emerge. Figure 2 shows the predicted relational network. Responses during test trials were not reinforced and the trial types were as follows: SAME/B1 [*C1*-C2-N1], SAME/C1 [*B1*-B2-N1], SAME /B2 [C1-*C2*-N1], SAME/C2 [B1-*B2*-N1], OPPOSITE/B1 [C1-*C2*-N1], OPPOSITE/C2 [*B1*-B2-N1], OPPOSITE/B2 [*C1*-C2-N1], and OPPOSITE/C1 [B1-*B2*-N1].

Responding in accordance with the predicted relational network required that subjects would (a) choose C1 given B1 in the presence of SAME; (b) choose B1 given C1 in the presence of SAME (C1 and B1 are both the same as A1 and therefore the same as each other); (c) choose C2 given B2 in the presence of SAME; (d) choose B2 given C2 in the presence of SAME (C2 and B2 are both opposite to A1 and therefore the same as each other); (e) choose C2 given B1 in the presence of OPPOSITE; (f) choose B1 given C2 in the presence of OPPOSITE (C2 is opposite to A1, and B1 is the same as A1, and therefore C2 is opposite of B1); (g) choose C1 given B2 in the presence of OPPOSITE; and choose B2 given C1 in the presence of OPPOSITE (C1 is the same as A1, and B2 is opposite to A1, and therefore C1 is opposite to B2).

Testing occurred in a block of 16 trials, with each task presented twice per block. Participants were required to emit a minimum of 14 out of 16 (i.e., 87.5%) correct

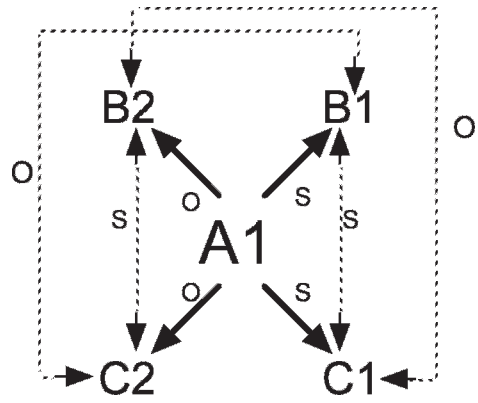

Fig. 2. Schematic diagram of the trained (solid) and tested (dashed) relational network. The letters 'S' and 'O' indicate Same and Opposite stimulus relations, respectively. See text for details.

responses in order to pass the arbitrary relational test. If this criterion was not met, participants were reexposed to the entire training and testing sequence from Phase 1 to Phase 4 (i.e., one ''cycle''). The predetermined maximum of cycles through the entire sequence was four.

Relational Completion Procedure (RCP)

Before beginning, the following instructions were presented onscreen and read aloud by the experimenter:

> Thank you for agreeing to participate in this study. You will be presented with a series of images or nonsense words on the top half of the screen from left to right. Then you will be presented with 5 images or nonsense words on the bottom of the screen. Your task is to observe the images or words that appear from left to right and drag one of these images or words from the bottom to the blank, yellow square. Click and hold the mouse over the image or word to drag it to the blank square. [In conditions with the confirmatory response requirement, the following was included in the instructions: To confirm your choice, click 'Finish Trial'. If you wish to make another choice, then click 'Start Again'.] Sometimes you will receive feedback on your choices, but at other times you will not. Your aim is to get as many tasks correct as possible. It is always possible to get a task correct, even if you are not given feedback.

Clicking on a check box at the bottom of the screen cleared the instruction screen and, after a 3-s interval, Phase 1 commenced.

During all nonarbitrary and arbitrary relational training and testing phases the computer screen was divided into two areas, the top two thirds was blue, the remainder gray. The sample appeared on the left upper portion of the screen; after 1 s the contextual cue appeared in the upper center, and after a further 1 s a ''blank'' comparison square appeared on the right upper portion of the screen (see Figure 3, left panels). Three comparison stimuli appeared simultaneously on the lower section of the screen. The location of the comparison stimuli across the bottom of the screen was randomized across trials.

The response requirements of the RCP required participants to drag one of the three comparisons into the blank comparison square by placing the cursor over a comparison and holding down the left mouse button (Figure 3, center panels). Moving the cursor over the blank square and releasing the left mouse button moved the selected comparison into the ''blank'' comparison square. The comparison stimulus that was moved was itself simultaneously replaced by a blank yellow square.

When the comparison was dropped, the confirmatory response requirement, in conditions where it was programmed (see Table 1), became operational: two buttons appeared on the bottom of the screen that displayed the captions 'Finish Trial' and 'Start Again', respectively. Hovering the cursor over the Finish Trial button produced a small text box with the caption ''Click here to finish this trial,'' and hovering over the Start Again button produced the caption ''Click here to start again.'' Pressing the Start Again button reset all the stimuli to where they were before the comparison was dropped (i.e., the comparison square on the upper portion of the screen became blank and the selected comparison returned to the lower portion of the screen). Pressing the Finish Trial button cleared the screen and produced the feedback screen during the training phases and the ITI during test phases (Figure 3, right panels). The feedback screen consisted of the sample, contextual cue and selected comparison from the preceding trial, arranged left to right, along with either ''Correct'' (following correct trials) or ''Wrong'' (following incorrect trials). During the ITI, which was 3 s in

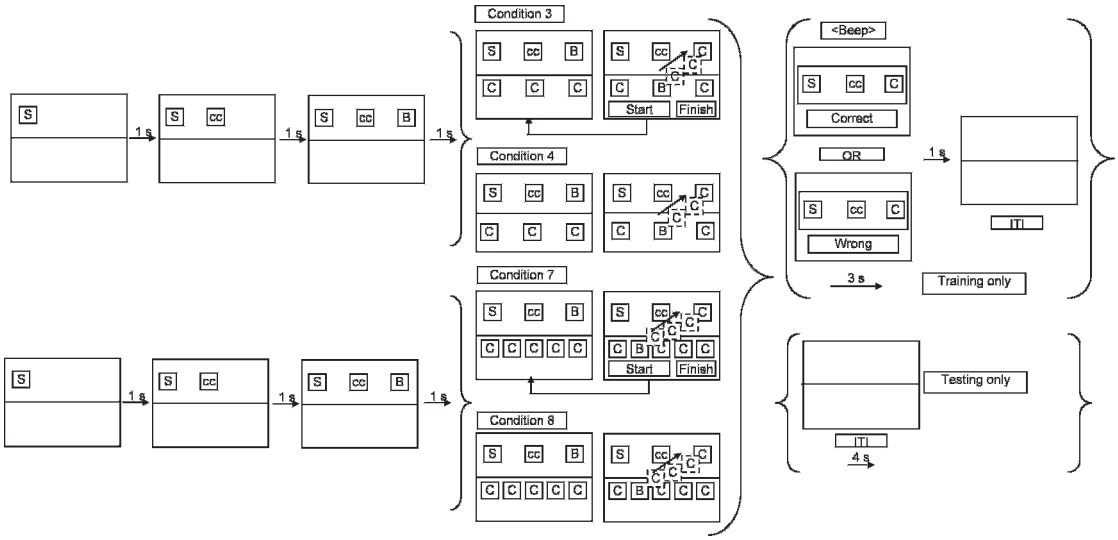

Fig. 3. Schematic diagram of the sequence and format of stimulus presentation during arbitrary relational training and testing in RCP conditions with and without the confirmatory response requirement. *Note*: S = sample, cc = contextual cue, C = comparison, B = blank square, dashed line = ''dragging'' a comparison stimulus, 3 = Condition 3 (RCP with three comparisons and confirmatory response), 4 = Condition 4 (RCP with three comparisons and no confirmatory response, 7 = Condition 7 (RCP with five comparisons and confirmatory response), and 8 = Condition 8 (RCP with five comparisons and no confirmatory response). See text for details.

duration, all stimuli were cleared from the screen and the background color remained blue.

Phase 1: Nonarbitrary relational training. During this phase, all the samples and comparisons were pictures of common objects or shapes related to each other along a nonarbitrary dimension (e.g., size). Six stimulus sets (see Table 2) were presented in random order. When participants produced eight consecutively correct responses they were immediately exposed to Phase 2.

Phase 2: Nonarbitrary relational testing. This phase followed the same format as Phase 1, with two exceptions: no feedback was presented (responses were simply followed by the ITI), and six novel stimulus sets were employed (see Table 2). Participants were required to respond correctly across all eight trials in order to immediately proceed to Phase 3; failure to do so resulted in reexposure to Phase 1.

Phase 3: Arbitrary relational training. During this phase the samples and comparison stimuli were all arbitrary stimuli (trigrams). Participants were presented with the same eight training trials as MTS participants: SAME/A1 [*B1*-B2-N1], SAME/A1 [*C1*-C2-N2], OPPOSITE/A1 [B1-*B2*-N1], OPPOSITE/A1 [C1-*C2*-N2], SAME/X1 [*Y1*-B1-N3], SAME/X1 [*Y2*-C1-N3], OPPOSITE/X1 [*Y3*-B2-N3], OPPOSITE/X1 [*Y4*-C2-N3]. Training occurred in blocks of eight trials, with each trial type presented twice per block. Participants were required to choose the correct comparison across eight consecutive trials before being immediately exposed to Phase 4.

Phase 4: Arbitrary relational testing. Responses during test trials were not reinforced and the trial types were as follows: SAME/B1 [*C1*-C2-N1], SAME/C1 [*B1*-B2-N1], SAME/B2 [C1-*C2*-N1], SAME/C2 [B1-*B2*-N1], OPPOSITE/B1 [C1-*C2*-N1], OPPOSITE/C2 [*B1*-B2-N1], OPPOSITE/B2 [*C1*-C2-N1], and OPPOSITE /C1 [B1-*B2*-N1]. Testing occurred in a block of 16 trials, with each task presented twice per block. Participants were required to emit a minimum of 14 out of 16 (i.e., 87.5%) correct responses in order to pass the arbitrary relational test. If this criterion was not met, participants were reexposed to the entire training and testing sequence from Phase 1 to Phase 4 (i.e., one ''cycle''). The predetermined maximum of cycles through the entire sequence was four.

Conditions 5 to 8

Conditions 5 to 8 were as follows (see Table 1): 5 (MTS with five comparisons and confirmatory response); 6 (MTS with five comparisons and no confirmatory response; 7 (RCP with five comparisons and confirmatory response); and 8 (RCP with five comparisons and no confirmatory response).

The procedure for Conditions 5 to 8 was identical to that of Conditions 1 to 4 except that five comparison stimuli were now presented on all trials across both procedures. During MTS and RCP, the following eight arbitrary relational training tasks were presented in Phase 3: SAME/A1 [*B1*-B2-N1-N2-N3], SAME/A1 [*C1*-C2-N1-N2-N3], OPPOSITE/A1 [B1-*B2*-N1-N2-N3], OPPOSITE/A1 [C1-*C2*-N1-N2-N3], SAME/X1 [*Y1*-B1-B2-N1-N3], SAME/X1 [*Y2*-C1-C2-N3-N4], OPPOSITE/X1 [*Y3*-B1-B2-N3-N4], OPPOSITE/X1 [*Y4*-C1-C2-N3-N4]. In Phase 4, the following eight arbitrary relational testing tasks were presented in both MTS and the RCP: SAME/B1 [*C1*-C2-N1-N2-N3], SAME/C1 [*B1*-B2-N1-N2-N3], SAME/B2 [C1-*C2*-N1-N2-N3], SAME/C2 [B1-*B2*-N1-N2-N3], OPPOSITE/B1 [C1-*C2*-N1-N2-N3], OPPOSITE/C2 [*B1*-B2-N1-N2-N3], OPPOSITE/B2 [*C1*-C2-N1-N2-N3], and OPPOSITE /C1 [B1-*B2*-N1-N2-N3].

RESULTS

In all conditions, the main dependent measures were the number of trials to criterion and overall yield (i.e., number of participants passing the arbitrary relations test). The upper panel of Figure 4 displays the mean yield in each of the eight conditions and the lower panel of Figure 4 displays the mean number of cycles in each of the eight conditions.

Conditions 1 to 4

In Conditions 1 to 4, there were yields of 50% and 25% in the MTS conditions with and without the confirmatory response, respectively. Those participants that passed required either two (P2, P7) or three cycles (P3) before meeting criterion on the arbitrary relational test (see Table 4). There were 75% and 25% yields in the RCP conditions with and without the confirmatory response, respectively. Participants took between one (P10) and four cycles (P13) before passing the arbitrary relational test. The overall mean number of cycles for conditions with the confirmatory response requirement was 2.5 cycles, while the overall mean for the conditions without the response requirement was 3.75 cycles. Overall, both RCP conditions required an average of 2.87 cycles, compared with both MTS conditions that required 3.37 cycles.

Conditions 1 to 4 demonstrated that the RCP was, to some extent, more effective than the MTS procedure when the confirmatory response was employed (Table 4). The yield was the same (25%) for both the MTS and the RCP in the absence of the confirmatory response. Overall, there was a slight advantage for the RCP in terms of number of cycles to criterion. These data suggest that the RCP and MTS are at least comparable in effectiveness when other parameters are equated.

Conditions 5 to 8

In Conditions 5 to 8, there were 75% and 25% yields in the MTS conditions with and without the confirmatory response, respectively. Participants that passed required two (P17), three (P18, P23) or four cycles (P19) to meet criterion on the arbitrary relational test (see Table 5). For the RCP condition without the confirmatory response, none of the participants passed the arbitrary relational test, whereas all of the participants passed the arbitrary relational test in the RCP condition where the confirmatory response was adopted. The overall mean number of cycles for the MTS conditions with and without the confirmatory response requirements was three for both conditions. Participants in the RCP condition with the confirmatory response requirement took a mean of two cycles to reach the mastery criterion.

In Conditions 5 to 8, only 1 of 8 participants in either the MTS or RCP conditions without the confirmatory response passed the arbitrary relational test (Table 5). In contrast, 7 of the 8 participants that received the confirmatory response with either MTS (Condition 5) or RCP (Condition 7) passed the arbitrary relational test (the only participant that failed received MTS). The effect of the confirmatory response was more pronounced in MTS Condition 5 than it had been in Condition 1, and in RCP Condition 7 than it had been in Condition 3.

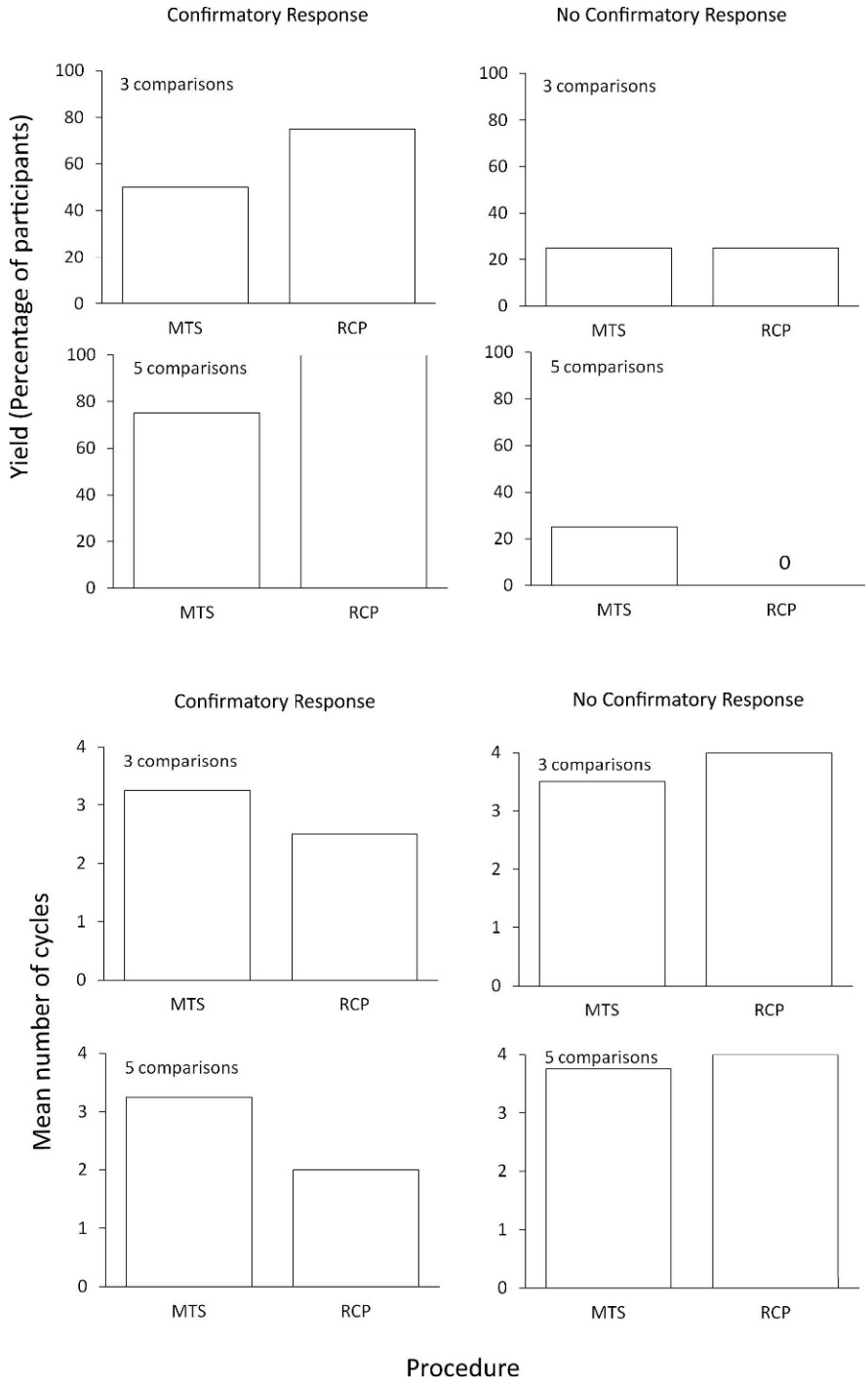

Fig. 4. Percentage yield (upper panel) and mean number of training and testing cycles (lower panel), per condition. See Table 1 and text for details.

Table 4

Individual data from Conditions 1 to 4, showing participant identifiers, task (MTS or RCP), presence or absence of the confirmatory response requirement, the percentage of correct arbitrary relational test trials, number of arbitrary relational training trials per cycle, and pass/fail status. The symbols "+" and "−" indicate presence and absence of the confirmatory response requirement, respectively.

				% correct arbitrary testing (& arbitrary training trials to criterion)				
				Cycle number				
Condition	Participant	Task	Confirmatory response	1	2	3	4	Status
1	P1	MTS	+	31 (86)	25 (8)	31 (8)	44 (18)	Fail
1	P2	MTS	+	56 (86)	88 (11)			Pass
1	P3	MTS	+	50 (35)	38 (17)	94 (8)		Pass
1	P4	MTS	+	6 (91)	31 (8)	31 (8)	56 (8)	Fail
2	P5	MTS	−	44 (39)	44 (10)	69 (8)	50 (14)	Fail
2	P6	MTS	−	25 (21)	25 (74)	56 (9)	56 (69)	Fail
2	P7	MTS	−	44 (74)	88 (33)			Pass
2	P8	MTS	−	31 (44)	31 (52)	50 (8)	31 (24)	Fail
3	P9	RCP	+	56 (277)	88 (8)			Pass
3	P10	RCP	+	88 (43)				Pass
3	P11	RCP	+	38 (27)	81 (20)	88 (8)		Pass
3	P12	RCP	+	25 (134)	19 (20)	6 (8)	38 (8)	Fail
4	P13	RCP	−	44 (168)	63 (11)	50 (8)	88 (9)	Pass
4	P14	RCP	−	44 (148)	50 (23)	19 (9)	31 (8)	Fail
4	P15	RCP	−	38 (157)	38 (21)	44 (8)	56 (8)	Fail
4	P16	RCP	−	69 (62)	38 (16)	50 (20)	63 (19)	Fail

Effect of Task Format: All Conditions

The mean overall yield across all four MTS conditions was 43.75%, and was 50% for the four RCP conditions. The upper panel of Figure 4 displays the yield in each of the eight conditions). Binomial probability tests were conducted for three independent variables (testing the null hypothesis that the variable had no effect on performance): confirmatory response (CR; presence or absence), number of comparisons (three or five), and procedure (MTS or RCP). The effect of CR was significant ($p = .0176$; 12 CR passers and 3 no-CR passers). The effect of comparison number was nonsignificant ($p > .05$, 7 passers with three comparisons, 8 passers with five comparisons). The effect of type of procedure was also not significant ($p > .05$, 7 passers in the MTS conditions, 8 passers in the RCP conditions).

Nonarbitrary Training: All Conditions

In order to investigate the role of task format on nonarbitrary training, the number of trials to criterion in Phase 1 (the nonarbitrary phase) was analyzed. The median number of trials to criterion (i.e., to eight consecutively correct responses) was 22.5 (interquartile range = 26.00) across all MTS conditions and 19.5 (interquartile range = 17) across all RCP conditions. This difference was not statistically significant (Mann-Whitney U, $z = 0.375$, $p > 0.05$).

Arbitrary Training: All Conditions

The median number of trials to criterion (i.e., to 14 out of 16 correct responses) was 124.5 (interquartile range = 84.25) across all MTS conditions and 143.5 (interquartile range = 138) across all RCP conditions. This difference was not statistically significant (Mann-Whitney U, $z = 0.188$, $p > 0.05$).

DISCUSSION

The present study undertook the first empirical investigation of an alternative methodology to traditional MTS for training and testing multiple stimulus relations of Same and Opposite. In Conditions 1 to 4, less than half of the participants (7 out of 16) demonstrated the predicted performances on the arbitrary relational tests using either the RCP or MTS procedure. Of these 7 participants who passed, 4 were exposed to the RCP, 3 of whom received the confirmatory response

Table 5

Individual data from Conditions 5 to 8, showing participant identifiers, task (MTS or RCP), presence or absence of the confirmatory response requirement, the percentage of correct arbitrary relational test trials, number of arbitrary relational training trials per cycle, and pass/fail status. The symbols ''+'' and ''−'' indicate presence and absence of the confirmatory response requirement, respectively.

				% correct arbitrary testing(& arbitrary training trials to criterion)				
				Cycle number				
Condition	Participant	Task	Confirmatory response	1	2	3	4	Status
5	P17	MTS	+	50 (122)	94 (21)			Pass
5	P18	MTS	+	44 (108)	56 (11)	94 (10)		Pass
5	P19	MTS	+	6 (68)	31 (38)	25 (18)	81 (25)	Pass
5	P20	MTS	+	50 (124)	50 (15)	50 (9)	50 (19)	Fail
6	P21	MTS	−	25 (126)	19 (187)	25 (151)	44 (50)	Fail
6	P22	MTS	−	6 (266)	31 (16)	19 (58)	44 (18)	Fail
6	P23	MTS	−	38 (261)	38 (25)	88 (8)		Pass
6	P24	MTS	−	63 (48)	63 (8)	44 (8)	31 (8)	Fail
7	P25	RCP	+	88 (30)				Pass
7	P26	RCP	+	50 (40)	82 (8)	94 (8)		Pass
7	P27	RCP	+	50 (66)	25 (13)	94 (12)		Pass
7	P28	RCP	+	100 (62)				Pass
8	P29	RCP	−	25 (78)	63 (10)	50 (8)	69 (8)	Fail
8	P30	RCP	−	13 (180)	25 (118)	31 (24)	19 (25)	Fail
8	P31	RCP	−	31 (155)	19 (8)	50 (10)	69 (15)	Fail
8	P32	RCP	−	19 (308)	0 (9)	6 (16)	19 (68)	Fail

requirement, and 3 were exposed to the MTS procedure, 2 of whom received the confirmatory response requirement. In Conditions 5 to 8, half of the participants demonstrated the predicted performances (i.e., 8 out of 16): 4 in the RCP and 4 in the MTS procedure. Again, all 4 participants in the RCP, and 3 out of 4 of the participants in the MTS procedure, had received the confirmatory response requirement.

Overall, the present findings, combined with those of Dymond et al. (2007, 2008), demonstrate that the RCP may have potential as an alternative to MTS for establishing Same and Opposite relations with adult humans. Participants exposed to the RCP produced a nominally but not significantly higher yield on tests for Same and Opposite relations (8 out of 16 participants in the RCP conditions and 7 out of 16 participants in the MTS conditions, across both experiments). The mean number of cycles was comparable across both procedures, with a minor advantage observed with RCP conditions employing the confirmatory response. The lower panel of Figure 4 displays the mean number of cycles in each of the eight conditions. The small sample size per condition partially explains the lack of statistical significance, but the individual response requirements of the RCP may well have contributed to these descriptive differences in acquisition of nonarbitrary and arbitrary relational training. That is, the format of the RCP differed from the MTS protocol in the following ways: the physical layout of the screen, the drag-and-drop and confirmatory response requirements, and the left-to-right presentation of the stimuli. We will now address each of these factors in turn.

In the RCP, participants were presented with the contextual cue and the sample on the top of the screen, on the same level as each other, and separate to the comparisons (see Figure 3). This separation was further emphasized by the use of a gray background for the comparison stimuli and a blue background for the contextual cue, sample stimulus and selected comparison stimulus. The participant selected and moved a comparison from the bottom of the screen to the top of the screen on the right of the sample. Next, the participant clicked on the ''Finish Trial'' button to confirm the selection and complete the trial. In contrast, participants in the MTS conditions were presented with the contextual cue on the top level, the sample on the middle level and

the comparisons on the lower level. Participants made a single response to both select the comparison and complete the trial. In the RCP conditions, participants placed the selected comparison stimulus on the same level as the contextual cue and sample, and away from the rejected comparison stimuli, thereby potentially enhancing the discriminative control by elements of a particular relation. Furthermore, this relation was then evaluated, in those conditions that adopted it, by the confirmatory response required to finish the trial, which is a similar requirement to that used in the REP (Hayes & Barnes, 1997). This discriminative control was still exerted, although to a lesser extent, in the RCP conditions without the confirmatory response requirement, which may partially explain the reduced yield seen in those conditions. In contrast, the MTS conditions without the confirmatory response resulted in a top-down arrangement of contextual cue, sample, and comparisons, and may have facilitated control by one comparison (the S+) as the trial was immediately terminated following picking this comparison. The likely facilitative effect of the confirmatory response in the MTS procedure may have arisen, at least in part, by it overcoming the diminished discriminative control exerted by the top-down presentation format. Of course, these explanations must remain speculative until further empirical research has been conducted.

The drag-and-drop response requirement of the RCP may have exerted greater stimulus control over participants' responding than that permitted by the MTS procedure. The additional response effort involved in selecting, dragging and dropping a comparison into position clearly sets the two procedures apart, and this undoubtedly contributed, in some undefined way, to the observed differences. However, further research is needed to develop a comparable response requirement with the MTS procedure and to determine its possible facilitative effects, if any. Although no previous MTS study has, to our knowledge, employed a drag-and-drop response requirement, a study by Lipkens and Hayes (2009) taught typically developing adults, in the presence of a sample stimulus and a contextual cue, to produce the correct comparison stimulus by typing letters on a computer keyboard. Lipkens and Hayes also employed selection-based measures in their study on same, opposite, different, and comparative relations, and thus the relative efficacy of producing versus selecting multiple stimulus relations remains to be determined (Polson, Grabavac, & Parsons, 1997; Polson & Parsons, 2000). This distinction between selection-based and response-based measures may be relevant, as the present drag-and-drop requirement more closely resembles the latter. Future studies should consider adapting the RCP to investigate producing relations by, for instance, removing the drag and drop requirement and replacing the trigram comparison stimuli with individual characters (e.g., Stromer et al., 1996).

The findings clearly identified the confirmatory response requirement as perhaps the critical component of both tasks. A possible reason for this improvement may be because the relation on the screen is likely to be evaluated in a similar manner to the REP (e.g., Stewart et al., 2004). The REP allows subjects to evaluate, or report on, the stimulus relation or relations that are presented on a given trial. For example, in the REP, a subject may be presented with a contextual cue for opposite and two arbitrary stimuli that are specified within that trial as participating in an opposite relation. The subject is then required to choose between two arbitrary shapes for which the response functions of TRUE and FALSE were previously established. Thus, the 'Finish Trial' and 'Start Again' confirmatory responses may have functioned in a similar manner to the 'True' and 'False' functions of the REP. That is, in the RCP, participants first complete the relation and then evaluate it, while in the MTS, participants select the relation and then evaluate it. Clicking 'Finish Trial', then, both evaluates and confirms their selections. Clicking 'Start Again' returns the stimuli to their original positions and may have functioned as a form of correction procedure (Stromer et al., 1996). The confirmatory response requirement also had a more pronounced effect in Conditions 5 to 8 than in Conditions 1 to 4. The presentation of five comparison stimuli in Conditions 5 to 8 may have resulted in additional sources of stimulus control emerging during the arbitrary relational training phase (i.e., responding according to orthographic or phonographic features). During this phase, the addition of the confirmatory

response presented participants with the opportunity to evaluate the sample, contextual cue, and comparison together: This may have facilitated the simultaneous discrimination of the selected comparison from the unselected comparisons. Taken together, these evaluative and correction functions of the confirmatory response requirement may have exerted powerful control over responding in both procedures.

A final, noteworthy aspect of the RCP is that the stimuli were presented sequentially from left to right, whereas stimuli in the MTS were presented from top to bottom. As mentioned in the Introduction, the left-to-right (LTR) sequential presentation of stimuli, combined with the drag-and-drop response requirement of the RCP, may have mimicked the verbal, relational processes involved in reading and completing sentences written in LTR languages, like English. One possible way to empirically test this notion would be to compare performance of right-to-left (RTL) presentation with LTR presentation. An additional test could employ participants who either read in RTL (e.g., Arabic) or from LTR languages. Superior performance when the stimulus presentation order overlaps with a participant's reading history would strongly suggest that presentation order is an important variable. Indeed, part of our objective in developing the RCP was to create a procedure that could be adapted to investigate a broad array of complex behavior, such as the derived relational processes seen in syntax or semantics. Research in domains outside of behavior analysis, such as cognitive neuroscience, often employs sentence-completion tasks that bear a close formal resemblance to the RCP (see Federmeier & Kutas, 1999; Kutas & Federmeier, 2000). Behavioral (i.e., accuracy and latency) and electrophysiological measures (e.g., event related potentials) reveal differences when participants are presented with sentence-completion tasks that conflict with their relational history (e.g., a sentence with an unexpected, low-frequency terminal clause). An important objective for future research, therefore, will be the development and further refinement of procedures such as the RCP to investigate the neural correlates of derived relational responding in a manner that might contribute to a synthesis of research from different domains (e.g., Hinton, Dymond, von Hecker, & Evans, 2010; Yorio et al., 2008).

In Conditions 5 to 8, the same eight arbitrary relational tasks as Conditions 1 to 4 were employed but with five comparisons presented on every trial. To achieve this, two additional incorrect comparisons were included on all nonarbitrary and arbitrary trials. There were several reasons why this was justified. First, employing five comparisons provided more exemplars of the particular dimension along which the comparison stimuli are related. This may have facilitated the acquisition of nonarbitrary and arbitrary relational responding in accordance with Same and Opposite. Second, presenting a greater number of incorrect comparisons during nonarbitrary relational training may have facilitated contextual control in accordance with Opposite and not Different relations. In a protocol with only three comparisons, one of the comparisons will always be the same as the sample stimulus and the other two stimuli will differ along some specified physical dimension (see Table 2). In the presence of the contextual cue for OPPOSITE, reinforcement is contingent on selecting the stimulus furthest along that particular dimension. However, it is possible that, at least initially, the comparison may be selected due to S- control in the presence of the OPPOSITE contextual cue, and thus the participant may choose between the two stimuli that are not the same as the sample stimulus (i.e., responding is controlled by a relation of difference rather than opposition). The inclusion of two additional comparisons prevents this type of control from emerging (see Dymond & Barnes, 1995, pp. 177–178, and Dymond et al., 2007, p. 257, for detailed discussion). Finally, presenting a greater number of comparisons ultimately allows for future research with either procedure to train and test a larger relational network. This may have important basic and applied implications for developing increasingly more complex analyses of derived relational responding that necessitate greater numbers of contextually controlled relations (see Rehfeldt & Barnes-Holmes, 2009).

As indicated in the Introduction, relational frame theory places considerable emphasis on multiple stimulus relations and has developed a nomenclature with which to describe and study these patterns of relational responding. Other theoretical accounts of derived relational responding have largely remained silent on

the topic of multiple stimulus relations, with one notable exception. Sidman (1994) stated that, ''the fact that a stimulus pair can be brought via contextual control into such differing relations as same, opposite, different, and so forth, can be handled by any formulation of equivalence that recognizes the role of context'' (p. 561). However, by defining relations between stimulus pairs in terms of contextually controlled equivalence classes, Sidman's previously accepted mathematical definition of equivalence in terms of reflexivity, symmetry, and transitivity becomes untenable. That is, reflexivity, symmetry, and transitivity fail to explain patterns of emergent relational responding seen with contextually controlled multiple stimulus relations. For instance, a relation of ''X is bigger than Y'' is not symmetrical: Y must be smaller, not bigger, than X. Similarly, if A is opposite to B and B is opposite to C, then A and C are the same, not opposite. In these examples, neither symmetry nor transitivity can be said to be present since the trained and derived relations differ. Reflexivity, symmetry and transitivity can, then, only account for emergent relations that are the same as the trained relations (i.e., equivalence relations). By adopting Sidman's (1994) account of multiple stimulus relations as forms of contextually controlled equivalence relations, we are thus left without a working definition of equivalence itself (Barnes-Holmes et al., 2001; Hayes & Barnes, 1997). In addition, Sidman (2008) appears to have acknowledged this crucial limitation by explicitly referring to his account as ''a *limited* theory in that it does not cover other kinds of relations than equivalence, as for example, relational frame theory attempts to do'' (p. 331, emphasis in original).

It has been argued that the response of picking a comparison in the presence of a sample when MTS is used explicitly encourages analyses based on the concept of stimulus class (Barnes-Holmes et al., 2001; Hayes & Barnes, 1997; Lipkens & Hayes, 2009). Research has consistently shown that the concept of stimulus class, and the MTS procedures most often used to study it, are limited in explaining derived relations other than equivalence and the patterns of transformation of functions that occur with such multiple stimulus relations as same, opposite, more-than and less-than (Barnes-Holmes et al., 2001; Dymond & Rehfeldt, 2000). The methodological emphasis on MTS, the theoretical status of the class concept, and the lack of empirical and conceptual clarity that results from retaining an equivalence-based definition of complex derived relational responding may have impeded research on multiple stimulus relations. Although the present findings reveal a potential advantage for the RCP over MTS, the MTS protocol has played, and will continue to play, an important role in research on derived relational responding. Indeed, some authors have proposed theories of stimulus control that emphasize the methodological characteristics of MTS as being critical to the subsequent emergence of equivalence relations (McIlvane, Serna, Dube, & Stromer, 2000). Whether or not such accounts can be readily extended to multiple stimulus relations, such as Same and Opposite, and readily account for the performances seen in the current experiment, remains to be seen.

In conclusion, the present findings indicate that the RCP has potential as a novel procedure for the generation of multiple, derived stimulus relations. In principle, in much the same way as other variants of MTS, the RCP could be adapted for use with any derived stimulus relation, such as equivalence or comparative (more than/less than) relations. Furthermore, the RCP can potentially be used to train and test several relations at the same time because participants may be trained to construct the relation onscreen. For example, consider the relation: A same as B, B opposite to C. In the RCP, a participant could be presented (from left to right) with a sample, a SAME contextual cue, an empty box, an OPPOSITE contextual cue, and another empty box. A participant could complete the relations by dragging the B stimulus to the right of the SAME cue and by dragging the C stimulus to the right of the OPPOSITE cue. Undertaking further research such as this with a larger sample of participants, including those who are less verbally sophisticated than those in the present study (i.e., young children or individuals with developmental disabilities), is an important objective for future research.

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