Relational Responding: Testing, Training, and Sequencing Effects among Children with Autism and Typically-developing Children

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Abstract

Relational Frame Theory (RFT) proposes that derived relational responding is crucial to the development of verbal behavior. According to RFT, typically-developing children acquire the ability to derive relations through natural language interactions. In contrast, children with autism often do not acquire these skills as readily and require interventions to target their development. Limited research has examined the optimal training context for establishing the core relational skills, such as the sequence in which the relations might be optimally trained. The current research comprised three studies to investigate the emergence of specific relational responding repertoires in typically-developing children and children with autism. The results demonstrate that the typically-developing children had a fluent repertoire of these relational skills, while those with autism demonstrated significant deficits. The results shed some light on the possible role of training sequence.

Keywords: typically-developing children, autism spectrum disorder, relational frame theory, derived relational responding, training sequence

Relational Responding: Testing, Training, and Sequencing Effects among Children with Autism and Typically-developing Children

Relational Frame Theory (RFT) centres fundamentally around the concept of derived relational responding and its role in all aspects of language and cognition. The approach draws mainly on the concept of *arbitrarily applicable relational responding* (AARRing, also known as relational framing; see Barnes, 1994), which is offered as the basis for linguistic generativity and verbal behavior more broadly (Barnes-Holmes, McHugh, & Barnes Holmes, 2004). For RFT, early verbal exchanges provide the essential learning context for the complex verbal repertoires that emerge subsequently, and RFT points primarily to word-object interactions in this regard. For example, in naturalistic settings many exemplars of naming behavior are directly reinforced and appear to give rise to subsequent emergent performances.

Consider a simple example involving a child interacting with a ball. In establishing the word-object relation (“ball”-ball), a parent may ask a child "Where's the ball?" and the child will point to the ball, followed by parental praise. The object-word relation with the ball would be established similarly. The parent would hold up the ball and ask "What's this?", to which the child would say "ball", followed by praise. In the context of the ball, therefore, both word-object and object-word relations have been directly trained. Now consider how this learning might generalize to interactions with a toy car. In establishing the word-object relation, the parent may ask "Where's the car?" and the child will point to the car, followed by praise. If the parent now holds up the car and asks "What's this?", the child will likely say "car", *even without a history of reinforcement for doing so.* According to RFT, this is a derived mutually entailed word-object coordination relation that emerges from the direct

learning history of both word-object and object-word relations with the ball, the trained word-object relation with the car, and so on. In short, the behavior is novel, but based on a history of direct training with other stimuli and relations.

The Educational Significance of Relational Responding

Given the substantive body of evidence supporting the core concepts of RFT (e.g., Barnes & Keenan, 1993; Barnes-Holmes, Barnes-Holmes, Smeets, Cullinan & Leader, 2004; Hayes, Barnes-Holmes, & Roche, 2001), and growing evidence of the theory's applied utility in establishing verbal behavior (e.g., Barnes-Holmes, Barnes-Holmes, Smeets, Strand, & Friman, 2004; Berens & Hayes, 2007; Dunne, Foody, Barnes-Holmes, Barnes-Holmes, & Murphy 2014; O'Connor, Rafferty, Barnes-Holmes, & Barnes-Holmes, 2009), calls have been made to incorporate RFT-based protocols into traditional Early Intensive Behavioral Intervention (EIBI) programs, especially for children with autism (e.g., Lerman et al., 2005; Luciano et al., 2009; Moore, 2009; Rehfeldt, 2011). RFT proposes that derived relational responding is the root of complex verbal ability and the basis of much generalized behavior - skills often deficient in children with autism. Thus, Barnes-Holmes, Barnes-Holmes, Roche, and Smeets (2001) recommended that the core relational frames should be targeted directly and trained to high levels of flexibility, as part of remedial training of verbal behavior.

The Training Context for Establishing Relational Repertoires

There is some evidence to support the efficacy of incorporating relational training into early intervention for children with developmental disabilities (e.g., Murphy & Barnes-Holmes 2006; Murphy & Barnes-Holmes, 2009; Rosales & Rehfeldt, 2007). For example, Murphy, Barnes-Holmes, and Barnes-Holmes (2005) developed procedures for establishing generative manding in children with autism and adults with learning impairments. The results showed that seven participants with autism successfully

demonstrated derived manding - in the first clear demonstration of a derived or generative form of one of Skinner's (1957) verbal operants with this population.

In spite of a growing body of supporting evidence, many details of relational training regimes remain to be investigated. For example, there is little empirical evidence to suggest the putative role of the sequence in which the frames are established. A sequence along the lines of coordination, distinction, opposition, comparison, and finally hierarchical relations would make developmental sense. Specifically, coordination relations appear to emerge first because they form the basis of the other relations (Luciano, Gomez Becerra & Rodriguez, 2007). Distinction relations may emerge thereafter because these form the basis of opposition and comparison relations. For example, one must discriminate that two stimuli are different in order to discriminate that they are opposite. It would seem logical to assume that opposition relations emerge before comparison relations, because opposition relations appear more similar in nature to distinction relations than comparison relations. Furthermore, opposition relations would appear to be less complex than comparison relations. In developing a training sequence for relational responding, Rehfeldt and Barnes-Holmes suggested that the establishment of each relational frame potentially renders the next easier to acquire, because all relational frames share the same properties of generalized operant behavior (Hayes, Fox et al., 2001).

In one of the few relevant studies, Cassidy, Roche, and Hayes (2011) used multiple exemplar training to establish coordination, opposition, and comparison relations (see also Cassidy, 2008). In Study 1, four typically-developing children, between the ages of 8 and 12 years old, were presented with a training sequence that targeted coordination, opposition, and then comparison relations. Both an experimental and a control group were exposed to equivalence testing and training that comprised conditional discrimination training, and tests

for symmetry and transitivity. The experimental participants were exposed to four additional phases of multiple exemplar training for equivalence, coordination, opposition, and comparison relations. The results indicated statistically significant improvements on the WISC, relative to the control group. In Study 2, eight children with educational and behavioral difficulties were presented with an alternate training sequence utilizing multiple exemplar training involving coordination, *comparison, and then opposite* relations. Again, most of the participants showed significant improvements on the WISC.

In a more recent study, Dunne et al. (2014) sought to establish various repertoires of relational responding in children with autism who showed significant deficits in these skills. The researchers began by testing and training the targeted relational frame in non-arbitrary form before proceeding to testing and training the arbitrary form. In Study 1, all nine children with autism successfully acquired coordination relations, although the amount of training required varied from 320 to 875 training trials. Interestingly, higher scores on the VB-MAPP were related to less training. In Study 2, four of the same children successfully acquired opposition relations, but again the amount of training required varied from 10 to 340 training trials. Again, higher VB-MAPP scores were related to less training. In Study 3, two of the same children successfully acquired distinction relations, but again the amount of training required varied with one participant passing all stages with no training and the other requiring 240 training trials. Finally in Study 4, the same two children successfully acquired comparison relations, but again the amount of training varied from 168 to 600 training trials.

The training sequence implemented for participants involved establishing coordination, opposition, distinction, and comparison relations in that order, at least for two of the children with autism. The researchers and the data suggested that for some children, but clearly not for all, training of the initial relations may have facilitated the acquisition of

relations trained subsequently. Taken together, the two sets of studies above highlight training sequences through which coordination, distinction, opposition, and comparison relations can be successfully established/facilitated in typically-developing and some autistic children. However, there have been no studies in which this has been explored more directly.

The current research sought to assess and facilitate/establish relational responding in children with autism. We attempted to explore the relative benefits of manipulating the sequence of testing and training of the core repertoires of relational responding, and to loosely compare these skills between children with autism and typically-developing children. Specifically, Study 1 tested relational responding in five typically-developing children in the following sequence: coordination, distinction, comparison, and opposition relations. Study 2 replicated Study 1 with 11 children with autism and attempted to remediate the various relational responding deficits identified during the testing procedure. Study 3 replicated Study 2 with a further four children with autism, except the order of the opposition and comparison relations was altered during testing and training, in order to determine any impact this might have on learning outcomes.

Study 1 Method

Participants

Five children; three female and two male with an age range from 4 years and 1 month to 8 years and 9 months (mean age 6 years and 10 months), participated in Study 1. All were typically-developing and enrolled full-time in a mainstream school. Results of the Peabody Picture Vocabulary Test (PPVT) indicated that one participant (P3) was categorized as low average in receptive verbal ability (i.e., scoring 85-100), two participants (Ps 2 and 4) were categorized as high average (scoring 100-115), and two (Ps 1 and 5) were moderately high (scoring 115-140) at baseline. According to the Kaufman Brief Intelligence Test (K-BIT),

three participants (Ps 1, 3, and 5) were categorized as average in expressive verbal ability (scoring 90-109) and two (Ps 2 and 4) were above average (scoring 110-119) at baseline.

Setting

Each session was conducted in the same quiet classroom within each participant's educational setting. Each child participated individually, accompanied only by the researcher. During all trials, the researcher was seated beside the participant at a small table. Sessions were conducted once a week, with each participant receiving a total of 24 sessions. The maximum duration of a session was 20 minutes.

Materials

The materials employed in Study 1 comprised two printed standardized psychometric measures and a printed protocol for testing relational responding (see below).

Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997). The PPVT was used to assess *receptive* verbal ability. For instance, participants were shown a page of four pictures (e.g., a baby, a car, a fish, and candies) and asked "Put your finger on the picture that shows the baby". In scoring the PPVT, participant raw scores are calculated and converted into age-based standard scores. The minimum standard score is 20, the maximum is 160, and the mean is 100, with a standard deviation of 15. The PPVT provides descriptive categories based on standard scores: 20-70=extremely low; 70-85=moderately low; 85-100=low average; 100-115=high average; 115-140=moderately high; and 140-160=extremely high. The current research analyzed age-based standard scores.

Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 2004). The K-BIT was used to assess *expressive* verbal ability. For example, participants were shown a picture of a bed and asked "What is this?" Three possible outcomes are generated by scoring the K-BIT: a verbal composite based on the total score of the vocabulary subtest; a nonverbal

composite based on the matrices subtest; and an IQ composite (based on a summary of the two subtest composites). The minimum IQ composite score is 40, the maximum is 160, and the mean is 100, with a standard deviation of 15. The KBIT provides the following descriptive categories for the range of IQ composite scores: <69=below the lower extreme; 70-79=well below average; 80-89=below average; 90-109=average; and 110-119=above average. The current research analyzed IQ composite scores.

Relational responding test protocol. The sequence of testing relational responding followed in the current study is similar to that reported by Dunne et al. (2014). In short, this sequence targeted four relational frames, each presented as both non-arbitrary and thereafter arbitrary trials in the following order: coordination; distinction, comparison, and opposition relations.

Programmed Consequences

All K-BIT, PPVT, and relational responding trials were first presented as a test and there were no programmed consequences for correct or incorrect responding. A correct response in each of these required the participant to emit the appropriate nonverbal or verbal response within 5 seconds of the instruction. Hence, an incorrect response was one that did not correspond to the correct answer or that occurred after a delay of 5 seconds. Although these were test trials, specific contingencies were in place for various forms of on-task behavior and these delivered either verbal praise (e.g., “Nice listening” or “You’re doing really good work”). If participants failed one of the tests for a target relational frame, it was intended that they would then be presented with the same trials in a training format, during which positive reinforcement in the form of tangibles and corrective feedback would be provided on each trial. A range of items had been identified as tangible reinforcement (e.g., access to an iPad, toys, stickers). *However, it is worth noting at this point that none of the five*

children who participated in Study 1 failed any of the relational tests presented, hence explicit training of the target relations was not required at any point.

Procedure

The current study comprised five stages, some with a number of phases (see below). These included administration of the PPVT and K-BIT in Stage 1. Stages 2-5 involved the relational responding test protocol presented as coordination, distinction, comparison, and opposition relations (in that order). All of the target relational performances were first tested as non-arbitrary relations followed by arbitrary relations, before proceeding to the next relational frame.

Stage 1: Baseline of standardized measures of verbal ability. All participants were administered the PPVT first followed by the K-BIT, as measures of their baseline receptive and expressive verbal abilities, respectively.

Stage 2: Coordination relations. There were two phases in the testing of coordination relations. Phase 1 targeted non-arbitrary coordination relations, while Phase 2 targeted arbitrary relations. A series of 2x4 inch laminated color cards and a similar series of picture cards were employed. For non-arbitrary relations, there was a total of 28 color cards: two duplicates of 14 different colors (e.g., Set 1: blue and red, Set 2: yellow and green, etc.); as well as 60 picture cards: three duplicates of 20 different cards that presented a picture of a common item (e.g., a tractor, a car, a dog, a cat, a house, etc.). For arbitrary relations, the same 60 picture cards were employed (excluding any used previously).

Phase 1: Non-arbitrary coordination relations. There were 6 subphases to the assessment/establishment of non-arbitrary coordination relations, three involving colored cards and three thereafter involving picture cards. This extensive experimental sequence was designed to include training where weak test performances were observed and to thereafter

provide adequate testing of the derived relations on novel stimuli that had not been involved in training. However, as noted above, explicit training was never required.

The first phase began with a 20-trial test using only one (colored) stimulus set. The pass criterion was always 80% correct (unless specified otherwise). All trials involved a blue or red colored card as the sample and two comparison stimuli that were also blue and red, one of which was identical to the sample. Ten trials presented the blue sample, while 10 presented the red sample. On each trial, the researcher said "Match same" and participants were required to place the sample on top of the correct (same) comparison (e.g., blue-blue). A correct (identity matching) response required a stimulus match. The designated comparison and its location on the left or right were always randomized.

A second non-arbitrary coordination test followed with a novel color set -- a yellow or green card as sample and two comparisons that were also yellow and green. Ten trials presented the yellow sample, 10 trials presented the green. This ascertained whether the non-arbitrary coordination relations could be derived on a novel set. The third test was a generalization test involving *multiple* novel color sets to ascertain generalization of the relational performances across stimuli. A new color set was presented on each trial.

The three subphases above (training stimulus set, novel set, then multiple novel sets) were then repeated, but picture sets were now employed to ascertain whether the relations could be derived on a more complex stimulus set than basic colors. That is, the fourth test involved a single picture set -- a tractor or a house as sample and two comparisons that were also tractor and house. Again, 10 trials presented the tractor as sample, and 10 presented the house. The fifth test followed with a car or dog card as samples and comparisons to ascertain whether the relations could be derived on a novel picture set. The sixth subphase comprised a

generalization test involving *multiple* novel picture sets to ascertain generalization of the relational performances across sets. Each test trial presented a new picture set.

Phase 2: Arbitrary coordination relations. Arbitrary coordination trials always involved four identical picture cards (e.g., four pictures of a bus). These were laid out initially as one sample above and *two* comparisons below. The researcher pointed to one of the comparisons and said "This one is the same". She then handed the sample to the participant and instructed: “Match with same”, which required the participant to place the sample on top of the comparison that had been designated as “same”. The first arbitrary coordination test involved 20 trials, with the same set (i.e., three pictures of a bus). A second test followed with a novel picture set (i.e., three pictures of a tree) to ascertain whether these relations could be derived on a novel picture set. The third test was a generalization test with *multiple* novel picture stimulus sets to ascertain generalization of the relational performances across sets.

Stage 3: Distinction relations. There were four phases in Stage 3 that included testing distinction relations and combining distinction relations with the coordination relations test from Stage 2. Specifically, Phase 1 targeted non-arbitrary distinction relations; Phase 2 targeted arbitrary distinction relations; Phase 3 targeted non-arbitrary mixed coordination and distinction relations; and Phase 4 targeted arbitrary mixed coordination and distinction relations.

Phase 1: Non-arbitrary distinction relations. There were 6 subphases to the assessment of these relations, three involving colored cards and three thereafter involving picture cards. This phase began with a 20-trial test using only one (colored) stimulus set. All trials involved two non-identical color cards (one red, the other blue) presented as comparisons and a sample that was either red or blue. Each participant was instructed to

"Match different" and required to place the sample on top of the correct (different) comparison. Ten trials presented the blue sample, 10 presented the red.

A second test followed with a novel color set (yellow and green) to ascertain whether the non-arbitrary distinction relations could be derived on a novel color set. The third test was a generalization test with *multiple* novel color stimulus sets to ascertain generalization of the relational performances across sets.

The three subphases above (training stimulus set, novel set, then multiple novel sets) were then repeated, but picture sets were now employed to ascertain whether the relations could be derived on a more complex stimulus set than basic colors. That is, the fourth test involved a single picture set -- a tractor or a house as sample and two comparisons that were also tractor and house. Again, 10 trials presented the tractor as sample, and 10 presented the house. A fifth test followed with a car or dog card as samples and comparisons to ascertain whether the relations could be derived on a novel picture set. The sixth subphase comprised a generalization test involving *multiple* novel picture sets to ascertain generalization of the relational performances across sets.

Phase 2: Arbitrary distinction relations. There were three arbitrary distinction tests. The first presented three identical pictures of a house, as one sample and two as comparisons. On each trial, the researcher pointed to one comparison and said "This one is different". She then handed the sample to participants and instructed "Match different" and participants were required to place the sample on top of the correct ('different') comparison. A second test followed with a novel picture set (i.e., three pictures of a tree) to ascertain whether these relations could be derived on a novel picture set. The third test was a generalization test with *multiple* novel picture stimulus sets to ascertain generalization of the relational performances across sets.

Phase 3: Non-arbitrary mixed coordination and distinction relations. Phase 3 involved an amalgamation of the non-arbitrary coordination and distinction trials from Stages 2 and 3 across six tests. The first 20-trial test presented a randomized series of 10 non-arbitrary coordination trials (matching blue with blue and red with red) and 10 distinction trials (matching blue with red and red with blue). The pass criterion was 80% correct with no more than 2 errors on the same relation. The second test involved a novel color set, with the third generalization test presenting a novel color set on each trial. The fourth test presented a randomized series of 10 non-arbitrary coordination trials and 10 distinction trials using a picture set, followed by a fifth test with a novel picture set, and a sixth test with a novel picture set presented on each trial.

Phase 4: Arbitrary mixed coordination and distinction relations. Phase 4 involved a single 12-trial test of arbitrary coordination, distinction, and mixed coordination/distinction relations. It is important to note that *each trial contained all three of these elements.* To test arbitrary coordination relations, each participant was presented with a sample (e.g., picture of a dog) and two identical comparisons (e.g., two identical pictures of a dog). Pointing to one comparison, the researcher said “This one is the same”. Pointing to the other comparison, the researcher then said “ And this one is different”, followed by the request to “Match same”.

The second element of the trial targeted arbitrary distinction relations. Using the same stimulus arrangements, the researcher pointed to one comparison and said “This one is the same”. She then pointed to the other comparison, said “And this one is different”, and asked “Match different”.

The third element of the trial targeted mixed relations. The researcher pointed to one comparison and said "This one is the same", she then pointed to the other comparison and

said “This one is different", and then asked "Are they the same or different?" The pass criterion was 11/12 correct responses.

Stage 4: Comparison relations. Again, there were two phases in the testing of comparison relations -- Phase 1 for non-arbitrary relations and Phase 2 for arbitrary relations. A series of 2x4 inch laminated cards was employed for this. For non-arbitrary relations, there was a total of 6 cards that comprised two stimulus sets (i.e., three cards depicting brass coins; one with one coin, one with two coins, and one with three coins, as well as three cards depicting silver coins; again, one with one coin, one with two coins, and one with three coins). For experimental purposes, alphanumeric labels were used to refer to the coin cards. Specifically, for non-arbitrary trials, the one-coin cards were always denoted as the A stimuli, the two-coin cards as B, and the three-coin cards as C. For arbitrary relations, there were two sets of three identical cards (i.e., each depicting one brass/silver coin) denoted as A, B, and C.

Phase 1: Non-arbitrary comparison relations. There were two tests (36 trials per test) of non-arbitrary comparison relations. These trials always involved six different trial-types denoted for experimental purposes using alphanumeric labels as follows: A<B<C; A<C>B; B>A>C; B<C>A; C>A<B; C>B>A. Each trial-type contained six elements. Four of these were mutual entailment trials that targeted the relations between two stimuli (i.e., A-B; B-C; C-B; and B-A). The remaining two trials targeted combinatorial entailment in which relations among the three A, B, and C stimuli were assessed (i.e., A-C, C-A). This generated a total of 36 test trials; 24 mutual entailment and 12 combinatorial entailment.

Non-arbitrary comparison trials involved the presentation of three non-identical cards of brass coins (i.e., A-B-C). On the first mutual entailment trial, the participant was instructed, for example, that A was less than B and B was less than C (i.e., A<B<C). Pointing to B, the researcher then asked “Is this more or less than this (pointing to A)?” Responding

"More", for example, was recorded as correct. The second mutual entailment trial involved the researcher pointing to C and asking "Is this more or less than this (pointing to B)?" In the mutual entailment trials, we included the broader question, for example "Is this (B) more or less than this (A)?" rather than simply asking "Is this (A) less than this (B)?" which would have involved repeating part of the initial instruction "A is less than B and B is less than C". Hence, when B was pointed to, the target mutually entailed relation is actually B>A (rather than A<B), but the derivations among the three stimuli are ultimately the same. This broader question circumvented repetitions and ruled out other possible sources of control.

In the following combinatorial entailment trial, the researcher pointed to C, for example, and asked "Is this more or less than this (pointing to A)?" On the third mutual entailment trial, the participant was then instructed that C was more than B and B was more than A (as the researcher pointed to C first). Then, pointing to B, the researcher asked "Is this more or less than this (pointing to C)?" The fourth mutual entailment trial involved the researcher pointing to A and asking "Is this more or less than this (pointing to B)?" In the second combinatorial entailment trial, the researcher pointed to A, for example, and asked "Is this more or less than this (pointing to C)?" In short, non-arbitrary comparison test trials involved testing each of the six trial-types (each with four mutual entailment trials and two combinatorial entailment trials) with the researcher pointing from left to right during the first three trials and then pointing from right to left for the remaining three trials for each of the six trial-types. The test sequence was then repeated with a novel picture set of silver coins.

Phase 2: Arbitrary comparison relations. There were two tests (24 trials per test) of arbitrary comparison relations. Testing arbitrary comparison relations involved three *identical* cards of brass coins. The test of arbitrary comparison trials comprised four trial-types as follows: A<B<C; A>B>C; C<B<A, and C>B>A. Again there were six trials per trial-type;

four mutual entailment trials, and two combinatorial entailment trials. This generated a total of 24 test trials; 16 mutually entailed relations and 8 combinatorially entailed relations. Across all arbitrary trials, the stimuli targeted were randomized to ensure the participants were not responding based on spatial position.

On the first mutual entailment trial, the participant was instructed, for example, that A was less than B and B was less than C (i.e., A<B<C). Pointing to both A and B, the researcher then asked "Which of these is more?" The second mutual entailment trial involved the researcher pointing to both B and C, for example, and asking "Which of these is more?" In the first combinatorial entailment trial, the researcher pointed to both A and C and asked "Which of these is more?" On the third mutual entailment trial, the researcher pointed to both A and B, and asked "Which of these is less?" The fourth mutual entailment trial involved the researcher pointing to both B and C, for example, and asking "Which of these is less?" In the second combinatorial entailment trial, the researcher pointed to both A and C and asked "Which of these is less?" Participants who passed the first test were retested on a novel picture set of silver coins. It is important to note that the spatial locations of the stimuli were always fixed in a manner that was consistent with the trial-type. For example, if the trial-type was A<B<C, A was on the left, B in the center, and C on the right. However, to ensure that correct responding was not influenced by stimulus location, no reference was made to location. The research simply pointed to the two target stimuli and asked, for which is more or less.

Stage 5: Opposition relations. There were two phases in the testing of opposition relations -- Phase 1 for non-arbitrary relations and Phase 2 for arbitrary relations. A series of 2x4 inch laminated cards were employed. For non-arbitrary relations, there was a total of 8 different cards that comprised two stimulus sets (i.e., four cards depicted footballs; two with a

small football and two with a big football, while four cards depicted brass coins; two with one coin and two with three coins). For experimental purposes, alphanumeric labels were used to refer to the cards. Specifically, for non-arbitrary trials, the two identical cards were always denoted as A and C, while the non-identical card was always denoted as B. For arbitrary relations, there were two sets of three identical cards (i.e., all depicted a big football or three brass coins) denoted as A, B, and C.

Phase 1: Non-arbitrary opposition relations. There were two tests (12 trials per test) of non-arbitrary opposition relations. Testing these relations involved four trial-types denoted as follows: A opposite B opposite C (with the researcher pointing from left to right); A opposite B opposite C (right to left); C opposite B opposite A (left to right); and C opposite B opposite A (right to left). Again, each trial-type contained three elements, two mutual entailment trials and one combinatorial entailment trial. This generated a total of 12 test trials; 8 mutual entailment and 4 combinatorial entailment trials, with an accuracy criterion of 80%.

Non-arbitrary opposition relations involved two non-identical cards (e.g., one with a small football and the other with a big football; denoted as A and B, respectively) presented as comparisons, with a third sample C that was always identical to comparison A. On the first mutual entailment trial, the participant was instructed, for example, that A was big and that it was opposite to B, and that B was opposite to C (i.e., A opposite B opposite C). Pointing to B, the researcher then asked “Is this big or small?” “Small” was recorded as correct. The second mutual entailment trial involved the researcher pointing to C and asking “Is this big or small?” The combinatorial entailment trial involved the researcher pointing to C and asking “Is this the opposite of this (pointing to A)?” “No” was a correct response. This three-step

procedure was repeated for each of the four trial-types. The full tests sequence was then repeated with a novel picture set of identical brass coin pictures.

Phase 2: Arbitrary opposition relations. There were two tests (12 trials per test) of arbitrary opposition relations. These trials involved the presentation of three *identical* cards of big footballs (A, B, and C). Testing involved four trial-types denoted as follows: A opposite B opposite C left to right; A opposite B opposite C right to left; B opposite A opposite C left to right; and B opposite A opposite C right to left. Again, each trial-type contained three elements, two mutual entailment trials and one combinatorial entailment trial. This generated a total of 12 test trials; 8 mutual entailment and 4 combinatorial entailment trials. Across all arbitrary trials, the designated stimuli were randomized to ensure that the participants were not responding based on spatial position.

The first mutual entailment trial involved the participant being instructed, for example, that A was big and then being asked to imagine that it was opposite to B, and that B was opposite to C (i.e., A opposite B opposite C). Pointing to B, the researcher then asked "Is this big or small?" The second mutual entailment trial involved the researcher pointing to C and asking "Is this big or small?" In the combinatorial entailment trial, the researcher pointed to C and asked "Is this the opposite of this (pointing to A)?" The full test sequence was then repeated with a novel picture set of identical brass coins.

Results and Discussion

The primary aim of Study 1 was to examine the emergence of the target patterns of relational responding for the five typically-developing children. All participants passed all stages of testing on the first exposure, see Table 1, suggesting that these skills were already in each participant's repertoire. These performances provide support for RFT's suggestion that responding in accordance with arbitrary coordination, distinction, opposition, and comparison

relations is established in typically-developing children between the ages of four and eight years old (Luciano, et al., 2009).

INSERT TABLE 1 HERE

These results also raise the question of how children with lower levels of verbal ability would perform on the same tests? Study 2 addressed this question by involving children with impairments in verbal ability relative to the sample in Study 1.

Study 2

Method

Participants, Setting, and Materials

A total of 11 children, all males, participated in Study 2. Their ages ranged between 4 years, 2 months and 13 years, 6 months (mean age 8 years and 10 months). All had been independently diagnosed with autism and attended full-time at a special needs school. All aspects of the setting and materials were identical to Study 1.

Procedure

All aspects of the experimental sequence were identical to Study 1, except that all participants were provided with explicit training on any relational tests which they failed to pass. This training was conducted on each relational frame prior to testing the next frame. Across all relations, training trials were identical to test trials, except that corrective feedback was delivered contingently upon responding. That is, correct responding was followed by reinforcement, while incorrect responding was not reinforced. Where a participant was not successful in learning from this contingency, additional prompting was used according to the principle of least to most guidance. Training blocks consisted of the same number of trials as test blocks. Each block of training trials was followed by a test. If participants passed this test, they proceeded to the next stage of testing. If they did not pass, they returned to training

until they passed this set of test trials. Across all training and testing, the same materials were employed.

Results and Discussion

The primary aim of Study 2 was to examine competencies on the target relational repertoires in participants with verbal abilities lower than typically-developing counterparts. The results showed considerable variation across participants in competencies on the target relations and the various levels of training required. Table 2 presents the results of each participant's performances on both non-arbitrary and arbitrary trials of the four types of relations targeted. Please note that the second figure presented for any test is the number of training trials required before passing a second exposure to the test.

INSERT TABLE 2 HERE

Participant 1. P1 scored as moderately low (81) on the PPVT and average (101) on the K-BIT. He demonstrated both types of coordination relations and distinction relations immediately, as well as passing the mixed tests. He failed for the first time on non-arbitrary comparison relations (53/72), with errors on both mutual and combinatorial entailment. He required 72 training trials, all on mutual entailment, to pass the full test. He subsequently passed the arbitrary comparison test without training. He also failed the non-arbitrary opposition test, again with errors on both mutual and combinatorial entailment (12/24). He required 24 training trials to pass, and then passed the arbitrary opposition test without training. Overall, this participant required minimal training (96 trials in total) only on non-arbitrary comparison and opposition relations which seemed to facilitate responding on arbitrary trials thereafter.

Participant 2. P2 scored as low average (89) on the PPVT and below average (83) on the K-BIT. He demonstrated both types of coordination relations and distinction relations

immediately. He also passed the non-arbitrary mixed tests, but scored 0 on the arbitrary mixed test, requiring 24 training trials to pass. He failed the non-arbitrary comparison test (43/72) and required 216 training trials to pass. He also failed the arbitrary comparison test (30/48), but required only 12 training trials to pass. He failed the non-arbitrary opposition test (11/24) with errors on combinatorial entailment and needed 24 training trials to pass. He then passed the arbitrary opposition test without training. Overall, P2 required more training (276 trials in total) than P1, on the arbitrary mixed, non-arbitrary comparison, arbitrary comparison, and non-arbitrary opposition relations.

Participant 3. P3 scored as low average (88) on the PPVT and average (96) on the K-BIT. He passed both types of coordination and distinction relations, as well as the non-arbitrary mixed test. He failed the arbitrary mixed test with 0 correct responses, but required only 12 training trials to pass. He failed the non-arbitrary comparison test (41/72) and passed only after 288 training trials, although he then passed the arbitrary comparison test immediately. He failed the non-arbitrary opposition test (14/24) and passed after 96 training trials. He also produced 0 correct responses on the arbitrary opposition test and required 48 training trials to pass. Overall, P3 required considerable training (444 trials in total) on mixed relations, non-arbitrary (288 trials in total) and arbitrary comparison, and non-arbitrary and arbitrary opposition relations.

Participant 4. P4 scored as low average (88) on the PPVT and below average (86) on the K-BIT. He immediately failed the non-arbitrary coordination test (100/120) and required 80 training trials to pass (i.e., 40 on first color set, and 40 again after the second color set was introduced). He passed the arbitrary coordination test immediately, but failed the non-arbitrary distinction test (60/120), and required 60 training trials to pass. He passed the arbitrary distinction test immediately, as well as the non-arbitrary mixed test. However, he

then scored 0 correct responses on the arbitrary mixed test, which he subsequently passed after only 12 training trials. He passed both types of comparison test immediately, but failed the non-arbitrary opposition test (12/24), and required 72 training trials to pass. He then passed the arbitrary opposition test. Overall, P4 required modest training (224 trials in total) on non-arbitrary coordination, non-arbitrary distinction, arbitrary mixed, and non-arbitrary and arbitrary opposition relations.

Participant 5. P5 scored as extremely low (40) on the PPVT and below the lower extreme (20) on the K-BIT. He failed the non-arbitrary coordination test (100/120), but passed all tests after 40 training trials on the first color set. However, the delivery of these trials was aversive to the participant, hence he proceeded immediately to the non-arbitrary distinction test (i.e., no test of arbitrary coordination was conducted), but failed (80/120), and required 60 training trials to pass. Again, given difficulties encountered in training, P5 was then exposed to the non-arbitrary mixed test and produced a poor performance (23/120). Participation was terminated after 640 training trials and little improvement. Overall, P5 required considerable training (740 trials in total) on non-arbitrary coordination, non-arbitrary distinction, and non-arbitrary mixed relations, but could not acquire adequate flexibility on non-arbitrary coordination and distinction relations to pass the mixed test or proceed beyond this point.

Participant 6. P6 scored as extremely low (40) on the PPVT and below the lower extreme (20) on the K-BIT. He passed the non-arbitrary coordination test immediately but encountered difficulties during its delivery. Hence, he proceeded immediately to the non-arbitrary distinction test (i.e. no test of arbitrary coordination relations was conducted). He failed this test (80/120) and required 780 training trials to pass (400 using color stimuli and 380 using picture stimuli). Given this level of required training, he proceeded

immediately to the non-arbitrary mixed test (i.e., there was no arbitrary distinction test) but failed (22/120). Participation was terminated after 1040 training trials and little improvement. Overall, P6 required very extensive training (1820 trials in total) on non-arbitrary coordination, non-arbitrary distinction, and these non-arbitrary relations mixed. However, there was not adequate flexibility on these relations to pass the mixed test nor to proceed to testing these relations in arbitrary form or beyond.

Participant 7. P7's score was indeterminable on the PPVT due to an extremely low level of responding and he also scored below the lower extreme (20) on the K-BIT. He passed the non-arbitrary coordination test immediately, but found the trials aversive. Hence, he proceeded directly to the non-arbitrary distinction test (no arbitrary coordination test was conducted), but failed (70/120), and eventually passed after 520 training trials (260 using color stimuli and 260 using picture stimuli). Given the level of training required, he proceeded immediately to the non-arbitrary mixed test (no test of arbitrary distinction was conducted), but produced 0 correct responses. Participation was terminated after 160 training trials and little improvement. Overall, P7 required considerable training (560 trials in total) on non-arbitrary coordination, non-arbitrary distinction, and the mixed test of these relations. However, there was not adequate flexibility on these relations to pass the mixed test nor to proceed to testing these relations in arbitrary form or beyond.

Participant 8. P8 scored as extremely low (40) on the PPVT and below the lower extreme (20) on the K-BIT. He passed the non-arbitrary coordination test, but found it aversive, hence proceeding directly to the non-arbitrary distinction test, which he failed (18/120). Participation was terminated after 880 training trials using color stimuli only and little improvement. Overall, P8 passed only non-arbitrary coordination relations, but could

not complete training on non-arbitrary distinction relations, in spite of extensive training, nor could he proceed beyond this point.

Participant 9. P9's score was indeterminable on the PPVT due to an extremely low level of responding and was below the lower extreme (20) on the K-BIT. However, he passed the non-arbitrary coordination test with some difficulties on delivery of trials and thus proceeded directly to the non-arbitrary distinction test, which he failed with a very weak performance (27/120). Participation was terminated after 260 training trials using color stimuli only and little improvement. Overall, P9 required modest training (260 trials in total) on non-arbitrary coordination and non-arbitrary distinction relations.

Participant 10. Participant 10's score was indeterminable on the PPVT due to an extremely low level of responding and was below the lower extreme (20) on the K-BIT. He passed the non-arbitrary coordination test on first exposure of both color and picture stimuli. However, he failed the non-arbitrary distinction test (46/120). Participation was terminated after 380 training trials using color stimuli only and little improvement. Overall, P10 required modest training (380 trials in total) on non-arbitrary coordination and non-arbitrary distinction relations, but could not complete training on the latter, hence he could not proceed to the remaining relations.

Participant 11. Participant 11's score was indeterminable on the PPVT due to an extremely low level of responding and was below the lower extreme (20) on the K-BIT. He passed the non-arbitrary coordination test immediately, but difficulties therein suggested the utility of proceeding directly to non-arbitrary distinction relations. He failed this test (82/120), but eventually passed after 240 training trials (mostly on the color stimuli). He was exposed directly to the non-arbitrary mixed test, but performed poorly (50/120) and required 840 training trials to pass. Given that he had now passed the non-arbitrary mixed test, he was

exposed to the arbitrary distinction test, and passed without training. He also passed the arbitrary mixed test without combinatorial entailment trials, but however, failed once these trials were tested (10/12) and the participant was asked “are these same/different?”. Overall, P11 required extensive training (1060 trials in total), mostly on the non-arbitrary mixed relations. There was some evidence that this facilitated responding on arbitrary distinction relations, yet he could not proceed beyond arbitrary distinction relations, in spite of extensive training.

Study 2 involved 11 children with autism. These individuals demonstrated different competencies in the various patterns of relational responding, and in some cases, but not others, these were remediated through explicit training. Four of the 11 participants (Ps1, 2, 3, and 4) completed the full test sequence, one (P11) reached arbitrary distinction relations, three (Ps 5, 6, and 7) reached non-arbitrary distinction, and three (Ps 8, 9, and 10) reached reached non-arbitrary coordination. There was some support for the suggestion that higher scores on the standardized measures was related to less training. Overall, the results provide some evidence for the use of an RFT-based intervention program, especially the utility of targeting non-arbitrary relations before arbitrary relations, to support the development of relational responding skills in children with autism.

One important issue raised by the findings from Study 2 concerns the potential impact of the *sequence* of the testing and training. In other words, if the order various relations was reversed, would similar patterns of responding be observed? This issue was addressed in Study 3.

Study 3 Method

Participants, Setting, and Materials

Four experimentally naïve children, all males, participated in Study 3. All were aged between 3 years, 4 months and 4 years, 2 months (mean age 4 years). All had been independently diagnosed with autism and attended full time at a special needs school.

Procedure

All aspects of the experimental sequence were identical to Study 2 with the exception of the sequence of testing and training being rearranged, such that opposition relations were now targeted before comparison relations.

Results

The primary aim of Study 3 was to examine the impact of a specific testing and training sequence on the relational responding performances of four participants with autism. The results showed considerable variation across participants in competencies on the target relations and the levels of training required. Table 3 presents the results of each participant's performances on non-arbitrary and arbitrary trials in each of the target relations.

INSERT TABLE 3 HERE

Participant 1. P1 scored as high average (104) on the PPVT and average (97) on the K-BIT. She immediately passed both types of coordination and distinction test, as well as the non-arbitrary mixed test, but surprisingly produced 0 on the arbitrary mixed test, although only 12 training trials were required. She also failed the non-arbitrary opposition test (12/24), but again passed after 12 training trials. She then passed arbitrary opposition, and both types of comparison relations immediately. Overall, P1 required very little training (24 trials in total) on the arbitrary mixed and non-arbitrary opposition relations, but was able to complete the full test protocol.

Participant 2. P2 scored as low average (99) on the PPVT and average (98) on the K-BIT. He immediately passed all tests prior to the non-arbitrary opposition test (12/24),

which he passed after only 12 training trials. He then passed all subsequent tests without further training. Overall, P2 required very little training (12 trials in total) only on non-arbitrary opposition relations to complete the full test protocol.

Participant 3. P3 scored as high average (103) on the PPVT and average (90) on the K-BIT. He passed both types of coordination tests immediately, but failed the non-arbitrary distinction test (101/120), which he then passed after only 20 training trials. He passed the arbitrary distinction and non-arbitrary mixed tests immediately, but produced 0 on the arbitrary mixed test. However, he required only 12 training trials to pass. He then passed all further tests without training. Overall, P3 required very little training (44 trials in total) on non-arbitrary distinction and arbitrary mixed relations before completing the full tests protocol.

Participant 4. P4 scored as moderately low (80) on the PPVT and well below average (73) on the K-BIT. He immediately passed all tests prior to non-arbitrary opposition relations (12/24), but passed this after only 12 training trials. He then passed all further tests without training. Overall, P4 required very little training (12 trials in total) on non-arbitrary opposition relations to complete the full tests protocol.

General Discussion

The current research comprised three studies that sought to explore the baseline and establishment of key repertoires of non-arbitrary and arbitrary relational responding in typically-developing children and children with autism. We also explored the potential relationship between participants' expressive and receptive language on standardized measures and their performances on the relational test protocol. In comparing Studies 2 and 3, we were also interested in the potentially different outcomes that may be associated with altering the sequence in which the relations were tested and/or trained.

Study 1 involved five typically-developing children, aged between 4 and 8 years old, with expressive language skills from average to above average and receptive language skills from low average to moderately high, and tested the relational repertoires in the order of (non-arbitrary and arbitrary) coordination, distinction, comparison, and opposition. Given their ages and levels of linguistic competence, it is perhaps not surprising that all five children demonstrated competency on all relations, although it was a little unexpected that none required training at any point.

A very different set of outcomes emerged in Study 2 which presented the same test sequence to 11 children with autism, aged between 4 and 13 years old, with expressive language skills from below the lower extreme to average and receptive language skills from indeterminable to average. Only four participants (Ps1, 2, 3, and 4) completed the full test sequence, after 96-444 training trials. The remaining seven fell considerably short of completing the full test protocol. One participant (P11) reached arbitrary distinction relations, but only after 1080 training trials, mostly on the non-arbitrary mixed relations. Three participants (Ps 5, 6, and 7) reached non-arbitrary distinction relations, but required between 560 and 1820 training trials to do so. And three participants (Ps 8, 9, and 10) reached only non-arbitrary coordination relations, even after 260-880 training trials.

The outcomes in Study 3 more closely resembled Study 1 than Study 2, even though all four participants had a diagnosis of autism, and some clearly presented with limitations in receptive and expressive language, relatively speaking. This sample ranged in age from 3 to 4 years old and scored between moderately low and high average on receptive language skills, and well below average to average on expressive language skills. All four completed the full test protocol after 44 training trials or less. P1 required training on arbitrary mixed and non-arbitrary opposition relations; P2 also on non-arbitrary opposition relations; P3 on

non-arbitrary distinction and arbitrary mixed relations; and P4 on non-arbitrary opposition relations. What also distinguished Studies 2 and 3 is that the test sequence alternated the order in which the opposition and comparison tests were presented.

Relational Frame Theory would suggest that typically-developing children acquire relational responding through natural language interactions with caregivers from a young age and that this development parallels the emergence of language (Luciano et al., 2009). The current research provides evidence to this effect, with typically-developing children proceeding through the test sequence with no training requirements, while participants with autism, particularly those with lower receptive and expressive language competencies, demonstrated deficits in many of the relations targeted. This provides support for the suggestion that responding in accordance with arbitrary coordination, distinction, opposition, and comparison relations is established in typically-developing children between the ages of four and eight years old (Luciano, et al.). The data, especially from Study 2 also show the challenges involved in developing interventions to establish these generative behaviors when they are deficient. The utilization of interventions based on RFT to establish generative behaviors may be of tremendous benefit in EIBI programmes (Luciano et al.).

Dunne et al. (2014) questioned the optimal sequence of training relational responding in children with autism. And, Rehfeldt and Barnes-Holmes (2009) suggested that comparison relations may be better targeted *after* opposition relations. Given the study designs and the considerable variations in the sample, it was difficult to draw any firm conclusions about the possible role of the testing sequence. However, to aid in this possible comparison, we specifically selected the data from participants in Study 2 with higher verbal scores (i.e., >80 on the PPVT and >80 on the KBIT) to generate a profile of similar participants across studies. This indicated that the differences in performances across the studies remained. That

is, presenting opposition relations prior to comparison relations may have been more beneficial in the acquisition of comparison relations. Evidence to this effect is seen through examining the different amounts of training required for participants in Study 2 and 3.

The positive outcomes of the current studies in implementing a relational responding training sequence are consistent with previous research with regard to coordination relations (Dunne et al., 2014; O'Connor et al., 2009), distinction relations (Dunne et al.), opposition relations (Dunne et al.), and comparison relations (Dunne et al.), also in children with autism. The findings from the current research also support previous interventions that include multiple exemplar training, explicit feedback, and targeting non-arbitrary trials prior to arbitrary trials (Vitale et al., 2008). Indeed, the data reported in the current paper support previous research which has found that training in non-arbitrary relations facilitates responding to arbitrary relations in children with deficits in this regard (Barnes-Holmes et al., 2004; Barnes-Holmes et al., 2004; Gorham et al., 2009). It may be said that the current findings provide some support for the suggestion that in some, but not all, cases the establishment of each relational frame may provide a basis for the establishment of the next relational frame, due to the existence of common features (Hayes et al., 2001).

The findings of the current studies provide support for the very likely relationship between verbal ability, as assessed on standardized measures, and repertoires of relational responding. This relationship has been previously supported by a number of RFT studies (Devany et al., 1986; Dunne et al., 2014; Lipkens et al., 1993; Luciano et al., 2007). The current studies provide support for this relationship with evidence that participants with higher verbal abilities produced superior performances on the relational tasks. This is particularly obvious when the performance of participants 5-11 in Study 2, who had the lowest verbal scores, are compared to the performances of other participants in the current

studies. Participants 5-11 in Study 2 demonstrated significant deficits in relational responding that impeded their ability to proceed through the testing and training sequence, while all other participants progressed with little difficulty.

The current study had a number of limitations which limit conclusions that may be drawn and which do not enable us to be certain that spurious sources of influence did not affect the outcomes. For example, we used identical stimuli to test arbitrary relations for all frames, but this created the possibility, for example, that participants selected a comparison stimulus because it was the last stimulus identified by the researcher. This methodological weakness is hard to circumvent in *arbitrary* relational training protocols, and simply highlights the challenges faced by behavioral practitioners in establishing highly generative repertoires. It also highlights the importance of using multiple exemplars and generalization tests.

A similar methodological weakness surrounds the procedure used for testing the transformation of function in opposition, where it could be argued that the big/small relation may be a form of "same" and "different" relations as taught in the arbitrary coordination/ distinction procedures. To examine this possibility, we carefully scrutinized the performances of the eight participants who reached arbitrary opposition relations. Of these, six did not require any training on arbitrary opposition, and the two who did had not received training on arbitrary coordination or distinction relations. This does not preclude the possibility that competencies on the earlier relations accounted for apparent competence on opposition relations. Only more detailed research can decipher what is controlling behavior in a given training context.

Furthermore, the current research did not employ baseline relation tests across the entire training sequence. The current authors were operating on the assumption of a

developmental trend in the acquisition of relational skills therefore it was assumed that if a participant required training on one relational frame they would not have the skills to respond to subsequent relational frames. This assumption made by the authors may have limited the potential to draw solid conclusions on the rate of acquisition of relational skills among participants.

Numerous other interpretations of the variables controlling responding are always possible in detailed training protocols of arbitrary relations. While these open up a range of possible explanations, they more importantly highlight the challenges faced by researchers and practitioners in establishing complex generative repertoires. The current data show that individuals, who may initially appear as homogenous can vary considerably in these critical verbal skills and that for some individuals, these verbal skills are highly deficient and very hard to establish. The aim of the current research was to highlight these deficits and shed some light on how they might be established. However, given the current failure to train a number of the children with autism, much more research is needed to indicate how these critical repertoires can be established.

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Table 1

Total number of correct responses out of total number of test trials (in brackets) by each participant across non-arbitrary (NA) and arbitrary (A) trials for each relational frame in Study 1

P	Verbal Scores		Coordination		Distinction		Mixed Coordination and Distinction		Comparison		Opposition	
	PPVT	K-BIT	NA (120)	A (60)	NA (120)	A (60)	NA (120)	A (12)	NA (72)	A (48)	NA (24)	A (12)
1	120	106	120	60	120	60	120	12	72	48	24	12
2	105	115	120	60	120	60	120	12	72	48	24	12
3	85	90	120	60	120	60	120	12	72	48	24	12
4	112	112	120	60	120	60	120	12	72	48	24	12
5	116	101	120	60	120	60	120	12	72	48	24	12

Table 2

Total number of correct responses out of total number of test trials (in brackets) and total number of training trials by each participant across nonarbitrary (NA) and arbitrary (A) trials for each relational frame

P	Verbal Scores		Coordination		Distinction		Mixed Coordination and Distinction		Comparison		Opposition	
	PPVT	K-BIT	NA (120)	A (60)	NA (120)	A (60)	NA (120)	A (12)	NA (72)	A (48)	NA (24)	A (12)
1	81	101	120	60	120	60	120	12	53 72	48	12 24	12
2	89	83	120	60	120	60	120	0 24	43 216	30 12	11 24	12
3	88	96	120	60	120	60	120	0 12	41 288	48	14 96	0 48
4	88	86	100 80	60	60 60	60	120	0 12	72	48 12	12 72	12
5	40	20	100 40		80 60		23 640**					
6	40	20	120		80 780		22 1040**					
7	*	20	120		70 520		0 160 **					
8	40	20	120		18 880 **							
9	*	20	120		27 260**							
10	*	20	120		46 380 **							
11	*	20	120		82 240	60	50 840	10**				

Note. Table presents participants' performances in relational testing as the figures in the top line per participant, with number of training trials needed to meet criterion presented below these.

* Indicates scores were indeterminate **Indicates criteria not met

Table 3

Total number of correct responses out of total number of test trials (in brackets) and total number of training trials by each participant across non-arbitrary (NA) and arbitrary (A) trials for each relational frame

P	Verbal Scores		Coordination		Distinction		Mixed Coordination and Distinction		Opposition		Comparison	
	PPVT	K-BIT	NA (120)	A (60)	NA (120)	A (60)	NA (120)	A (12)	NA (24)	A (12)	NA (72)	A (48)
1	104	97	120	60	120	60	120	0 12	12 12	12	72	48
2	99	98	120	60	120	60	120	12	12 12	12	72	48
3	103	90	120	60	101 20	60	120	0 12	12 12	12	72	48
4	80	73	120	60	120	60	120	12	12 12	12	72	48

Note. Table presents participants' performances in relational testing as the figures in the top line per participant, with number of training trials needed to meet criterion presented below these.