# Competing Arbitrary and Non-Arbitrary Relational Responding in Normally Developing Children and Children Diagnosed with Autism

Article *in* The Psychological Record · June 2014

DOI: 10.1007/s40732-014-0042-y



3 authors:

Neil Kenny
Dublin City University


Dermot Barnes-Holmes
University of Ulster


Ian Stewart
Ollscoil na Gaillimhe – University of Galway

Psychol Rec
DOI 10.1007/s40732-014-0042-y

ORIGINAL ARTICLE

# Competing Arbitrary and Non-Arbitrary Relational Responding in Normally Developing Children and Children Diagnosed with Autism

**Neil Kenny · Dermot Barnes-Holmes · Ian Stewart**



**Abstract** The current study seeks to further investigate the previously reported disruptive effect of competing non-arbitrary stimulus relations on derived relational responding (Stewart et al. *The Psychological Record, 52*, 77–88, 2002; Kenny et al. *The Psychological Record,* 2014). Initially, Experiment 1 utilised procedures adapted from the previous Stewart et al. (*The Psychological Record, 52*, 77–88, 2002) study, rendering them developmentally appropriate for a participant population of normally developing children. The results showed all participants demonstrated equivalence class formation when only black stimuli were used and maintained criterion levels of equivalence-consistent responding in the Colour Test condition, where a competing non-arbitrary colour relation was present. Experiment 2 exposed a cohort of children diagnosed with autism to identical training and testing procedures. While these participants also demonstrated equivalence class formation with stimuli only black in colour, five of the six participants showed significantly lower levels of equivalence-consistent responding in the Colour Test condition. These results are consistent with previously reported research findings that children with autism perform more poorly in tasks containing competing sources of stimulus control (Huizinga et al. *Neuropsychologia, 44*, 2017–2036. 2006; Baker et al. *Clinical Neurospsychologist, 15*(3), 309–313. 2001; Pennington et al. 1997). The results of Experiment 1 suggest possible procedures to undermine spurious sources of non-arbitrary stimulus control in normally developing children.

**Keywords** Autism · Arbitrary Relational Responding · Relational Frame Theory

N. Kenny (✉)
Department of Psychology, University of Limerick, Limerick, Republic of Ireland
e-mail: Neil.Kenny@ul.ie

D. Barnes-Holmes
Department of Psychology, National University of Ireland, Maynooth, Ireland

I. Stewart
Department of Psychology, National University of Ireland, Galway, Ireland

Relational Frame Theory (RFT) proposes that when language-able humans are exposed to particular contingencies of reinforcement over a prolonged period of time, they will produce responding based on derived or arbitrarily applicable relations (Hayes et al. 1996). These relations are defined by contextual cues operating in the environment, rather than by properties of the relata themselves. Stimulus equivalence is one of the earliest reported examples of arbitrary relational responding and was first examined by Sidman (1971). This seminal study attempted to use systematic behaviour analytic methodologies to devise improved methods for teaching reading comprehension to a participant with learning disabilities. The results demonstrated that, following relational training, the participant readily demonstrated the taught relations. More importantly, however, additional derived relations also emerged between stimuli that had not been directly trained. The term equivalence class is used today to describe such classes of mutually substitutable stimuli (Barnes et al. 1995a, b; Fields et al. 1990; Sidman 1994).

There are a number of studies within the behavioural literature demonstrating that the formation of equivalence classes may be disrupted or prevented by introducing a proponent response as a competing source of spurious stimulus control. Proponent responses "are erroneous responses that are called out, either by some salient feature of the environment or by some features rendered salient through previous learning" (Biro and Russell 2001, p. 98). In the case of competing arbitrary relational responses, disruption occurs because

Published online: 24 May 2014

stimuli are deliberately chosen that likely participate in pre-experimentally established relations that were in conflict with the to-be-induced relations within the experimental context (e.g., Barnes et al. 1995a, b; Watt et al. 1991).

However, RFT additionally makes the distinction between responding under the control of arbitrary and non-arbitrary stimulus relations. Non-arbitrary stimulus relations are defined in terms of the physical properties of the stimuli, rather than purely by social or verbal convention. Interestingly, there has been relatively little research into the effects of a competing non-arbitrary relational response on derived relational responding. A study by Stewart et al. (2002) demonstrated that the existence of a proponent colour matching response disrupted equivalence class formation in language-able adults. While participants in this study were divided into three groups, the critical condition (the Colour Test condition) involved training participants using stimuli that appeared in black, and then presenting the same stimuli during the equivalence test in various colours. Specifically, during equivalence testing, the predicted equivalence relations involved stimuli that differed in colour, whereas the non-equivalent sample-comparison relations involved stimuli that matched in terms of colour. Results showed that equivalence performance during this Colour Test condition was significantly poorer than in the two control conditions. Another recent study (Kenny et al. 2014) used the same training, and testing procedures replicated the findings of the earlier study.

The aim of the current study is to determine if conflicting non-arbitrary relational responses would disrupt equivalence class formation in populations that have been shown to demonstrate significantly lower levels of responding in tasks that contain a proponent response and require response flexibility. With that aim in mind, populations of normally developing children and children with a diagnosis of autism were exposed to procedures adapted from those used in earlier studies (Stewart et al. 2002; Kenny et al. 2014). There is a significant body of research reporting that normally developing children readily demonstrate equivalence-class formation from a very young age if exposed to conditional discrimination training (e.g., Luciano et al. 2007; Lipkens et al. 1993). However, the performances of children in tests that assess subsets of rule-governed behaviour and contain competing proponent responses vary widely depending on age (Huizinga et al. 2006). Young children have been reported as showing perseverative patterns of responding on the Wisconsin Card Sorting Task (WCST), and as requiring more moves to solve the Tower of London task (Baker et al. 2001; Lehto 2004; Welsh et al. 1991). However, by contrast, an analysis of the performance of 12-year-old children in the WCST shows their performance is comparable to that of young adults (Levin et al. 1991a, b; Welsh et al. 1991), suggesting that the ability to shift set and switch between tasks skills is well developed by this age.

The current study also seeks to compare the performance of normally developing children to that of children diagnosed with autism in tasks containing competing non-arbitrary proponent responses derived from the procedures developed by Stewart et al. (2002). There is a well-established literature on the deficits and patterns of behavioural responding associated with autism. Wing and Gould (1979) characterised autism as consisting of a triad of impairments in the domains of socialisation, communication, and imaginative play. Internationally accepted handbooks such as the ICD-10 (World Health Organisation 1992) and the DSM-IV (American Psychiatric Association 1994) have standardised these criteria for the diagnosis of autism.

Interestingly, there is also a strong body of evidence that children with a diagnosis of autism are vulnerable to proponent responses across a variety of differing tasks (Ozonoff et al. 1991; Hughes et al. 1994; Biro and Russell 2001; McEvoy et al. 1993; Pennington et al. 1997; Ozonoff 1995) and demonstrate perseverative patterns of inflexible responding relative to other participant populations (Turner 1999; McEvoy et al. 1993). Indeed, they have also shown a deficit in cognitive flexibility across a number of studies (Pennington et al. 1997) with participants showing an inability to shift set in such tasks as the WCST (Ozonoff 1995) and the spatial reversal task (McEvoy et al. 1993). Other studies have shown that individuals with autism performed more poorly than normative controls in sorting objects according to shape or colour or in the classification of objects according to categories (Sigman et al. 1987).

However, of particular interest to the current paper is the finding that participants with a diagnosis of autism show lower levels of responding relative to controls in tasks containing a competing ‘proponent response’ and tasks that contain arbitrary rules (Ozonoff et al. 1991; Hughes et al. 1994; Biro and Russell 2001). This suggests that children diagnosed with autism might be more vulnerable to spurious sources of stimulus control and show greater levels of colour matching responses in the presence of competing non-arbitrary relational response.

## Current Study

The overall aim of these studies is to provide a behavioural methodology for investigating the effect of competing non-arbitrary stimulus relations on derived relational responding in children with a diagnosis of autism compared to normally developing children in similar test settings. While there is evidence in the research literature that children perform more poorly than older participants in tasks containing competing proponent responses (Huizinga et al. 2006; Baker et al. 2001; Lehto 2004; Welsh et al. 1991), there is significant evidence that children diagnosed with autism show severe deficits in such tasks. With this aim in mind, this study comprises two separate experiments. Experiment 1 exposes normally developing children to procedures derived from Stewart et al. (2002) while Experiment 2 exposes a participant population of children diagnosed with autism to the same procedures. It is hoped that this approach will provide a clear comparison between the performances of each participant cohort under test conditions.

## Experiment 1

This experiment seeks to examine the disruptive effects of competing source of non-arbitrary stimulus control on derived relational responding in a participant population of normally developing children. The intention is to use procedures similar to those used in previous studies in this area (Stewart et al. 2002). Match-to-sample procedures (MTS) are the most common method of training conditional discriminations (Sidman, 2000). In this MTS procedure often implemented to train conditional relations and to one stimulus is presented as the sample and two or more stimuli are presented as comparisons. In the presence of a particular sample, the selection of a particular comparison stimulus is reinforced and the selection of any other stimulus is not. In other words, this procedure serves to strengthen the selection of that particular comparison stimulus in the presence of that particular sample stimulus (Cooper et al. 2007). However, given that Matching-to-Sample is a form of conditional discrimination and that previous research has shown that normally developing children may have difficulty in acquiring conditional discriminations (Augustson and Dougher 1991; Etzel et al. 1996; Lipkens et al. 1993; Schilmoeller et al. 1979; Zygmont et al. 1992), it was felt necessary to modify the procedures used with this participant population.

In designing the procedures for the current experiment, two substantive modifications were made to the automated procedures previously employed (see Stewart et al. 2002; Kenny et al. 2014). Firstly, it was thought necessary to adopt a type of A-B-A reversal design. In short, participants were initially taught two sets of A-B and B-C relational responses (see Fig. 1 for representation). After participants reached a criterion level of responding for the A-B and B-C relations, they were tested for the untaught C-A equivalence relation, again using all black stimuli (this was designated as the baseline condition in the ABA reversal design). However, when criterion levels of equivalence responding were reached, the participant was re-exposed to the MTS training with black stimuli before being tested for C-A equivalence responding using stimuli either red or green in colour (the B component in the reversal design). In effect, this testing phase introduced competing non-arbitrary stimulus relations into the equivalence test (see Fig. 2. for representation). Following this exposure, the participants were cycled through a training and testing exposure that was identical to baseline conditions (i.e., a return to the baseline condition). The procedural modifications are outlined in more detail in the Procedure area of the Method section.

The decision to adopt this type of experimental design was based on three considerations. First, the amount of time and effort required to work with young children on equivalence-based tasks extends well beyond that required when working with adults, and thus it was not realistic to employ large groups of children. Secondly, the number of available children who could participate within the experiment was limited. Third, and perhaps most importantly, the reversal design clearly demonstrates the impact of the critical variable, in this case the effect of non-arbitrary stimulus relations on equivalence responding. This form of single-participant methodology would, in essence, provide a much sharper demonstration of disruptive effect of competing colour relations being manipulated in the current series of experiments.

The second modification to the procedures employed was the inclusion of an initial training and testing exposure using a stimulus set of familiar stimuli that comprised simple pictures of common items that would be known to the children, the items being presented in black on a white piece of card (See Fig. 3 for representation). It is common for equivalence training programs to frequently commence MTS training with familiar stimuli, and to systematically decrease familiarity as training progresses. Previous research has indicated that the familiarity of stimuli enhanced the performance of children in acquiring classes of arbitrary relational responding (Holth and Arntzen 1998; O'Connor et al. 2009); these stimuli were used in existing stimulus classes, and this might facilitate their use in new classes. Additionally, the participants were required to demonstrate a criterion level of equivalence-consistent responding during the test phase with this familiar stimulus

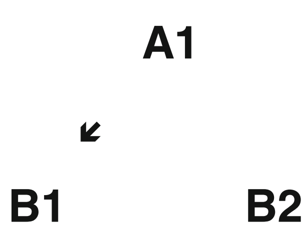


**Fig. 1** A1-B1 match to sample training trial

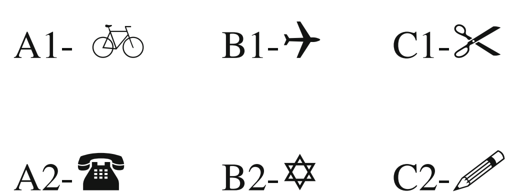


**Fig. 2** Pictures of common objects used in initial condition of experiment. Note that participants were not exposed to the alphanumeric labels, which are used here for communicative purposes

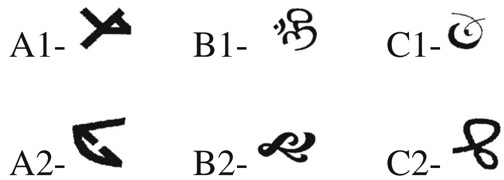


**Fig. 3** Symbols used in experiment. Note that participants were not exposed to the alphanumeric labels, which are used here for communicative purposes

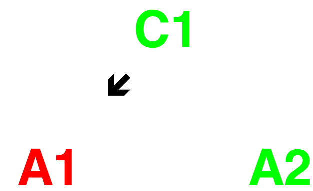


**Fig. 5** Colour Test condition with competing non-arbitrary relation of colour

set in order to progress to training and testing with the set of novel stimuli (See Fig. 4 for representation of novel stimulus set). This provided participants with exposure to training and testing phases across two sets of different black coloured stimuli prior to the introduction of a competing non-arbitrary colour relation in the Colour–Test condition with the novel stimulus set (see Fig. 5 for schematic representation of training and testing schedule).

The final modification to the procedure used was to change from automated to non-automated or tabletop procedures. The latter appears to offer some advantages when working with young children for whom the social interaction involved in such procedures appears to provide social reinforcement for maintaining on-task behaviour (Dymond et al. 2005).

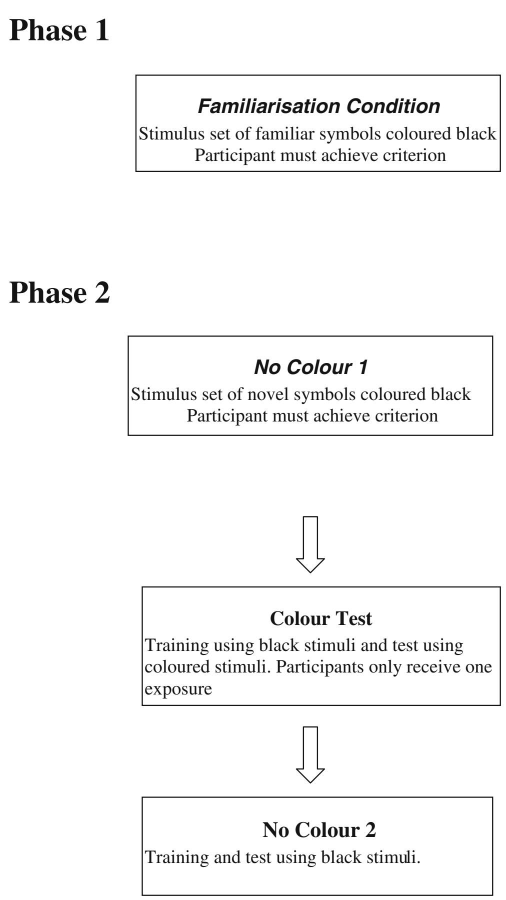


**Fig. 4** A schematic representation of the overview of the experimental sequence

Furthermore, when the current experiments were conducted, a tabletop format provided a more naturalistic learning environment than that provided by the computer-based equivalence program (i.e., the children had very limited experience with computers in an educational context). In short, a tabletop format allowed the researcher to provide social reinforcement throughout the experimental sessions, and the children did not need to adapt to, or learn about, a novel educational environment.

Overall, it was hoped that this design would be effective in establishing robust acquisition of the derived arbitrary relational response prior to the introduction of a competing colour relation in the Colour Test condition with the novel stimulus set.

## Method

### *Participants and Participant Identification*

Three female and one male participant were employed. Each of the participants were pupils in a local mainstream national school in the Dublin area of the Republic of Ireland, and were accessing education through the national primary school curriculum in a mainstream classroom setting. Their ages ranged from 6 to 7 years of age. All participants only participated in the current study following written informed consent being granted by their parents or guardians in line with the ethical guidelines of the Psychological Society of Ireland. Although the children were not formally assessed for the purposes of the experiment, neither their teachers nor parents had reported any behavioural, learning or emotional difficulties with any of the children.

### *Stimuli and Setting*

All training and testing trials were conducted individually, with each participant seated at a small table in a quiet room. Three of the participants took part in the experiment in the child's school environment. One participant (P3) participated in a quiet room in their home. During the training phase, each participant was taught a series of two interrelated conditional discriminations using abstract shapes (alphanumerics are used to label these shapes, but participants never saw these labels). A MTS format was used for each trial. For the A-B training trials, participants were presented with either A1 or A2 as the sample stimulus, with B1 and B2 as comparison stimuli. A correct response was choosing B1 in the presence of A1 or B2 in the presence of A2. For the two B-C tasks, participants were presented with either B1 or B2 as the sample stimulus and two comparison stimuli, C1 and C2. The correct response was the choice of C1 in the presence of B1 and C2 in the presence of B2.

During training trials, all of the stimuli were black in colour and appeared in bold print on white laminated paper sized 8 cm by 8 cm. Figure 3 presents examples of the symbols used. For each trial, the subject was presented with two comparison stimuli that were placed along the lower edge of the table, one at the left corner and the other at the right. The left and right positioning of the comparisons was counterbalanced across trials to prevent responding on the basis of stimulus position alone. The sample stimulus was then placed into the participant's hand accompanied by the verbal antecedent "*Goes with*?" The participant responded by placing the sample stimulus with one of the two comparison stimuli.

The materials used during the testing trials were the same as those employed during the training phase, except that the C stimuli served as samples and the A stimuli as comparisons (correct responding was defined as choosing A1 given C1 and choosing A2 given C2). Furthermore, during some test sessions, the stimuli were altered from black to coloured forms (i.e., red and green). Colour was assigned to the stimuli such that one of the comparisons was always the same colour as the sample stimulus whereas the other was a different colour. The correct comparison stimulus was a different colour to the sample stimulus in 70 % of presentations, but was of the same colour as the sample stimulus in 30 % of presentations.

*Reinforcers*

During the training phases of this experiment, the experimenter provided the participants with consequences for their responses. If the participant responded correctly, positive reinforcement was delivered in the form of verbal praise ("Well done, that's right") as well as small edibles, such as individual "Smarties" and the occasional small toy. While verbal reinforcement accompanied each correct response on a fixed schedule, access to edible reinforcements was provided on a variable schedule of every four to eight correct responses, with access to toys or activities being given on a much thinner variable schedule of every 15–20 correct responses. The reinforcers used during the experiment were selected based on an informal assessment of the child's preferences and interests obtained via pre-experimental meetings between the child and the researcher, and generally comprised items such as edibles, toys and games as chosen by the particular child. While the edible reinforcers were selected at random by the experimenter during training trials in order to maintain a sufficiently rapid pace of progress, the participant was offered a choice between two exemplars when toys or activities were offered, in order to maximise reinforcing effects.

*Procedure*

The experiment was conducted over several sessions with each child. Sessions lasted approximately 20 minutes, but no longer than 30 minutes. Testing phases were always conducted immediately after the participant had reached the appropriate training criteria. Due to practical constraints arising from the school or home context in which the research was conducted, it was not possible to obtain measures of interobserver reliability (this applied to all experiments). Given the exploratory nature of the research in which no formal hypotheses or predictions were made, the lack of such a measure was not deemed to be highly problematic.

*Phase 1: Initial Training and Testing with Familiar Stimuli* All participants were exposed to an initial training and testing condition in which a stimulus set comprising symbols representing common objects was used (see Fig. 3 for an example of the pictures of familiar items used). This condition was used to familiarise participants with the form of the MTS trials used in the experiment; hereafter it is referred to as the Familiarisation Condition.

The training commenced with the experimenter sitting on one side of a desk with the child sitting facing him on the other side. The experimenter started the session by showing the participant some sweets or other choice reinforcers and asking the participant "Would you like to play a game with me and earn some —?" All stimuli presented during the training phase were black in colour.

*Linear Training* Initially, participants were exposed to a linear training procedure whereby each arbitrary relational response was trained in isolation until a criterion level of arbitrary responding was demonstrated. At the end of each trial, the experimenter provided the participant with a consequence for their response (i.e., praise/ access to reinforcer or correction of incorrect response) and removed the comparison stimuli from the table, signalling the end of that trial. After a time period of approximately two to three seconds, the experimenter placed the next two comparison stimuli on the table equidistant in front of the participant, one to the participant's left and the other to the right. The next trial commenced by again presenting the sample stimulus in the centre of the "*goes with*".

The target criterion for correct responding was achieved when a participant produced eight consecutive arbitrary relational responses within a 20-trial block. When a criterion was achieved with one relation, training with the next relational response commenced. The first relation to be trained was A1-B1, followed by A2-B2 task, then by B1-C1, and finally B2-C2.

The training procedure of the initial A1-B1 relation involved the participant being shown the two comparison stimuli, B1 and B2, and then being presented with the sample stimulus, A1, along with the verbal antecedent "goes with". The participant was required to put A1 with the correct comparison B1. If the participant responded correctly, the experimenter delivered verbal praise on a fixed ratio of one (FR1) and delivered edible reinforcement (or the occasional small toy) on a variable schedule (please see reinforcer section for exact clarification of schedules used).

If the participant responded incorrectly by placing the sample stimulus with the incorrect comparison, B2, the experimenter repeated the antecedent and used hand-over-hand physical guidance to place the sample over the correct comparison. This correction procedure was used for all incorrect responses during training. The right-left position of the two comparison stimuli was varied in a random fashion.

For each relation, the same training procedures as for the A1-B1 relation were used. After criterion levels of performance were achieved for each of the four relations, the mixed training phase was initiated.

*Mixed Training* In the mixed training phase, all four trial-types (two A-B and two B-C relations) were randomly presented within blocks of 20 trials. The mastery criterion for this training phase was set at a minimum of four correct responses out of five for arbitrary relational response (A1-B1, A2-B2, B1-C1, B2-C2). If the participant failed to achieve the set criterion for any trial type, the participant restarted the training procedures (i.e., was cycled through both Linear and Mixed training procedures). This procedure was repeated until the participant demonstrated criterion levels of arbitrary relational responding for all four responses. The participant was then deemed to have qualified for the equivalence test.

*Equivalence Testing* Throughout the equivalence test, performance-contingent feedback for matching responses was not provided (the experimenter simply provided a 2-second inter-trial interval, during which no direct interaction with the child occurred). Each participant was tested for equivalence responding using the same MTS task as that used during training, but the following two untrained relations were presented; C1-A1 and C2-A2. The child was presented with ten C1-A1 trial-types and ten C2-A2 trial-types. These two tasks were presented in a random order within 20-trial blocks.

In order to prevent response extinction due to the lack of contingent feedback during testing, after approximately every five trials (VR5), the experimenter reinforced on-task behaviour irrespective of the child's matching responses (e.g., "That's great sitting in your chair"… "That's great listening to your teacher", etc.). Any direct request by a participant for an edible or toy during the testing phase was ignored by the experimenter, who simply continued with the testing procedure.

If a participant produced a minimum of 90 % matching responses that were consistent with the trained baseline relations (i.e., C1-A1 and C2-A2) across the 20 trials, he or she progressed to the next phase of the experiment (hereafter, relation consistent responding will be described as "correct"). If the participant failed to achieve the criterion of 90 % correct, he or she recycled through training and testing for a second time (blocked training, mixed training, and equivalence test).

*Phase 2: Full Training and Testing with Novel Black and Coloured Stimuli* During Phase 2, participants were exposed to three separate test conditions that comprised the A-B-A reversal experimental design. The three test conditions were the *No Colour 1* condition, *Colour Test* condition, and *No Colour 2* condition. The No Colour conditions functioned as baseline and return to baseline test conditions, respectively. The training procedures that preceded each condition were identical to the training procedures outlined in Phase 1.

*No Colour 1* In the first test condition, *No Colour 1*, participants were exposed to the same sequence of training and testing described above, except that novel stimuli were employed (see Fig. 4). That is, participants were trained and tested for the formation of two three-member equivalence classes using black stimuli throughout. Participants were required to achieve the same criterion level of equivalence-consistent responding as was specified in Phase 1 (90 % equivalence consistent responding) in order to progress to the next test condition.

*Colour Test* During the second test condition, the *Colour Test* condition, participants were retrained with the same stimuli again, but during the equivalence test the C and A stimuli were presented in colour, rather than in black. That is, the comparison and sample stimuli were either red or green in colour. For 70 % of the trials, the "correct" comparison stimulus was a different colour than the sample stimulus. For example, if the sample stimulus was green in colour, then the "correct" comparison was red (see Fig. 2 for representation). For these test trials, therefore, there was a conflict between the arbitrary equivalence relation that was predicted based on the trained conditional discriminations and the pre-experimentally established non-arbitrary relation of sameness (in terms of colour) between the sample and comparison stimuli. For the remaining 30 % of test trials, the equivalent (correct) stimulus was the same colour as the sample.

Participants were provided with only one exposure to the equivalence test with coloured stimuli (i.e., they were not cycled between training and testing until a criterion performance was reached).

*No Colour Test 2* Following exposure to this single equivalence test, participants progressed to the third test condition, *No Colour 2*, where they re-exposed to the conditional discrimination training procedures (described previously) with the same stimuli before being re-exposed to the equivalence test again, but using all black stimuli for one final exposure. Following this third cycle of training and testing with the same set of stimuli, participation in Experiment 1 was complete. An overview of the experimental sequence is presented in Fig. 5.

## Results and Discussion

The number of training trials and number of correct equivalence responses produced by each participant across the experiment are presented in Table 1. All four participants completed the MTS training using the familiar stimuli, but then failed to reach the mastery criterion during the first equivalence test. Three participants (P1, P2, and P4) did reach criterion after being re-exposed to the MTS training; P3 required a third cycle of training and testing before producing the required equivalence responding.

When novel stimuli were employed in Phase 2, Participants 1 and 2 passed the equivalence test on their first exposure, P4 on the second exposure, and P3 on the fourth exposure. During the critical Colour Test condition, when coloured stimuli were used during the equivalence test, all four participants maintained the equivalence response patterns observed in the previous test exposure. That is, the introduction of coloured stimuli and competing non-arbitrary sameness relations appeared to have little impact on the equivalence responding. During the final training and testing, No Colour 2, all four participants again maintained the previously established equivalence responding.

Overall, therefore, the current findings showed that all four children demonstrated equivalence responding after two or three cycles of training and testing with a set of familiar stimuli. Equivalence responding was also observed for all participants when novel stimuli were employed, although between one and four cycles of training and testing were needed. When the coloured stimuli were introduced (*Colour Test*) and subsequently removed (*No Colour 2*), this had virtually no impact on the participants' equivalence responding.

The findings are in clear contrast to the data obtained from previous studies using adult participants, which reported disruption of derived equivalence responding in the presence of a competing non-arbitrary relational response

**Table 1** Number of training trials and number of correct responses for each participant during test blocks in Experiment 1

| Training and Test Blocks | | Participant 1 | Participant 2 | Participant 3 | Participant 4 |
|---|---|---|---|---|---|
| Phase 1- Familiarisation Condition | | | | | |
| | Train | 51 | 53 | 55 | 57 |
| | Test | 11/20 | 13/20 | 3/20 | 15/20 |
| | Train | 49 | 48 | 48 | 49 |
| | Test | **19/20** | **20/20** | 15/20 | **20/20** |
| | Train | | | 52 | |
| | Test | | | **19/20** | |
| Phase 2 | | | | | |
| No Colour1 | Train | 57 | 51 | 53 | 58 |
| | Test | **18/20** | **20/20** | 0/20 | 13/20 |
| | Train | | | 48 | 49 |
| | Test | | | 12/20 | **20/20** |
| | Train | | | 49 | |
| | Test | | | 17/20 | |
| | Train | | | 49 | |
| | Test | | | **19/20** | |
| Colour Test | Train | 48 | 54 | 48 | 48 |
| | Test | **20/20** | **20/20** | **18/20** | **19/20** |
| No Colour2 | Train | 48 | 48 | 48 | 50 |
| | Test | **20/20** | **20/20** | **20/20** | **19/20** |

The figures in bold text indicates where criterion levels of responding have been achieved and the participants qualifies for the next phase of training/testing.

(Stewart et al. 2002; Kenny et al. 2014). An interpretation of the current results is that the procedures developed in this study were effective in teaching a population of normally developing children to *ignore* the competing non-arbitrary relation of matching colour. Indeed, results show that all participants were effective in maintaining derived equivalence responding across all testing conditions. The importance of these procedural modifications is further emphasised by a number of past studies that documented the difficulties in teaching conditional discriminations, at least in the absence of special training procedures, for both normally developing children (e.g., Augustson and Dougher 1991; Etzel et al. 1996; Lipkens et al. 1993; Schilmoeller et al. 1979) and for individuals with developmental disabilities (e.g., with children, Eikeseth and Smith 1992; with adults, McIlvane et al. 1990; Saunders and Spradlin 1989, 1990, 1993; Zygmont et al. 1992).

The next experiment aims to investigate if the same procedures could produce similar results when used with a population of children diagnosed with autism. As discussed earlier in the current article, children diagnosed with autism have been shown by past research to demonstrate perseverative patterns of responding in similar tasks that present a viable proponent response (Turner 1999; McEvoy et al. 1993). It is possible, therefore, that such a participant population might show greater response vulnerability in the presence of competing non-arbitrary relations between stimuli than was evident with the present participants.

## Experiment 2

The current study aims to expose a population of children diagnosed with Autism to identical training and testing procedures to those used in Experiment 1. There is a mixed literature regarding comparisons in performance between children diagnosed with autism and normally developing children in the acquisition of repertoires of derived relational responding. While a number of studies have focused on the relative acquisition difficulties among populations with developmental disabilities (e.g., Saunders and Spradlin 1989, 1990; McIlvane et al. 1990; Zygmont et al. 1992), other studies have found little difference in acquiring repertoires of derived relational responding in normally developing children compared to children diagnosed with autism (Gorham et al. 2009; Barnes-Holmes et al. 2004; Berens and Hayes 2007).

While the results of Experiment 1 illustrate the effectiveness of the procedural modifications used in undermining the disruptive effect of competing non-arbitrary stimulus relations on derived equivalence responding, there is a significant research literature suggesting children with autism show performance deficits in tasks containing a competing proponent response (Sigman et al. 1987; Ozonoff et al. 1991; McEvoy et al. 1993; Hughes et al. 1994; Biro and Russell 2001). Experiment 2 aims to examine if the procedures used in the previous Experiment would also be effective in teaching participants with a diagnosis of autism to *ignore* competing non-arbitrary stimulus relations.

### Method

#### *Participants and Participant Identification*

There were six participants, four male and two female. Each of the participants had a diagnosis of autism. Their ages ranged from 5 to 7 years of age. All participants were enrolled in Comprehensive Application of Behavior Analysis to Schooling (CABAS) school programmes in Ireland. The CABAS® systems approach is a learner-driven and system-wide application of evidence-based behavioral therapy to all of the people involved in educating children with autism (students, parents, teachers, supervisors, and administrators). Five of the six participants were attending the CABAS® Dublin School, while the sixth was a pupil in the CABAS® School, Drogheda. All participants only participated in the current study following written informed consent being granted by their parents/ guardians in line with the ethical guidelines of the Psychological Society of Ireland. Permission was also requested and received from the boards of management of both schools to carry out research with the children on school premises.

All the participants were assessed using the PIRK assessment tool. This is a criterion-referenced instrument for assessing the categorised repertoires of verbal behaviour acquired by pre-school children according to the conceptual scheme found in Skinner's Verbal Behaviour (1957) (Please see Greer et al. 1996 for a more detailed discussion of the PIRK assessment tool). All participants in the experiment produced similar results, indicating very similar repertoires of verbal behaviour.

#### *Stimuli and Setting*

The setting used to work with the participants was identical to the school setting used in the Experiment 1.

#### *Reinforcers*

During the training phases of the current experiment, the researcher provided the participants with consequences for their responses. If a participant responded correctly, positive reinforcement was delivered in the form of verbal praise

("Well done, that's right") and small edibles, such as individual "Smarties" and occasional access to a small toy. The reinforcers used during this experiment were those used during the participant's typical school day. They had been established for the participant prior to the onset of the experiment and were specified by the preferences and interests of the participant. In the CABAS system, students gain access to positive reinforcers contingent on correct responding according to schedules individualised to the needs of each student. For example, a student gains access to secondary reinforcement on a VR3 schedule of three correct responses. All participants received access to reinforcing items of their own choice and the schedules used with the participants in this experiment were similar to those used during their educational programmes on a normal school day in order to maximised their effectiveness (See Lipkens et al. 1993 for discussion).

### *Procedure*

The procedures used in this experiment were identical to those used in Experiment 1 of the current study. All six participants were cycled through both phases of the procedure.

## Results and Discussion

The number of training trials and number of correct equivalence responses produced by each participant during Phase 1 and Phase 2 of the current experiment are presented in Table 2. In Phase 1, five of the six participants exposed to the MTS training procedure qualified for the testing conditions immediately, but one participant (P2) failed to meet the criterion (indicated by a line in the Table) and required an additional training exposure. Participant 6 (P6) produced criterion levels of equivalence-consistent responding on the first testing exposure, but the remaining five participants required between two and six exposures to the MTS training and testing procedures to demonstrate criterion levels of equivalence with the familiar stimulus set. All participants qualified for Phase 2 of the experiment.

The data for Phase 2 of the experiment show that all six participants produced criterion levels of equivalence-consistent responding in the *No Colour 1* condition, but they all required multiple exposures to the MTS training and testing procedure to achieve this criterion. The number of training trials presented to achieve criterion ranged from 686 training trials during twelve MTS exposures for P2 to 147 trials in two exposures for P6. The mean number of training trials required to produce equivalence-consistent responding across all six participants was 374. This is a significantly higher level of training than was required by the normally developing participants in Experiment 1.

When the participants were exposed to the Colour Test condition, they all again completed the training, but critically, five of the six participants failed to produce equivalence-consistent responding when the stimuli were presented in colour. When the participants returned to training and testing with all black coloured stimuli (No Colour 2), equivalence-consistent responding returned to criterion levels for four of the participants who failed with the colour stimuli; one participant (P1) failed to reach criterion by just one response. Participant 3, who produced equivalence-consistent responding during the Colour Test condition, unexpectedly fell below criterion, but only by two responses.

Only one of the participants failed to show the "disruptive" effect (P3), but at the current time, the reason for this difference remains unclear. Nevertheless, the test performance obtained from P3 suggests that children diagnosed with autism may not always succumb to control by non-arbitrary relations in the context of equivalence testing.

### *Error Analysis*

The error data indicate that the introduction of the non-arbitrary relation of colour was perhaps the main variable responsible for the majority of errors during the Colour Test condition. Table 3 presents the total number of errors made by each participant in the Colour Test condition, and the number of those errors that involved matching a comparison stimulus that was the same colour as the sample stimulus (i.e., colour-matching). For the five participants who failed to reach criterion, the majority of errors involved colour-matching. P3 only produced one error, but this error also involved colour-matching.

Overall, the results of the current experiment demonstrated that all six participants achieved criterion levels of arbitrary relational responding during training and produced relatively robust levels of derived equivalence responding during the No Colour conditions. However, five of the six participants produced lower levels of equivalence-consistent responding in the Colour Test condition relative to those demonstrated in the No Colour 1 and No Colour 2 conditions. These results demonstrate that, as was the case for the normative participants in Experiment 1, the procedures were relatively effective in producing derived relational responding in a participant population of children diagnosed with autism when training and testing occurred with stimuli that were only black in colour. When a competing non-arbitrary colour relation was introduced in the Colour Test condition, however, these participants tended to demonstrate weaker or completely disrupted equivalence responding. These results provide clear evidence that children diagnosed with autism are far more susceptible than their normally developing peers to the disruption of equivalence responding by competing non-arbitrary stimulus control.

**Table 2** Number of training trials and number of correct responses for each participant during test blocks in Phase 2 of Experiment 2

| Exposure # | | P 1 | P 2 | P 3 | P 4 | P 5 | P 6 |
|---|---|---|---|---|---|---|---|
| Familiarisation Condition | Phase 1 | | | | | | |
| 1 | Train | 51 | 64 | 55 | 53 | 60 | 50 |
| | Test | 16/20 | — | 3/20 | 17/20 | 11/20 | **20/20** |
| 2 | Train | 48 | 50 | 48 | 49 | 57 | |
| | Test | **19/20** | 14/20 | 15/20 | **20/20** | 16/20 | |
| 3 | Train | | 48 | 52 | | 66 | |
| | Test | | 17/20 | **19/20** | | 10/20 | |
| 4 | Train | | 48 | | | 51 | |
| | Test | | **19/20** | | | 11/20 | |
| 5 | Train | | | | | 48 | |
| | Test | | | | | 17/20 | |
| 6 | Train | | | | | 48 | |
| | Test | | | | | **19/20** | |
| No Colour 1 | Phase 2—Novel Stimulus Set | | | | | | |
| 1 | Train | 51 | 64 | 65 | 58 | 58 | 50 |
| | Test | 12/20 | 12/20 | — | 12/20 | — | 2/20 |
| 2 | Train | 51 | 52 | 50 | 52 | 77 | 49 |
| | Test | 14/20 | — | 9/20 | 15/20 | 10/20 | 17/20 |
| 3 | Train | 48 | 35 | 49 | 55 | 62 | |
| | Test | 17/20 | 19/20 | 12/20 | 11/20 | 9/20 | |
| 4 | Train | | 60 | 50 | 48 | 53 | |
| | Test | | 11/20 | 15/20 | 13/20 | 13/20 | |
| 5 | Train | | 66 | 49 | 49 | 53 | |
| | Test | | 9/20 | 16/20 | 13/20 | 17/20 | |
| 6 | Train | | 66 | 48 | 53 | 52 | |
| | Test | | 9/20 | 14/20 | 13/20 | 17/20 | |
| 7 | Train | | 60 | 51 | 48 | | |
| | Test | | 9/20 | 16/20 | 14/20 | | |
| 8 | Train | | 56 | 48 | 48 | | |
| | Test | | 15/20 | 17/20 | 17/20 | | |
| 9 | Train | | 61 | | | | |
| | Test | | 14/20 | | | | |
| 10 | Train | | 58 | | | | |
| | Test | | 11/20 | | | | |
| 11 | Train | | 56 | | | | |
| | Test | | 17/20 | | | | |
| | Train | 48 | 52 | 48 | 48 | 49 | 48 |
| | Test | **19/20** | **19/20** | **20/20** | **19/20** | **20/20** | **20/20** |
| Colour Test | Train | 51 | 48 | 48 | 48 | 49 | 48 |
| | Test | **15/20** | **9/20** | **19/20** | **7/20** | **9/20** | **6/20** |
| No Colour 2 | Train | 54 | 52 | 48 | 48 | 48 | 48 |
| | Test | **17/20** | **19/20** | **16/20** | **18/20** | **19/20** | **20/20** |

The figures in bold text indicates where criterion levels of responding have been achieved and the participants qualifies for the next phase of training/testing.

The - symbols in the table indicates that participant did not reach the criterion performance in training and did not qualify for the testing condition on this exposure.

**Table 3** Number of error responses and number of colour matching errors for all participants during Colour Test condition

| Participant | Number of errors during Colour Test condition | Number of colour response errors during Colour Test condition |
|---|---|---|
| 1 | 5 | 4 |
| 2 | 11 | 10 |
| 3 | 1 | 1 |
| 4 | 13 | 11 |
| 5 | 11 | 9 |
| 6 | 14 | 14 |

## General Discussion

The current article presents the first series of experiments designed to explore the effects of competing non-arbitrary stimulus relations on equivalence class formation in normally developing children and those diagnosed with autism. Thus, the general approach offered here should be seen as "bottom-up", targeting a specific deficit in stimulus control that may potentially refine our understanding of certain deficits associated with autism. As such, it constitutes the first attempt to develop a behaviour-analytic methodology for identifying and assessing a pattern of responding seemingly closely related to previously reported deficits among populations diagnosed with autism (Ozonoff et al. 1991; Hughes et al. 1994; Bennetto et al. 1996; Pennington and Ozonoff 1996; Ozonoff and Jensen 1999; see Hill 2004 for review). When both experiments are compared, the results of Experiment 1 suggest clearly that normally developing children do not show the same level of vulnerability attributable to competing sources of non-arbitrary stimulus relations, as is evident in the results reported for Experiment 2 with a population of children diagnosed with autism. This contrast between the patterns of equivalence responding observed during the *Colour* Test condition for both the normally developing children and children with autism is broadly consistent with the previous research comparing the performance of similar participant cohorts in tasks containing a competing proponent response (Sigman et al. 1987; Ozonoff et al. 1991; McEvoy et al. 1993; Hughes et al. 1994; Biro and Russell 2001).

This pattern of responding observed for the participants with autism in Experiment 2 shows many similarities to results reported in previous studies when competing proponent non-arbitrary stimulus relations have been introduced (Stewart et al. 2002; Kenny et al. 2014). An analysis of the error results of Experiment 2 shows that the majority of the errors made by these participants were responses in accordance with the proponent non-arbitrary relational response. In other words, participants matched stimuli according to colour, despite have demonstrated a robust acquisition of equivalence-consistent with the same stimuli, coloured black.

From an RFT perspective, a history of reinforcement for responding in accordance with non-arbitrary relations provides an important historical context for the establishment of their arbitrary counterparts in a child's behavioural repertoire. Indeed, past research has shown that positive outcomes may be obtained when non-arbitrary interventions have been employed as a means of establishing arbitrary relational responses (Barnes-Holmes et al. 2004; Berens and Hayes 2007). However, in the context of the results for autistic participants in Experiment 2, the pre-existing non-arbitrary relational response classes appear to disrupt more recently established classes of derived equivalence responses when introduced in an equivalence test context. The results for Experiment 1 suggest this is not the case for a cohort of age-matched normally developing children.

The results of Experiment 1 are of significant interest in their own right when seen in the context of the contrasting result observed for the participants with autism in Experiment 2. While the result of Experiment 1differ from the result reported in previous studies examining the effect of competing proponent responses on derived relational responding in adults, the procedures utilised in the current studies differed significantly from those used previously. Indeed, the results of the current normally developing children suggest that these procedures might also have utility in establishing robust repertoires of equivalence responding in the presence of multiple competing sources of non-arbitrary stimulus control. As such, these results may suggest a strategy for reducing the disruptive effect of competing sources of irrelevant stimulus control when establishing repertoires relational responding, which may have utility in an educational context.

However, it is not possible in the context of the present study to determine exactly what procedural modifications were responsible for producing such robust equivalence responding in the normally developing children. Future research may be required to systematically examine why these results differed so significantly from those observed in previous studies with adult participants. Such an intensive analysis may also suggest interventions to improve the performance of children diagnosed with autism under test conditions containing a non-arbitrary proponent response such that the deficits observed in the current study might be reduced or abolished. The results reported in Experiment 1 did, however, provided a firm basis from which to explore the impact of non-arbitrary stimulus relations on equivalence responding with children diagnosed with autism.

Children with autism often demonstrate relative strengths in concrete thinking and understanding of visual-spatial relationships when compared to normally developing children, but have relative difficulties in abstract and relational thinking, social cognition, and attention (Quill 1995). As such, a potential interpretation of the currents results is that the participants with autism defaulted to responding to the less complex and more visual striking features of the available stimuli during Colour Test exposures (i.e., the colour matching response). By contrast, the same participants successfully maintained equivalence responding in the absence of a competing non-arbitrary response during the control No Colour conditions. At the very least, the current research speaks to autism specific educational programs in which a variety of classes of arbitrary relational responding are established in naturalistic settings containing multiple sources of competing stimulus control.

As the current research adopts a behaviour-analytic approach, it is primarily concerned with influencing as well as predicting behaviour. Therefore, as this deficit in relational responding for children diagnosed with autism has been identified, efforts need to be made to improve this participant population's ability to overcome sources of competing non-arbitrary stimulus control. In this context, it is of interest that one participant (P3) with autism did not show disruption of equivalence responding during the Colour Test condition, suggesting that disruption of equivalence responding may not be observed in all children diagnosed with autism under similar circumstances. While it should be acknowledged that the reasons for such variance in results among participants with autism is not clear at this point, future research might systematically examine such divergences among participants with autism in similar test settings.

One approach suggested by RFT that may have utility in reducing the vulnerability observed in current cohort of children diagnosed with autism is Multiple Exemplar Training. Recent behavioural studies have provided empirical evidence for the efficacy of exemplar training in establishing repertoires of derived relational responding in normally developing children (Barnes-Holmes et al. 2001, 2004) and children with autism (O'Toole et al. 2009; Murphy et al. 2005). Indeed, another study has also suggested that training across multiple exemplars of coloured stimuli may be effective in reducing the disruption attributable to competing sources of non-arbitrary stimulus control in an adult participant population (Kenny et al. 2014). Future research might explore the utility of exposing participants diagnosed with autism to such multiple exemplar training and testing procedures, to investigate if such an approach serves to reduce the disruptive effect of competing non-arbitrary relations in a Colour Test context.

A potential criticism of the current experiments concerns the use of verbal antecedents during training trials with both participant cohorts. When compared to typically developing children, children with autism may frequently have delayed receptive language skills (Chavez-Brown et al. 2005), and have been shown to respond more poorly to verbal antecedents, due to responding to non-salient features of the target stimulus (Maurice et al. 1996; Taber et al. 1998). Children diagnosed with autism typically use less eye gaze, engage in less joint attention and respond less to verbal interaction than do their counterparts without autism (Baker et al. 1998). It could be suggested that the use in the current experiments of a tabletop interactive approach and both verbal antecedents ("goes with") and verbal consequences for responses (e.g., "Well done, that's right") may have had a differential effect on the responding of both participant cohorts.

It was decided to use verbal antecedents and instructions in the current research, as normally developing children have been shown to have great difficulty in acquiring classes of conditional discriminations in the absence of instructions or a similar verbal context (Pilgim et al. 2000), and it could be reasonable suggested that children with autism might also struggle under similar training and testing conditions (Gorham et al. 2009; Berens and Hayes 2007). However, autistic participants in the current research attended the CABAS school system over a number of years, where a strong feature of the training involves the systematic use of verbal antecedents. Additionally, both vocal and non-vocal reinforcements used in the current experiments were matched to those used effectively during each participants schooling. In other words, the participants had a long history of responding under similar response conditions and the reinforcement contingencies closely matched those found to be most effective for each participant in the past. As such, the training procedures closely resembled the 'natural' learning situations for these children, thus maximising their effectiveness for learning outcomes (Lipkens et al. 1993). Further research may be needed, however, to further investigate any potential intergroup differences between these participant populations.

In summary, the results reported in the current article suggest the training and testing procedures used in both experiments were very effective in establishing repertoires of derived relational responding in normally developing children and children diagnosed with autism. However, the most significant result to emerge from the experiments in this article is the failure of the participants diagnosed with autism in Experiment 2 to maintain derived equivalence responding when a competing non-arbitrary relation was introduced after identical training and testing procedures. This result contrasts sharply with those observed for the normally developing children in Experiment 1, but is consistent with the previously reported related research literature (Ozonoff et al. 1991; Hughes et al. 1994; Bennetto et al. 1996; Pennington and Ozonoff 1996; Ozonoff and Jensen 1999; see Hill 2004 for review). These observed results suggest that children diagnosed with autism show a significantly higher level of disruption attributable to pre-experimentally established relational repertoires compared to their normally developing peers.

## References


American Psychiatric Association. (1994). Diagnostic and statistical manual of mental disorders (4th Ed.) Washington, DC.

Augustson, K. G., & Dougher, M. J. (1991). Teaching conditional discrimination to young children: some methodological successes and failures. *Experimental Analysis of Human Behavior Bulletin, 9*, 21–24.

Baker, M. J., Koegel, R. L., & Koegel, L. K. (1998). Increasing the social behavior of young children with autism using their obsessive behaviors. *Journal of the Association for Persons with Severe Handicaps, 23*(4), 300–308.

Baker, K., Segalowitz, S. J., & Ferlisi, M. C. (2001). The effect of differing scoring methods for the tower of London task on developmental patterns of performance. *Clinical Neurospsychologist, 15*(3), 309–313.

Barnes, D., Browne, M., Smeets, P. M., & Roche, B. (1995a). A transfer of functions and a conditional transfer of functions through equivalence relations in three to six year old children. *The Psychological Record, 45*, 405–430.

Barnes, D., Lawlor, H., Smeets, P. M., & Roche, B. (1995b). Stimulus equivalence and academic self-concept among mildly mentally handicapped and nonhandicapped children. *The Psychological Record, 46*, 87–107.

Barnes-Holmes, Y., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2001). Exemplar training and a derived transformation of functions in accordance with symmetry. *The Psychological Record, 51*, 287–308.

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, P. M., Strand, P., & Friman, P. (2004). Establishing relational responding in accordance with more-than and less-than as generalized operant behavior in young children. *International Journal of Psychology and Psychological Therapy, 4*, 531–558.

Bennetto, L., Pennington, B., & Rogers, S. (1996). Intact and impaired memory functions in autism. *Child Development, 67*, 1816–1835.

Berens, N. M., & Hayes, S. C. (2007). Arbitrarily applicable comparative relations: experimental evidence for a relational operant. *Journal of Applied Behaviour Analysis, 40*, 45–71.

Biro, S., & Russell, J. (2001). The execution of arbitrary procedures by children with autism. *Development and Psychopathology, 13*, 97–110.

Chavez-Brown, M., Scott, J., & Ross, D. E. (2005). Antecedent selection: comparing simplified and typical verbal antecedents for children with autism. *Journal of Behavioral Education, 14*(3), 153–165.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). Applied behavior analysis (2nd ed.). Upper Saddle River, NJ: Merrill/Prentice Hall.

Dymond, S., Rehfeldt, R. A., & Schenk, J. (2005). Non-autyomated procedures in derived stimulus relations: a methodological note. *The Psychological Record, 55*, 461–481.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: the role of naming. *Journal of the Experimental Analysis of Behavior, 58*, 123–133.

Etzel, B. C., Milla, S. R., & Nicholas, M. D. (1996). Arranging the development of conceptual behavior: A technology for stimulus control. In S. W. Bijou & E. Ribes (Eds.), *New directions in behavior development* (pp. 91–130). Reno: Context Press.

Fields, L., Adams, B. J., Verhave, T., & Newman, S. (1990). The effects of nodality on the formation of equivalence classes. *Journal of the Experimental Analysis of Behavior, 53*, 345–358.

Gorham, M., Barnes-Holmes, D., Barnes-Holmes, Y., & Berens, N. M. (2009). Derived comparative and transitive relations in young children with and without autism. *The Psychological Record, 59*, 221–246.

Greer, R. D., McCorkle, N. P., & Twyman, J. S. (1996). *Preschool Inventory of Repertoires for Kindergarten (P.I.R.K.)*. Yonkers: The Fred S. Keller School and CABAS.

Hayes, S. C., Gifford, E., & Ruckstuhl, L. E. (1996). Relational frame theory and a behavioural approach to executive function. In R. Lyon (Ed.), *Attention, memory, and executive function*. Brookes: Baltimore.

Hill, E. L. (2004). Executive dysfunction in Autism. *TRENDS in Cognitive Sciences, 8*(1), 26–32.

Holth, P., & Arntzen, E. (1998). Stimulus familiarity and the delayed emergence of stimulus equivalence or consistent non-equivalence. *The Psychological Record, 48*, 81–110.

Hughes, C., Russell, J., & Robbins, T. W. (1994). Evidence for executive dysfunction in autism. *Neuropsychologia, 32*(4), 477–492.

Huizinga, M., Dolan, C. V., & Van der Molen, M. V. (2006). Age related trends in executive function: developmental trends and a latent variable analysis. *Neuropsychologia, 44*, 2017–2036.

Kenny, N., Devlin, S., et al. Barnes-Holmes, D., Barnes-Holmes, Y., & Stewart, I. (2014). Competing arbitrary and non-arbitrary stimulus relations: The effect of exemplar training in adult participant. *The Psychological Record*. doi:10.1007/s40732-014-0004-4.

Lehto, J. H. (2004). A test of children's goal directed behaviour: a pilot study. *Perceptual and Motor Skills, 98*(1), 223–236.

Levin, H. S., Goldstein, F. C., Williams, D. H., & Eisenberg, H. M. (1991a). The contribution of frontal lobe lesions to behavioural outcomes of closed head injuries. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.), *Frontal lobe function and dysfunction* (pp. 318–338). New York: Oxford University Press.

Levin, L. H., Culhane, K. A., Hartmann, J., Evankovich, K., Mattson, A. J., Harward, H., et al. (1991b). Developmental changes in performance on tests of purported frontal lobe functioning. *Developmental Neuropsychology, 7*(3), 377–395.

Lipkens, G., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of derived stimulus relations in an infant. *Journal of Experimental Child Psychology, 56*, 201–239.

Luciano, C., Becerra, I. G., & Valverde, M. R. (2007). The role of multiple exemplar training and naming in the establishing derived equivalence in an infant. *Journal of Experimental Analysis of Behaviour, 87*, 349–365.

Maurice, C., Green, G., & Luce, R. S. (Eds.). (1996). *Behavioral interventions for young children with autism*. Austin: Pro-Ed.

McEvoy, R. E., Rogers, S. J., & Pennington, B. F. (1993). Executive function and social communication deficits in young autistic children. *Journal of Child Psychology and Psychiatry, 34*, 562–578.

McIlvane, W. J., Dube, W. V., Kledaras, J. B., Iennaco, F. M., & Stoddard, L. T. (1990). Teaching relational discrimination to individuals with mental retardation: some problems and possible solutions. *American Journal of Mental Retardation, 95*, 283–296.

Murphy, C., Barnes-Holmes, D., & Barnes-Holmes, Y. (2005). Derived manding in children with autism: synthesizing Skinner's Verbal

Behavior with relational frame theory. *Journal of Applied Behavior Analysis, 38*, 445–462.
O'Connor, J., Rafferty, A., Barnes-Holmes, D., & Barnes-Holmes, Y. (2009). The role of verbal behavior, stimulus nameability, and familiarity on the equivalence performances of autistic and normally-developing children. *The Psychological Record, 59*, 53–74.
O'Toole, C., Barnes-Holmes, D., Murphy, C., O'Connor, J., & Barnes-Holmes, Y. (2009). Relational flexibility and human intelligence: extending the remit of Skinner's *Verbal Behavior. International Journal of Psychology and Psychological Therapy, 9*, 1–17.
Ozonoff, S. (1995). Reliability and validity of the Wisconsin Card Sorting Test in studies of autism. *Neuropsychology, 9*, 491–500.
Ozonoff, S., & Jensen, J. (1999). Specific executive function profiles in three neurodevelopmental disorders. *Journal of Autism and Developmental Disorders, 29*(2), 171–177.
Ozonoff, S., Pennington, B. J., & Rogers, S. J. (1991). Executive function deficits in high functioning autistic individuals: relationship to theory of mind. *Journal of Child Psychology and Psychiatry, 32*(7), 1081–1105.
Pennington, B. F., & Ozonoff, S. (1996). Executive function and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*(1), 51–87. Roberts & Pennington, 1996.
Pennington, B. F., Rogers, S. J., Bennetto, L., Griffith, E. M., Reed, D. T., & Shyu, V. (1997). Validity test of the executive dysfunction hypothesis of autism. In J. Russell (Ed.), *Autism as an executive disorder* (pp. 143–178). Oxford: Oxford University Press.
Pilgim, C., Jackson, J., & Galizio, M. (2000). Acquisition of arbitrary consitional discriminations by young normally developing children. *Journal of the Experimental Analysis of Behaviour, 73*(2), 177–193.
Quill, K. A. (1995). *Teaching children with autism: Strategies to enhance communication and socialization*. New York: Delmar.
Saunders, K. J., & Spradlin, J. E. (1989). Conditional discrimination in mentally retarded adults: the effect of training the component simple discriminations. *Journal of the Experimental Analysis of Behavior, 52*, 1–12.
Saunders, K. J., & Spradlin, J. E. (1990). Conditional discrimination in mentally retarded adults: the development of generalized skills. *Journal of the Experimental Analysis of Behavior, 54*, 239–250.
Saunders, K. J., & Spradlin, J. E. (1993). Conditional discrimination in mentally retarded subjects: programming acquisition and learning set. *Journal of the Experimental Analysis of Behavior, 60*, 571–585.
Schilmoeller, G. L., Schilmoeller, K. J., Etzel, B. C., & LeBlanc, J. M. (1979). Conditional discrimination responding after errorless and trial-and-error training. *Journal of the Experimental Analysis of Behavior, 31*, 405–420.
Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research, 14*, 5–13.
Sidman, M. (1994). *Equivalence relations and behaviour: A research story*. Boston: Authors Cooperative, Inc.
Sidman, M. (2000). Equivalence relations and the reinforcement contingency. *Journal of the Experimental Analysis of Behavior, 74*, 127–146.
Sigman, M., Ungerer, J. A., Mundy, P., & Sherman, T. (1987). Cognition in autistic children. In D. J. Cohen & A. M. Donnellan (Eds.), *Handbook of autism and pervasive developmental disorders* (pp. 103–120). New York: John Wiley & Sons.
Skinner, B. F. (1957). *Verbal behavior*. Englewood Cliffs: Prentice-Hall.
Stewart, I., Barnes-Holmes, D., Roche, B., & Smeets, P. M. (2002). Stimulus equivalence and non-arbitrary relations. *The Psychological Record, 52*, 77–88.
Taber, T. A., Alberto, P. A., & Fredrick, L. D. (1998). Use of self-operated auditory prompts by workers with moderate mental retardation to transition independently through vocational tasks. *Research in Developmental Disabilities, 19*, 327–345.
Turner, M. (1999). Repetitive behaviour in autism: a review of psychological research. *Journal of Child Psychology and Psychiatry, 40*, 839–849.
Watt, A., Keenan, M., Barnes, D., & Cairns, E. (1991). Social categorization and stimulus equivalence. *The Psychological Record, 41*, 33–50.
Welsh, M. C., Pennington, B. F., & Grossier, D. B. (1991). A normative developmental study of executive function; A window on prefrontal function in children. *Developmental Neuropsychology, 7*(2), 131–149.
Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. *Journal of Autism and Developmental Disorders, 9*, 11–29.
World Health Organisation. (1992). *The ICD-10 classification for mental and behavioural disorders: Clinical descriptions and diagnostic guidelines*. Geneva: WHO.
Zygmont, D. M., Lazar, R. M., Dube, W. V., & McIlvane, W. J. (1992). Teaching arbitrary matching via sample stimulus-control shaping to young children and mentally retarded individuals: a methodological note. *Journal of the Experimental Analysis of Behavior, 57*, 109–117.