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RESEARCH ARTICLE

Assessing and Training Comparative Relations in Children with Autism Spectrum Disorder

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Children with Autism Spectrum Disorder (ASD) often present with developmental deficits in the area of generative verbal behaviour and the ability to accomplish arbitrary applicable relational responding (AARR). This study used Relational Frame Theory and the Training and Assessment of Relational Precursors and Abilities assessment protocol in the form of table-top tasks to assess and train comparative relations in three boys with ASD. On exposure to multiple exemplar training (MET), all three participants successfully reached mastery criterion on four separate stages of training. This provides evidence that MET can be used to teach AARR in individuals with ASD.

Keywords: Relational Frame Theory; Autism Spectrum Disorder; Arbitrarily Applicable Relational Responding

Typically developing children acquire levels of linguistic and cognitive performance based on normal levels of socioverbal interaction. However, many children with Autism Spectrum Disorders (ASD) cannot learn these repertoires in this way and thus present with communicational and other deficits. Research conducted over the past two decades has outlined that both typically developing children and children with ASD are capable of improving in many areas of development, such as language, using interventions based on the principles of applied behaviour analysis (Dixon, Belisle, Stanley, Daar, & Williams, 2016; Harris & Handleman, 2000; Lovaas, 1987) Although many children with ASD do reach age-typical linguistic milestones, a considerable number of this population continues to need intensive teaching as their language skills are "rote" (Ming, Moran, & Stewart, 2014). Research suggests that many children with ASD are unable to develop the ability to create and understand sentences that they have neither said nor heard before, known as generative language (Greer & Ross, 2008). The phenomenon of generative language has proven difficult to teach within applied behaviour analysis; however, developments in derived stimulus relations have provided promising research that will help (Rehfeldt & Barnes-Holmes, 2009).

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Derived Equivalence

One important development with derived stimulus relations is the phenomenon of derived stimulus equivalence. Derived stimulus equivalence is an example of derived relational responding (DRR). It is defined by three relations, namely reflexivity (X = X), symmetry (if X = Y, then Y = X) and transitivity (if X = Y and Y = Z, then X = Z). Sidman (1971) first empirically established derived stimulus equivalence with a young man with a learning disability in order to teach him to read. Initially the participant was able to use spoken words (X) when shown a picture (Y), and could select the correct picture (Y) when given the spoken word (X). The study involved teaching the participant to select printed words (Z) when presented with spoken words (X). Furthermore, the participant showed numerous untaught derived responses; such as emitting the correct spoken word (X) when shown a printed word (Z), and matching pictures (Y) to the correct printed word (Z). The participant could correctly respond to stimuli as if they were equivalent.

Research has shown that there is a link between stimulus equivalence and language. For example, derived equivalence relations have been shown to develop in tandem with language ability among typically developing individuals (Lipkens, Hayes, & Hayes, 1993). In contrast, individuals with severe language deficits are unable to show equivalence (Dugdale & Lowe, 2000). A theory is required to explain such deficits: Relational Frame Theory.

Relational Frame Theory

Relational Frame Theory (RFT) indicates that language and derived relations, including equivalence, are fundamentally the same phenomena. More specifically, generalised contextually controlled arbitrarily applicable relational responding (AARR), or simply relational framing (Ming et al., 2014). RFT offers a functional-analytic explanation of language and cognitive phenomena (Roche, Barnes-Holmes, Barnes-Holmes, Stewart, & O'Hora, 2002). Most species, including humans, display generalised relational responding with physical properties (e.g., identity matching, or identifying an object that is bigger or smaller than another object—this is called non-arbitrary relational responding; (Stewart & McElwee, 2009). These are relations that are based on physical properties of the stimuli that are being related. AARR, on the other hand, refers to another type of generalised relational responding that is learned, known as operant learning. This type of generalised relational responding relies on contextual cues as opposed to the physical properties of the related objects; for example, if I tell you that A is the same as B and B is the same as C, then you could derive several further relations including that B is the same as A, C is the same as B, A is the same as C, and C is the same as A. This relation is an example of sameness or coordination, which appears to be the foundation of framing (Moran, Stewart, McElwee, & Ming, 2014). In this example, the sequence of derived relational responding is not established on the physical properties of the letters, it is based on the contextual cue "same as". RFT theorists argue that contextual cues are established and learned through our reinforcement history, which is what allows organisms to respond in accordance with a sequence of stimulus equivalence (Ming et al., 2014). In addition to sameness, a variety of other patterns of derived relations have been demonstrated by RFT researchers, including distinction (Roche & Barnes, 1997), opposition (Barnes-Holmes, Y., Barnes-Holmes, D., & Smeets, 2004; Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, Strand, & Friman, 2004), analogy (Stewart, Barnes-Holmes, & Roche, 2004), temporality (O'Hora, Barnes-Holmes, Roche, & Smeets, 2004), deixis (McHugh, Barnes-Holmes, Y., & Barnes-Holmes, D., 2004) and comparison (Berens & Hayes, 2007). It is argued that the complexity, diversity, and generativity of human language is founded in the variety of relational frames.

Multiple Exemplar Training

From an RFT point of view, DRR is defined as generalised contextually controlled patterns of responding that are formed from a history of multiple exemplar training (MET), whereby functions of contextual cues control the response. MET is used as a means of establishing covert mediational processes to encourage DRR through exposure to contingencies of reinforcement (Stewart & McElwee, 2009). There is empirical evidence to suggest that MET can deliberately train framing repertoires in typically developing young children for whom they are absent (e.g., Vizcaíno-Torres et al., 2015). The first form of DRR that can be established is responding in accordance with coordination (“sameness”); this is the ability to derive the untrained relation between a word and an object after being taught the relation between that object and a word. This pattern is learned through access to reinforcement contingencies from an early age. Furthermore, RFT suggests that following training on a number of name-to-object and object-to-name exemplars, the “naming” or labelling of stimuli is established in the behaviour repertoire of the individual. Once the generalised operant of naming or labelling of the stimuli has been acquired, an individual is expected to have the skill to derive an untrained symmetrical relation from a taught relation, despite the physical properties of the word-object pair; (e.g., hear name A, look at object B, and relate them bidirectionally). RFT researchers such as Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, Strand and colleagues (2004) consider the derived relations of naming and stimulus equivalence as examples of contextually controlled relational responding. RFT research has shown that reinforced MET can facilitate the development of DRR. Over the past 10 years or so, there have been a number of studies that have demonstrated the use of MET to teach various framing relations in different populations in whom they were deficient or absent.

Barnes-Holmes, Y., Barnes-Holmes, D., Smeets, Strand and colleagues (2004) successfully demonstrated the use of MET in training AARR for opposite relations. They used abstract stimuli (paper “coins”) and arbitrarily assigned values (being able to buy “more” or “less” sweets with different coins). The participants in this study included three typically developing children, who were taught specific relations among “coins” (e.g., A > B > C or A < B < C). Once these relations were taught, the participants were asked to choose the coin that they would or would not use to purchase as much candy as possible. None of the participants could successfully perform in accordance to the tests. As a result, training was repeated, but with correction/reinforcement following incorrect/correct responding. MET was introduced, including training and testing across a number of different sets of stimuli. Following extensive MET, the three participants could successfully demonstrate generalized responding with comparative relations. Berens and Hayes (2007) replicated and extended the previous study where they adopted a multiple probe design. Their protocol involved a task involving same-size coloured stimuli (i.e., coloured coins) whereby children were provided with the contextual cues of “more” or “less” to establish arbitrary relations between the stimuli. The participants were then tested on their ability to derive the appropriate comparative relations. Berens and Hayes (2007) adopted a multiple-probe design whereby they showed that reinforced MET facilitated the development of arbitrary comparative relations. Furthermore, these skills were generalised across both stimuli and trial types. The researchers incorporated nonarbitrary training into their study by teaching the participants to respond correctly to physically different quantities of coins under the contextual cue of “more” or “less” prior to testing them for DRR with arbitrary stimuli.

Gorham, Barnes-Holmes, Y., Barnes-Holmes, D., and Berens (2009) subsequently replicated and extended this work to children with ASD as well as typically developing children, yielding similar results. Two studies were conducted, (Gorham et al., 2009), whereby the participants were presented with problem-solving tasks using coins in order to test and train the arbitrary relations of more than and less than. Study 1 consisted of a baseline phase that tested the relational repertoires of the participants. Following this, there were eight different phases to test and train the target relations. The further eight stages included testing A-B relations, testing B-C relations, testing A-B-C relations, testing A-B-C-D relations, training A-B relations, training B-C relations, training A-B-C relations, and training A-B-C-D relations. In Study 1, there were eight children, all of whom failed the baseline tests; however, seven of the participants were successful in the training phase and managed to demonstrate more-than and less-than relations with a novel set of stimuli. The aim of Study 2 was to build on the repertoires that had been established in Study 1 by extending the target relations to five coins instead of four. Study 2 was carried out in the same was as Study 1 with four typically developing children and two children with ASD. The typically developing children were successful in further developing the target relation. However, the children with ASD required an additional intervention whereby the children's attention was explicitly drawn to the stimuli. This intervention was then faded out, after which the ASD group could successfully derive the target relations in multiple novel exemplars.

Rehfeldt, Dillen, Ziomek, and Kowalchik (2007) conducted a study using MET to establish deictic framing in two typically developing children. During the initial testing stages, relational operants for simple, reversed, and double-reversed relations for I-you, here-there, and now-then were absent among these participants. Although this study used a smaller sample size than typical of this type of research, they used the protocol from McHugh and colleagues (2004) whereby participants were first trained in simple relations until they reached a mastery criterion of 90%. Once simple relations were established, training on reversed relations commenced; a mastery criterion of 90% was required also. Using this approach, Rehfeldt and colleagues(2007) successfully established these relations.

Cassidy, Roche, and Hayes (2011) also demonstrated the use of MET to establish various relational frames. Their work consisted of two studies designed to test the effectiveness of automated multiple-exemplar relational training in raising children's general intellectual skills. In Study 1, four participants were exposed to MET in stimulus equivalence and the relational frames of SAME, OPPOSITE, MORE THAN, and LESS THAN across several sessions and weeks. Wechsler Intelligence Scale for Children (WISC III-UK; Wechsler, 1991) measures were taken at baseline, following stimulus equivalence training, and again following relational frame training. When matched against a no-treatment control group, experimental participants showed significant improvements in full-scale IQ following stimulus equivalence training, and a further significant rise following relational frame training. Study 2 administered an improved MET based relational frame training intervention to eight children with a range of educational and behavioural difficulties. In seven out of eight cases, full-scale IQ as measured by the WISC (IV-UK; Wechsler, 2003) rose by at least one standard deviation and the improvement was statistically significant at the group level.

The literature evidently shows that the majority of research has been conducted among a typically developing population. As previously mentioned with regards to RFT, and the development of generative language; usually, typically developing children learn and develop these skills through their natural environment in accordance with their typical stages of developmental milestones. However, children with ASD have a deficit of these skills, and therefore, it is important to teach them (Greer & Ross, 2008). Basic language skills, including requesting and labelling can be taught as a part of early intervention programs; however, children with ASD often still present with little functional language flexibility (Moran et al., 2014). With this in mind, more research is clearly warranted to establish DRR skills and the teaching of various relational frames. Most of the research to date that has taught comparative frames using MET, only includes typically developing participants. There have been two studies that have included both typically developing children and children with ASD (i.e., Gorham et al., 2009; Murphy & Barnes-Holmes, 2010); however, there have been no studies to date that have explicitly focused on children with ASD alone regarding teaching comparative relations using MET.

An assessment and training method for relational framing, the Training and Assessment of Relational Precursors and Abilities (TARPA; Moran et al., 2014), tests the critical key forms of responding in order to develop generative verbal behaviour by training various forms of relational framing. The purpose of this study was to evaluate the degree to which multiple-exemplar training can be used to establish derived relational responding in accordance with a comparative frame in children diagnosed with ASD. The TARPA is typically a multi-level computer-based protocol that assess a number of key forms of responding that appear to be critical to enhance the development of generative behavior. However, in the current study, the TARPA was adapted to use as a table-top activity. Initially, in this study, the TARPA was considered a testing method that assesses individuals' abilities to learn repertoires necessary for the derivation of relations in order to derive comparative relations themselves. Thereafter it is a training procedure in order to establish comparative relational responding. The hierarchical ordering and content of the stages of the TARPA are, according to theory and previous research, based on simple discrimination skills and conditional discrimination skills with arbitrary and non-arbitrary stimuli. TARPA is theoretically situated in RFT and covers a wide range of skills, such as relational responding and relational framing.

Multiple Baseline Design

Applied Behaviour Analysis research typically employs a single-subject research design, where the data is collected on each participant and individually analysed, (Johnston & Pennypacker, 1993). Control of the independent variable (IV) over the behaviour is demonstrated if the behaviour can be altered at will by altering the experimental conditions, (Kazdin, 1973); therefore, each participant serves as his or her own control. The type of single-subject research design used in this study will be a multiple-probe across participants design, a variation of the multiple baseline design. This design consists of applying the IV to one participant at a time, while baseline conditions are maintained for all other participants. It has been shown that a minimum of 3 baselines is sufficient to establish confidence in controlling effects (Kazdin & Kopel, 1975; Wolf & Risley, 1971). The sample size for this study consisted of three participants, this is consistent with previous research in this area.

Method

Assessment and training was carried out using the TARPA assessment protocol in the form of table-top tasks. The assessment procedure consisted of six phases, and the training procedure consisted of four phases. Using a multiple baseline design across participants, MET was employed in an attempt to establish arbitrary and non-arbitrary applicable responding in accordance with comparative relations in three boys with ASD. The study took place between January 2016 and March 2016.

Participants

Information sheets and consent forms were distributed in an ASD unit in a primary school. The primary caregivers of seven students responded expressing interest for their child to participate in this study. The potential participants were all male, aged between 5–10 years. Following the TARPA assessment, which tested the participants' ability to respond to non-arbitrary and arbitrary relations, three boys were eligible to participate. The other four boys were ineligible as they successfully demonstrated arbitrary and non-arbitrary responding during testing; and arbitrary comparison was the target of training.

Participants were three boys diagnosed with ASD (Killian, Kasper, & Kuba) whose parents responded to the information sheet distributed in their primary school. The three participants were previously diagnosed with ASD by a multi-disciplinary team and attended a special unit in the school for children with ASD. The participants were required to be able to non-arbitrarily respond correctly to more/less relations. During an initial pre-experimental meeting, the participants' teacher was given an informal questionnaire regarding the children's preferred items in the classroom. The teacher filled out the Vineland Adaptive Behavior Scale (VABS), teacher's edition (Carter et al., 1998). A Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007), was carried out in order to determine language ability of the participants. These two tests were selected to test the participants' verbal abilities without exhausting the students prior to their participation in the intervention. The ages at initiation and completion, number of trials to completion, VABS performances (expressive and receptive verbal age) and PPVT-IV performances of the participants are outlined in Table 1.

Table 1. Demographic Information and Trials to Completion.

Participant	Age at initial session	VABS verbal age (receptive)	VABS verbal age (expressive)	PPVT-IV age	Trials to completion	Age at completion
Kasper	6 years 5 months	3 years 4 months	< 3 years	4 years 6 months	35	6 years 6 months
Killian	6 years 11 months	3 years	3 years 8 months	4 years 8 months	41	7 years
Kuba	6 years 2 months	< 3 years	< 3 years	4 years 9 months	52	6 years 3 months

Note. VABS = Vineland Adaptive Behavior Scale (VABS), teacher's edition by A.S. Carter and colleagues (1998); PPVT-IV = A Peabody Picture Vocabulary Test by L.M. Dunn and D.M. Dunn (2007).

Apparatus and materials

The sessions were conducted in the special class for children with ASD in the participants' school. During the sessions, participants were seated at a table to the right of the researcher who implemented the training. The table was placed against a blank wall in order to minimize distractions. Each child engaged in a session for 30 min, three times per week for 5.5 weeks. When a child reached mastery criterion on the final phase, they no longer participated in the study.

Experimental materials included three stimuli in the form of pictures of cartoon animals—an elephant, a monkey, and a lion (see Figure 1). The use of stimulus sets in this study was similar to the one employed in Berens and Hayes (2007) who trained comparative relations in typically developing children. For communication purposes, these animals will be referred to as animal A, animal B, and animal C; however, participants were aware of this. Each of these animals was accompanied by a picture of a coloured box, a red box, a blue box, and a green box. Other materials included reinforcers for the participants which were preferred items (e.g., toy car, spinning top).

TARPA Assessment

Phase 1: non-arbitrary (more). On each trial of phase 1, the researcher presented four pictures to the participant; two of which were different animal characters, and two of which showed the number of candies each animal respectively owned. For example, the child was shown a picture of animal A with a picture of two candies beside it, and animal B with a picture of four candies beside it. The child was then asked which character had more; a correct response required the child to select the correct animal. The Demonstration, Guidance, Independent

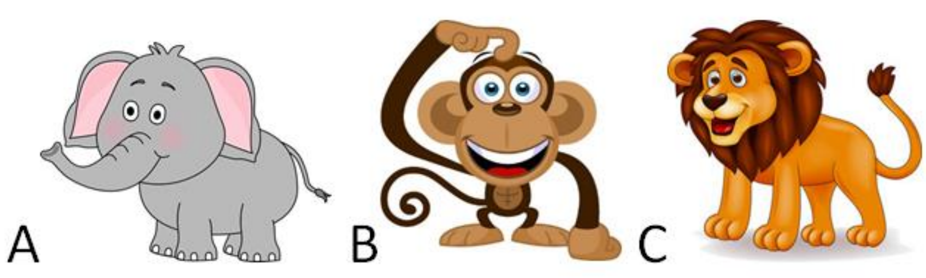

Figure 1. The cartoon animals that were used in the experiment.

(DGI) training procedure was used. On the first trial of each phase, the researcher demonstrated the correct response, the participant was then guided to making this response; the child was given the opportunity to respond independently. Thereafter, the participant was allowed to respond independently until they made an incorrect response; whereby they were then once again exposed to the DGI method to demonstrate and guide the correct response. When the participant responded correctly during a trial, reinforcement was presented. This process continued until the participant either got eight consecutive answers correct (after which they passed onto the next phase), until the child got a total of eight incorrect responses (whereby assessment for that phase finished) or until the session came to an end.

Phase 2: non-arbitrary (more & less). This is the same as Phase 1; except, on some trials the child was asked which animal had more candy, while on others they had to say which animal has less. As in Phase 1, the process continued until the child got eight consecutive responses correct, a total of eight incorrect ones, or until the session came to an end.

Phase 3: arbitrary mutual entailed (more). During this phase, for every trial, two animal characters were presented to the participant simultaneously. Each animal was accompanied by a covered box, which the child was told contained candy. The participant was informed that one animal had more than the other; they were then asked who had less. A correct response during this phase required deriving a correct answer in accordance with arbitrary comparative relations.

Phase 4: arbitrary mutual entailed (more & less). Phase 4 was conducted in the same way as Phase 3; however, on some trials the participant was informed by the researcher that one animal had more candy and subsequently they were required to derive which of the two had less. On the other trials, the participant was told which animal had less and had to derive which of the two had more.

Phase 5: arbitrary combinatorial entailed (more). During this phase, a third animal character was introduced (i.e. animal C), which was accompanied by a covered box. For the purpose of this experiment the animals were referred to as A, B, and C. Participants are told that A has more candy than B, and that B has more candy than C. Participants are then asked who (of A or C) has less candy; the relation that they are required to derive.

Phase 6: arbitrary combinatorial entailed (more & less). This phase was the same as Phase 5; however, on some trials the two relations provided were "more than" relations, while on other trials the relations were "less than".

Participants who passed the first two stages in the TARPA assessment stages but failed the remaining four stages were selected for the study.

Training

The children who progressed into the training phase were trained using the TARPA intervention. Stages 1–4 in the training procedure were conducted in the same way as the assessment stages 3–6; however, during the training stages, correct responses in trials were reinforced using preferred items. When an incorrect response occurred, the researcher demonstrated the correct response until the participant gave a correct response. A phase was considered mastered when a participant made eight consecutive correct responses within the same trial.

Procedure

Phase 1: arbitrary mutual entailed (more). At the start of each trial in Phase 1, two animal characters were presented to the participant. Each animal was accompanied by a covered box, which the participant was told contained candy. The child was informed that one animal had more candy than the other; they were then asked who had less. A correct response during this phase required deriving a correct answer in accordance with arbitrary comparative relations. Each correct response was reinforced using a preferred item. If the participant provided an incorrect response, the researcher used the DGI procedure to correct the participant. Concretely, the researcher first demonstrated the correct response, after which the participant was guided into making this response, and then finally, the child was given the opportunity to respond independently, receiving reinforcement for a correct response. Thereafter, the participant was allowed to respond independently, receiving reinforcement for every correct response, until they made an incorrect response; whereby they were then exposed to the DGI method again. Mastery criterion for each phase was eight consecutive correct responses before the participant could move onto the next phase.

Phase 2: Arbitrary mutual entailed (more & less). Trials in Phase 2 were conducted in the same way as Phase 1 in the training phase; however, this time, on some trails, the participant was informed that one animal had more candy and they were required to derive who had less. On the other trials, the participant was told which animal had less and had to derive who had more. The participant received reinforcement for correct responses made, just as in Phase 1. Whenever the child emitted an incorrect response, the DGI procedure was used. Mastery criterion was eight consecutive correct responses.

Phase 3: Arbitrary combinatorial entailed (more). During Phase 3 of the training procedure, the third animal character was introduced (e.g., a lion), which was accompanied by a covered box. Participants were told that A has more candy than B, and that B has more candy than C. Participants were then asked who (of A or C) has less candy; the relation that they were required to derive. When the participant gave a correct response, that behaviour was reinforced with a preferred item. Incorrect responses were trained using the DGI procedure. To achieve mastery, the child was required to make eight consecutive correct responses.

Phase 4: Arbitrary combinatorial entailed (more & less). Trials during this phase were conducted in the same way as Phase 3; however, on some trials the two relations provided were "more than" relations, while on other trials the relations were "less than". As in all of the training stages, correct responses were followed by reinforcement; and incorrect responses were trained using the DGI procedure. Mastery criterion was eight consecutive correct responses.

Design

Multiple baseline across participants. A multiple baseline and multiple probe design, training all four stages across participants was employed in order to control for maturation and extra-experimental contingencies. The next participant started the intervention phase once the previous participant completed four or more trial blocks in the first phase; for example, the first participant was required to complete four trials in Stage 1, thereafter the second child could start the training phase. This was important to probe test for generalisation to untrained stimulus sets in participants.

Multiple probes across stimulus sets. A multiple probe across two stimulus sets of trials (Sets 2 & 3) was used in order to evaluate the effect of reinforced responding on generalisation to untrained stimulus sets. The TARPA assessment included all sets of trials. Set 1 was used for the first phase until the participants met mastery criterion. Following mastery of Set 1, probes were carried out during each phase in order to test for generalisation to Sets 2 and 3; these were tested in random order.

Inter-observer Agreement

For 50% of the trials (25 trials in total), a second data collector independently scored each response as correct or incorrect based on the criteria outlined above. These trials consisted of a mix of baseline and training trials, depending on the availability of the second data collector; furthermore, they observed each child at least once. The second data collector was a teacher in the primary school where the study was conducted; they had also completed a Registered Behaviour Technician course at the university. The second data collector was required to reach 100% accuracy in two consecutive mock trials before they could score a real trial. Agreement data was collected across all participants and at least once during each phase. Observers reached agreement when they both scored a trial as being correct or incorrect. Disagreement occurred when the observers recorded a trial differently. A percentage agreement was calculated by dividing the total agreements by the combined total of agreements and disagreements and multiplying by

100. The percentage of total agreement scores was 98.6%.

Results

Figure 2 represents the data from all participants on all of their baseline performances across all stimulus sets. The analysis of the baseline trials for all participants indicates that none of the students demonstrated arbitrary relational responding in accordance with comparative frames during baseline. It is clear that all participants performed poorly on comparative relational tasks during each baseline session, and there were no improvements in the baselines 2, 3, and 4. Trials were delivered in blocks of eight. This data indicates that the participants did not have the targeted arbitrary comparative relational responses in their repertoire. Each participant will be discussed individually.

Kasper

Kasper took nine trial blocks to reach mastery criteria for Phase 1 (see Figure 2). His relatively slow acquisition of the targeted relational response during this phase is additional evidence that he did not previously have it in his repertoire. Kasper's exposure to his second baseline block showed poor responding to the second phase of the intervention. During the second training phase Kasper required only three trial blocks before reaching mastery criterion; showing relatively rapid acquisition after having received the training for Phase 1. During Phase 2, a second set of stimuli was introduced on the second trial block in order to test for the effectiveness of MET and generalisation; Kasper responded to seven trials correctly in this trial block. Although he did not reach mastery criterion until the following trial block, seven correct trials demonstrated good generalisation using a new stimulus set.

The third baseline set of trials demonstrated poor responding again which showed that Kasper did not have arbitrary responding in accordance with comparative relations in his repertoire. However, he successfully reached mastery criterion within five trials. As in Phase 2, new stimuli, Set 3, was introduced to serve as a probe during the third trial block in Phase 3. He responded well to the third stimulus set as he presented with seven correct responses; again, demonstrating generalisation. Although there was initially a low level of responding during baseline four, Kasper demonstrated the target response for a maximum of five trials showing he acquired the skill from the previous training phase as there was a mixture of "who has more/who has less" questions asked.

The acquisition of arbitrary responding in accordance to comparative relations was further demonstrated as it only required two trial blocks for Kasper to reach mastery criterion. Stimulus Set 2 was presented to Kasper on the final trial block, whereby he got a total of eight correct responses; demonstrating generalisation of the target relation. In total, it took 35 trials overall for Kasper to reach mastery criterion.

Killian

Overall, Killian required 41 sessions to reach mastery criterion. Killian had an extended baseline as he was the second participant in the study to be trained in target relational responding. His responding during the first baseline trial blocks was poor, confirming that deriving comparative relations was not previously in his repertoire. During Phase 1 of training, Killian reached mastery criterion in a total of eight trial blocks. When exposed to the second baseline, Killian's arbitrary responding returned to relatively low levels, reaching a maximum of four correct responses in a trial block. However, Killian acquired the target relational responding rather rapidly, taking only three trial blocks. During the Phase 2 teaching trial blocks, Killian was exposed to stimulus Set 2 on the third trial block, where he reached mastery criterion. Killian required six trial blocks to meet the mastery criteria for Phase 3; however, the third baseline suggested that he acquired some arbitrary responding as a result of the previous phases, since he responded correctly to five trials during baseline. On the other hand, his baseline for the fourth phase suggested that he did not retain the target relational responding as his numbers of correct answers were relatively low, reaching a maximum of four in a trial. However, Killian reached mastery criterion rapidly in the fourth training phase, getting a total of eight correct consecutively on the first trial block. The trial block in the fourth training phase consisted of the third stimulus set, with Killian's score thus demonstrating generalisation and the effectiveness of MET.

Kuba

Kuba was the third participant to receive the intervention in this study, therefore, his first baseline was the longest. Kuba required ten trial blocks to reach the mastery criteria in Phase 1, slightly longer that the other two participants. The sixth trial block in Phase 1 demonstrated unstable responding (see Figure 2); however, the next four trial blocks showed increased levels of responding in accordance to the target relation. Baseline during phase 2 showed relatively lower rates of correct responding than the previous training phase. There was an initial decrease in accuracy during training Phase 2; however, the fourth trial block in the training phase showed an increase again. Kuba took a total of eight trial blocks to reach mastery criterion in Phase 2. The seventh trial block in Phase 2 consisted of stimulus Set 2; resulting in seven correct responses. These levels of responding were respectively lower than

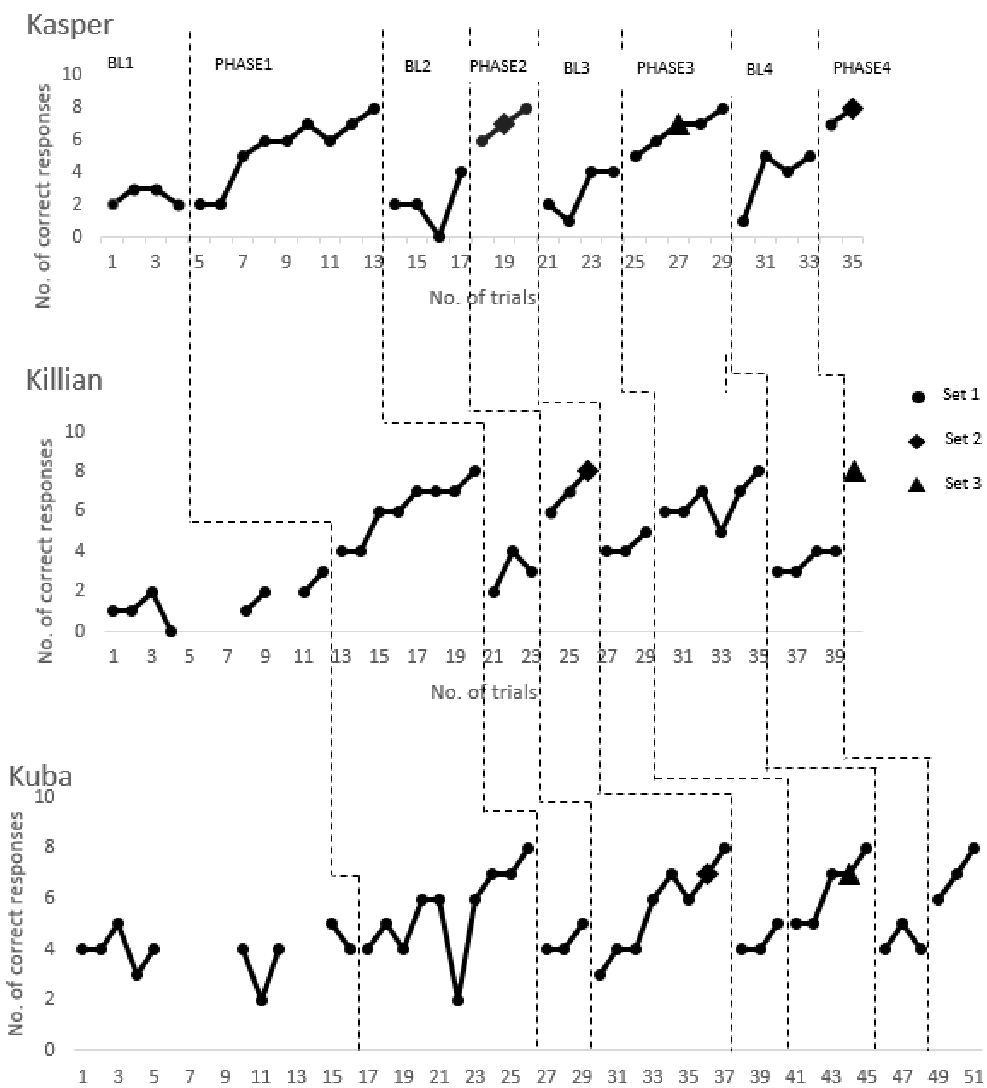

Figure 2. Results for all 3 participants showing four baselines trial blocks and four training phases. The three different stimulus sets are represented by three different types of data points.

the previous two participants during this Phase of the intervention.

Baseline 3 was Kuba's first exposure to arbitrary relational responding in accordance with comparative relations. His level of responding during baseline in phase 3 was at a stable level before training Phase 3 was implemented in order to teach derived comparative relations. Kuba's correct responding continuously increased during training phase 3; he reached mastery criterion in a total of five trial blocks. The fourth trial block in Phase 3 consisted of stimulus Set 3, where correct responding was designed to demonstrate generalisation and the effectiveness of MET. The correct responses emitted during the fourth baseline phase demonstrated the acquisition of derived arbitrary responding taught in Phase 3; however, he had not yet derived the "less than" relation at this point. This relation was taught in the following phase, Phase 4. Kuba showed rapid acquisition of the "less than" relation with three stimuli reaching mastery criterion in only three trial blocks. This was the most rapid learning demonstrated by Kuba in all four stages. Overall, Kuba reached mastery criterion in all four phases in 52 trial blocks.

Discussion

The present study focused on the effects of multiple-exemplar training to establish derived relational responding in accordance with comparison (more/less) in children with ASD using the TARPA protocol in table-top form. All three participants were successful in establishing comparative relations in all four phases through the use of multiple exemplar training. This study supports previous literature that provides controlled evidence that relational frames can be taught and learned. In addition, the data in this study further strengthens the concept that non-arbitrary relational responding fosters the development of arbitrarily applicable derived relational responding (Berens & Hayes, 2007), as all three participants already had non-arbitrary responding in their repertoire.

The initial baseline for all three participants indicated that they were all deficient in demonstrating the targeted relational response. Each child was tested and analysed individually; and the extended baseline for Killian and Kuba further supported the fact that these children had not learned to derive comparative relations consistently through their natural environments. The children were exposed to four separate baselines throughout the study which indicates that the target performances did not develop as a result of the repeated baseline testing alone.

After specific DGI training of the comparative relational responding, all three participants successfully demonstrated the target relational responding of all three stimulus sets. When the children were subjected to reinforcement across multiple examples of comparative relations, (e.g., pictures of candies, soccer balls, or pencils), responding improved on all stimulus sets. The term frame indicates that stimulus generalisation is important regarding relational framing (Berens & Hayes, 2007) as relational framing is arbitrarily applicable whereby cues can encourage patterns of relational responding with any stimuli.

Overall, there were no major differences observed between the training and testing profiles of the participants. This is unsurprising as the three children were at similar ages (chronological, VABS equivalent age, & PPVT equivalent age). Although only one of the baseline trial blocks for 2 of the participants resulted in zero correct responses (Killian & Kasper; see Figure 2), levels of correct responding during the baseline trial blocks was relatively low for all participants. Kuba presented with higher levels of correct responding in his baseline tests; however, he did not reach eight consecutively correct responses until the training stages were conducted. This shows that he was unable to consistently respond correctly in accordance with comparative relations before being explicitly exposed to the training.

Michael (1993) highlighted the importance of motivation manipulation in behaviour analysis in order to better control behaviours and teach new skills. The first two participants (Kasper & Killian) acquired the target relations relatively quickly; there are a number of possibilities as to why this happened. Firstly, these two children may have been particularly motivated by the materials in the intervention, increasing their level of correct responding. Secondly, their reinforcers, which were identified by their teacher, may have been especially potent, increasing the motivational value of a correct response. McCarthy and colleagues (2015) found that participants were likely to choose and complete harder tasks dependent on the level of reinforcement they would receive for correct responses. For instance, the stronger the reinforcer, they were more likely to attempt and complete the more difficult tasks in the experiment. In this study, the first two participants were not overly subjected to the element of boredom as their baselines were not too extensive; therefore, maintaining a high level of stimulation in the materials and reinforcers they were exposed to. And finally, it is likely that due to the number of correct responses in their baseline trial blocks, they may have been exposed to comparative relational responding prior to this study; resulting in a higher rate of learning and increasing correct responses.

Kuba took a little bit longer that the other two participants to reach mastery criterion in the training stages; there are a number of possible reasons as to why this pattern occurred. As Kuba was the final participant to receive the intervention, he was subjected to a longer initial baseline suggesting that this extended exposure to the materials decreased his motivation to respond. This is further supported by Kuba's lack of attention during the training stages in the intervention. Although Kuba's teacher identified his most potent reinforcer in the classroom, this may not have been motivating enough for the tasks presented in this study; resulting in lower levels of correct responding during trial blocks, as highlighted by McCarthy and colleagues (2015) previously. However, during the final training phase, he reached mastery criterion relatively quickly, suggesting that his motivation may have increased again.

All three participants passed the non-arbitrary relational framing test in the initial TARPA pre-intervention. They were required to have non-arbitrary relational responding in their repertoire in order to establish arbitrary applicable derived relational responding. The connection between the importance of non-arbitrary relations as a foundation for AARR has been suggested by extensive research in RFT (Barnes-Holmes, Barnes-Holmes, Smeets, et al., 2004; Steele & Hayes, 1991). As this was pre-experimentally assessed, none of the participants required further training in non-arbitrary relations. As the participants had this in their repertoire, they appeared to be able to learn the arbitrary applicable derived relational responding rather quickly overall.

As is the case with any scientific study, this one also has some limitations that deserve to be acknowledged. One limitation relates to the issue that the longer the third participant remained in the study, the greater the possibility that external variables influenced their learning. This is possible as the number of trial blocks required to reach mastery criterion in each phase decreased in length. Furthermore, there were inconsistencies in some of the baseline trial blocks, suggesting that external variables may have influenced learning. Another limitation to this study is that the sessions were conducted in a classroom with other lessons taking place; this may have caused some level of distraction for the participants. It may have been more suitable to conduct the sessions in a quiet room on a one-to-one basis in order to result in more consistent levels of responding. A further limitation is that it was conducted using simple table-top materials. Although this simplified the study, conducting the experiment on a computer or iPad using the TARPA software may have shown more accurate levels of responding as the child would have to select a correct or incorrect option on a computer; the computer would record the responses. Also, it would have allowed for lower levels of potential researcher delivery error; for example, accidental prompting. A final limitation to this study is the absence of follow-up testing. Given the time-frame available to conduct the research, it was not possible to complete a follow-up assessment of skills in order to determine if comparative relations had been maintained among the participants.

A possible intervention for future research would be to implement a peer-based teaching intervention to teach comparative relational responding to young children or children with ASD using MET and the TARPA protocol. As the teaching method in this study was relatively simple, an older child in the school (aged 11 or 12 years) could have been taught to deliver the intervention to the children in the ASD classroom. It would be interesting to compare the rate of learning and motivational value of the peer-based intervention delivery for the young children or children with ASD.

In conclusion, this study successfully employed MET and the TARPA protocol in order to establish arbitrary applicable responding in three children with ASD, and in accordance with comparative relations. The TARPA protocol has proven to be an effective and efficient way to determine derived comparative relational responding in this study. This experiment provides further evidence within the field of RFT that behavioural teaching interventions can teach complex language and cognitive skills, such as comparative relational framing, to individuals with ASD.

Conflicts of Interest

The author has no conflicts of interest to declare.

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