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ORIGINAL ARTICLE

Using a Respondent-Type Matching-to-Sample Exclusion Training Procedure to Establish Equivalence Responding

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Abstract

An exclusion training procedure involves presenting a sample stimulus with an unrelated comparison stimulus that is presented alongside other comparison stimuli that previously have acquired a negative relation to the sample stimulus. Due to the already established negative comparisons, the participant selects the unrelated stimulus, establishing a relation between the two stimuli. Of the large body of research on exclusion, there has been no research conducted that has combined respondent conditioning with an exclusion training procedure. This study used a respondent-type matching-to-sample (ReTMTS) exclusion training procedure with probe trials to train 3, three-member equivalence classes. A–B relations were trained using the ReTMTS procedure, and A–C relations were trained via exclusion using the ReTMTS procedure. Of the 10 participants who reached the test phase, only 2 failed to reach the criterion required to demonstrate equivalence responding. These findings are discussed in the context of previous research on exclusion training.

Keywords Exclusion · Stimulus equivalence · Respondent-type matching-to-sample · Equivalence relations

Introduction

In a typical matching-to-sample (MTS) procedure, a sample stimulus (A1) is presented alongside, or prior to, the appearance of two or more comparison stimuli (B1, B2, B3) and a participant must select the experimenter-defined correct stimulus (B1 in this instance) before this selection response is reinforced (Sidman & Tailby, 1982; Sidman et al., 1986). Selecting the other comparison stimuli is not reinforced in the presence of A1. Instead, other sample stimuli (A2 and A3) are presented on different trials and selections of B2 and B3 respectively are reinforced (Cumming & Berryman, 1965; Rodewald, 1974). In a One-to-Many (OTM) MTS procedure, following the successful training of A–B relations, A–C relations are then established (i.e., A1–C1, A2–C2, and A3–C3) in a similar way. Following training with arbitrary stimuli (i.e., stimuli that do not share any formal features with each other), if the results from tests for *reflexivity, symmetry*, and *transitivity* are conducted to examine the emergence of derived relations, then positive results lead to the conclusion that three equivalence classes (i.e., A1B1C1, A2B2C2, and A3B3C3) have been established (Fields & Verhave, 1987; Fields et al., 1984; Sidman, 1994; Green & Saunders, 1998).

Implicit rules within a typical MTS procedure are, "If A1, then select B1," "If A2, then select B2," "If A3, then select B3," "If A1, then select C1," "If A2, then select C2," "If A3, then select C3." These selection relations are sometimes referred to as Sample S+ controlling relations (S+ being the "correct" comparison stimulus for that sample; Arantes & de Rose, 2015; McIlvane et al., 1987). At the same time, the participant is also exposed to the presence of Sample S- controlling relations (S- being the negative comparisons), (e.g., "If A1, not B2 or B3," "If A2, not B1 or B3," and, "If A3, not B1 or B2"); all relations, then, are referred to as "select" and "reject" relations, respectively. Research has shown that equivalence class formation is more probable

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when the training displays both Sample S+ and Sample S-controlling relations (Arantes & de Rose, 2015; Carrigan & Sidman, 1992; de Rose et al., 2013; Stromer & Stromer, 1989; Tomonaga, 1993).

Evidence of control by reject relations is also referred to as control by *exclusion* (Dixon, 1977; Schenk et al., 2021). In studies that specifically focus on control by exclusion training typically begins as normal insofar as the selection of comparison B1 instead of B2 is reinforced in the presence of sample A1. Following this, the subsequent trials present A1 again with an undefined comparison stimulus (X1) alongside the previously defined negative comparison (B2). Usually, the selection of B2 in the presence of A1 does not occur and instead X1 is selected. Emergent relations are then examined by testing for the selection of X1 in the presence of B1 and vice-versa (de Rose et al., 1992; Plazas, 2021; Schenk et al., 2021; Stromer, 1989). Learning by exclusion has been demonstrated in many populations aside from verbal adults, including animals such as dogs and chimpanzees (Kaminski et al., 2004; and Tomonaga, 1993, respectively). Exclusion has been used to investigate reading acquisition in children (de Rose et al., 1996; Plazas & Maldonado, 2018). Exclusion is also commonly referred to as *fast mapping* (Carey & Bartlett, 1978) in developmental language and psycholinguistic research, and in that context refers to the ability of participants such as very young children to quickly learn the meanings of words with only the minimum exposure to training; a single exposure to training is sufficient in many cases (Kaminski et al., 2004; Wilkinson et al., 1998).

The majority of research in the area of stimulus equivalence, including exclusion, has involved operant procedures (e.g., Sidman, 1971; Watt et al., 1991). In contrast, there have been relatively few studies conducted using respondent-type procedures (also referred to as Stimulus Pairing Observation Procedures [SPOP]). A respondent-type (or ReT) procedure does not involve overt reinforcement at any point, the participant is simply tasked with viewing the relations between stimuli that appear on screen. (Leader et al., 1996; Rosales et al., 2013). Many of these ReT procedures have been used in studies interested in language acquisition with adults and children, both with and without developmental disorders (Brown et al., 2023). A study by Delgado and Rodriguez (2020), which used a respondent MTS procedure (hereafter referred to as the Respondent-Type MTS procedure, or ReTMTS; Todd et al., 2023) with negative comparisons and probe/verification trials, was very successful in establishing equivalence classes. In light of the demonstrable effectiveness of this respondent training procedure, and because there has been no research conducted that has combined respondent conditioning with an exclusion training procedure, the present study investigated whether a ReTMTS exclusion procedure is effective in establishing stimulus equivalence classes.

Method

Participants

Participants were 13 nonvulnerable adults over the age of 18 who could use and access a computer or smartphone that was connected to the internet and were recruited from both inside and outside the student body of Ulster University via opportunistic sampling. There was no incentive to take part in the experiment. Age and gender were not recorded because it was felt these variables were not important to the current study. The participants could use either a link to the experiment that they could conduct on their personal device, or they could scan QR code to access the experiment. Participants read an information sheet and completed a consent form before beginning the experiment.

Setting and Apparatus

This study took place using the online experiment building and hosting website "Gorilla" (Anwyl-Irvine et al., 2020; www.gorilla.sc) that allowed for the experiment to be conducted on desktop computers, laptops, and handheld smart devices like iPads or smartphones. The dimensions of the stimuli described here are given in the context of a 32 x 20.5cm laptop screen. The stimuli used in the task consisted of bold black Cyrillic, Hebrew, and Japanese Katakana letters presented against a white background (Fig. 1). Although the experiment could be conducted and tested completely online, the participants were tested within a small experimental suite in Ulster University due to potentially high levels of attrition. However, participants were tested on their own devices, which was most commonly a smartphone due to their ease of use.

Phase 1. A–B Training and Probe Trials

After participants had consented to take part in the experiment, they were taken to Phase 1 in which A–B relations were trained. On screen, they were first presented with the instructions:

> You will now see a figure or symbol on the top centre of the screen and three other symbols below. Only one of these three symbols is related to the figure above. Observe these relations carefully. If you focus your attention on these relations, you will be able to finish the task faster than if you get distracted.
> Click continue below to begin.

All instructions presented in this experiment were identical to the instructions used by Delgado and Rodriguez (2020) and were presented on the device the participant was

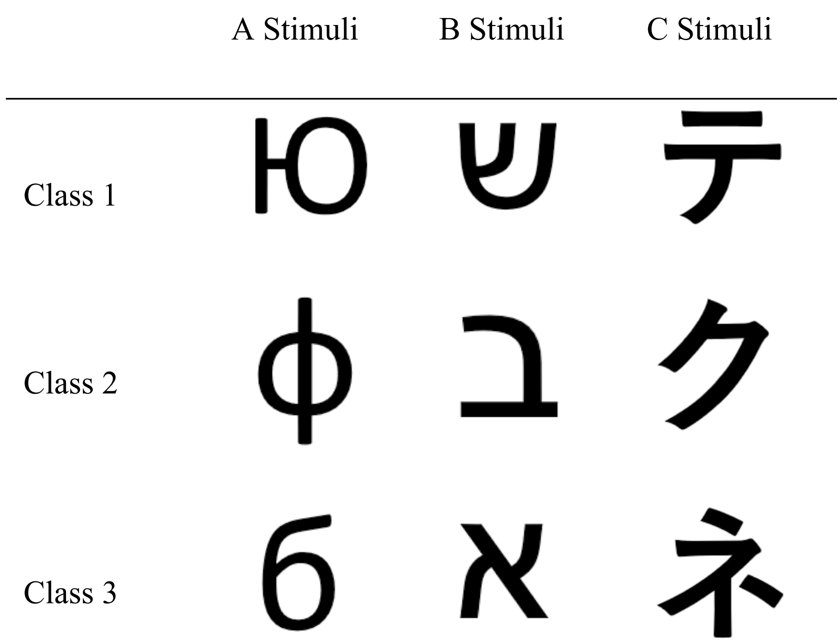

Fig. 1 Stimuli Used in This Study Arranged in Their Equivalence Classes. *Note:* The A and B stimuli were both in the Calibri font, whereas the C stimuli were in the Yu Gothic font due to the Katakana alphabet not being supported by the Calibri font. The C stimuli were in bold to give them a similar thickness to the other stimuli. The stimuli were the same symbols used by Todd et al. (2023).

using. This phase involved 12 trials that presented sequentially 4 A1–B1 trials, followed by 4 A2–B2 trials, and then 4 A3–B3 trials. During each training trial, the sample stimulus (A) was first presented alone at the top center of the screen (7.2 cm from the top of the screen, 11.5 cm from the bottom and 15.5 cm from each side of the screen); the sample stimulus was 1.5 cm tall and 1.5 cm wide. After 2 s, the comparison stimuli (B1, B2, and B3) appeared at the bottom of the screen, 6.3 cm below the sample stimulus, one appearing directly below, with the other two comparisons 5 cm to the left and right of the center comparison (the left and right comparisons were both 10.7 cm away from their respective side of the screen, and the center comparison was 15.5 cm away from both edges). Each comparison stimulus was smaller than the sample stimulus, each being 0.6 cm tall by 0.6 cm wide, and appeared 5.3 cm from the bottom of the screen. After a further 2 s, red boxes appeared around the sample stimulus and the related comparison stimulus (e.g., a red box appeared around B1, and another red box appeared around A1). The red box that appeared around the sample stimuli was 6.2 cm wide and 4.5 cm tall, with a line thickness of 0.2 cm. The center of the sample stimulus was 3 cm from the sides of the red box, and 2 cm from the top and bottom of the red box. The red box that appeared around the comparison stimuli was 3.6 cm by 2.6 cm, with a 0.1 cm thickness. The center of the stimuli was 1.7 cm from the sides of the comparison red boxes, and 1.2 cm from the top and bottom of the red boxes. All stimuli remained on screen for 3 s before being followed by a blank, white screen (the inter-trial interval). After 2 s, the next training trial began, and this followed the same sequence (see Fig. 2 for an example of this sequence).

Following the training trials, these instructions were presented:

> Now that you have observed, please select the symbol that corresponds with the one presented on top. Click to begin.

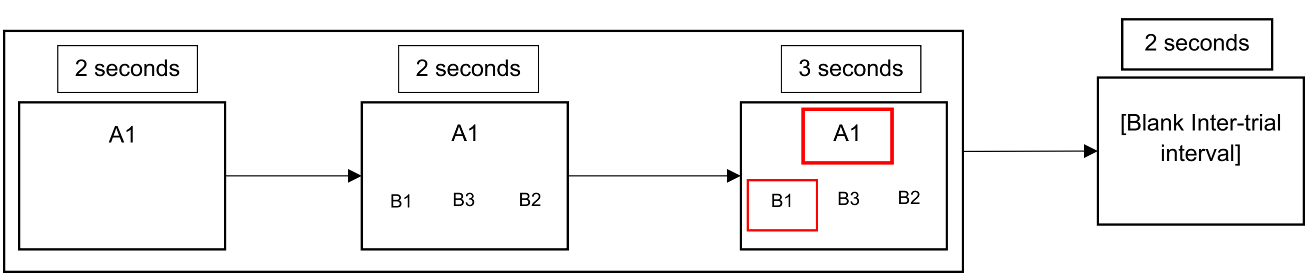

Fig. 2 Schematic Diagram of an A1–B1 Training Trial in Phase 1 which Lasted a Total of 7 s. *Note:* The timings before the next screen was displayed are shown. After the inter-trial interval, the next training trial began immediately. The timings used were identical to the timings used by Todd et al. (2023)

The participant was shown a screen similar to the training trials containing the sample and comparison stimuli (the red boxes were now absent). Gray borders were present around the comparison stimuli to indicate that they were now interactive "buttons" (see Fig. 3). The borders were 3.6c m wide by 2.6 cm tall, with rounded edges and thickness of less than 0.1 cm. Clicking on any comparison stimuli progressed the experiment to the next trial. The probe trials were presented sequentially by class as in the training block. After six trials (two per class), participants either progressed to Phase 2 or returned to the start of a shortened version of Phase 1 for retraining. Retraining involved viewing a block of nine A–B training trials (three per class) and then once again completing the same six probe trials. Failure to successfully answer all six probe trials after a second retraining session resulted in the experiment concluding, followed by debriefing. Advancement to Phase 2 was contingent on mastery of the probe trials criteria.

Phase 2- A–C Training and Probe Trials

Prior to beginning this phase, participants were once again presented with the instructions they saw prior to beginning Phase 1. Overall, the procedure for training trials in Phase 2 was the same as the procedure in Phase 1, however unlike in Phase 1, the 12 A–C training trials did not have red boxes as prompts to show the relations between sample and comparison stimuli. Instead, the A–C trials involved the presentation of the related sample and comparison stimulus (e.g., A1 and C1), with the already trained B stimuli acting as the negative comparisons (see Fig. 4). For example, in a trial showcasing the relation between stimuli A2 and C2, the stimuli B1 and B3 were used as negative comparisons. As red boxes were not present for these trials, this screen appeared for 5 s in total, meaning each individual A–C trial lasted 7 s, the same amount of time a A–B trial lasted in Phase 1.

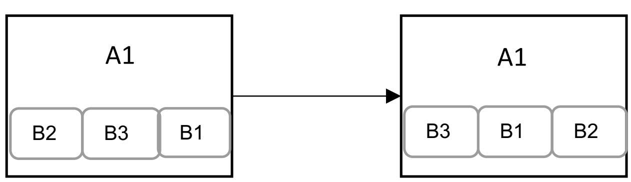

Fig. 3 Schematic Diagram of Two A1–B1 Probe Trials Used in Phase 1. *Note:* All probe trials were presented in a semi-random order. Once a participant selected one of the comparison stimuli, the next probe trial was presented. After the second A1–B1 probe trial, an A2–B2 probe trial was presented. This format for presenting probes was used for all A–B relations. Furthermore, during all probe trials, participants were not told if their selection was correct

Like in Phase 1, probe trials followed the training trials, and failure to achieve 100% accurate responding resulted in retraining. Unlike the training block of this phase, the probe trials in Phase 2 presented all C stimuli on screen acting as comparisons. Once the participants had successfully demonstrated that responding is under the control of the trained relations, they proceeded to Phase 3.

Phase 3.- Mixed Training and Mixed Probe Trials

After viewing the same instructions that came before the previous two training trial phases, the final training block, Phase 3, began. This training block trained both A–B and A–C relations, training them in the same fashion as they were in their previous respective phases. Like the previous phases, there were 12 trials with 4 trials per class, 2 of which trained A–B relations, with the other 2 trials trained A–C relations. Apart from this change, the training procedure was identical to the procedures used in the previous two phases.

The participant was presented with 12 mixed probe trials once they completed the training block. A margin of error was allowed for these probe trials (92% accuracy), instead of 100% accuracy like in the previous training and probe trial phases. Retraining in this phase, also unlike in the previous training phases, had 12 retraining trials instead of 9. Once

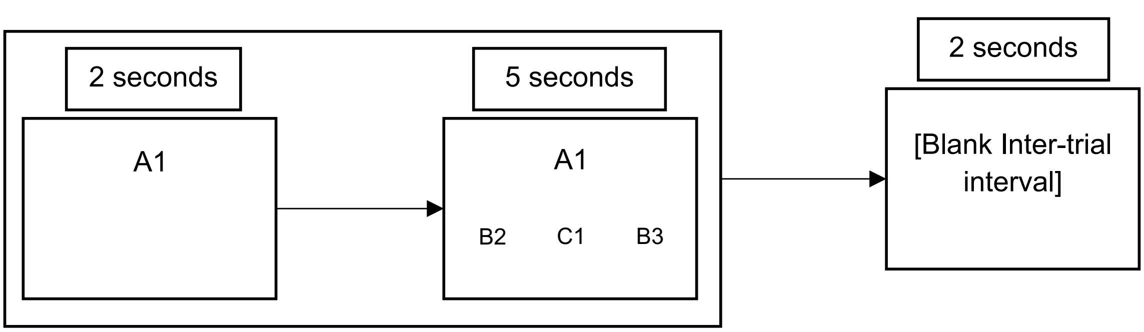

Fig. 4 Schematic Diagram of an A1–C1 Exclusion Training Trial in Phase 2. *Note:* B2 and B3 acted as negative comparisons. For A2–C2 training, B1 and B3 acted as negative comparisons. As with the A–B training trials, each A–C trial lasted 7 s. No prompts (i.e., red boxes) surrounded any stimuli during A–C training

the participant had successfully completed this phase, they progressed to Phase 4, the final testing phase.

Phase 4.- Test Trials

The final test phase began with the instruction:

'Excellent! You have reached the final phase.
'Click to Begin.'

These 36 trials were divided into 4 blocks and each tested for a different derived relation, with tests for symmetry (B–A, C–A) being presented to the participant first, followed by tests of equivalence (B–C, C–B).There were nine trials per block, with each class appearing three times per block randomly; during these trials, the comparison stimuli were highlighted by gray outlines, as in probe trials. Participants responded by clicking on one of the three presented comparison stimuli as they progressed through the trials. After they had completed all four test blocks the experiment concluded, and the participant was debriefed.

Results and Discussion

Table 1 shows the number of training trials for each participant in each of the three training phases. Each retraining cycle consisted of 9 trials in Phases 1 and 2. Three of the 13 participants (P02, P04, and P11) were unable to meet criteria during the training phases; P02 did not progress past Phase 1, whereas participants P04 and P11, although successful in progressing past the initial ReTMTS training phase were unable to progress past Phase 2, which trained the relations with an exclusion variation of the procedure. For the other 10 participants, performance in the training phases varied. Only P10 and P13 were not retrained at any point and were exposed to 36 training trials in total.

Table 2 shows the performances of each participant in each of the four test blocks in Phase 4. The criterion for demonstrating equivalence responding was 90% correct at each testing block (i.e., participants responded correctly to eight of the nine test trials). All but 2 of the 10 participants met this criterion in each of the test blocks. Four of the participants responded with 100% accuracy across all four test blocks, whereas the remaining four participants each displayed 90% accurate responding in one of the test blocks. P01 and P06 demonstrated 90% accurate responding in the C–A symmetry test block; P07 responded with 90% accuracy in the B–C equivalence test block, and P05 displayed 90% accurate responding in the fourth test block (i.e., the C–B equivalence tests). No participant made any errors in the B–A symmetry test block. Participants P09 and P12 both displayed 80% accurate responding in the C–A symmetry tests, and as such are considered to have not met the criterion required for demonstrating equivalence responding.

The goal of this study was to investigate whether a Respondent-Type Matching-to-Sample (ReTMTS) Procedure would be effective in generating three 3-member equivalence classes if the third member of each class (the C stimulus) was trained via exclusion. Prior to this study, no research on exclusion has been conducted using respondent-type procedures. If one were to take only the 10 participants who successfully completed training, 80% successfully

Table 1 Number of Training Trials Each Participant was Exposed to in Order to Achieve Mastery of each Baseline Relation in the Three Training Phases

Participant	Phase 1: A–B Trials		Phase 2: A–C Trials		Phase 3: Mixed A–B, A–C Trials		Total Trials
	Trials	Retraining Cycles	Trials	Retraining Cycles	Trials	Retraining Cycles	
P01	21	1	12	0	12	0	45
P03	21	1	21	1	12	0	54
P05	21	1	12	0	12	0	45
P06	21	1	12	0	12	0	45
P07	21	1	30	2	12	0	63
P08	12	0	21	1	12	0	45
P09	12	0	21	1	12	0	45
P10	12	0	12	0	12	0	36
P12	21	1	21	1	12	0	54
P13	12	0	12	0	12	0	36

Note: Under each training phase heading, trials refers to the number of training trials each participant was exposed to in each phase, and retraining cycles showcases the number of retraining cycles for each participant in each phase if required (to a maximum of two retraining cycles per phase.) For example, P07 was exposed to one retraining cycle in Phase 1 and two retraining cycles in Phase 2 and did not require retraining at all in Phase 3. The rightmost column displays the total number of training trials each participant was exposed to across the three training phases.

Table 2 Individual Scores Obtained by Participants in Phase 4, Divided across the Four Derived Relation Test Blocks

Participant	B–A Symmetry	C–A Symmetry	B–C Equivalence	C–B Equivalence
P01	100%	90%	100%	100%
P03	100%	100%	100%	100%
P05	100%	100%	100%	90%
P06	100%	90%	100%	100%
P07	100%	100%	90%	100%
P08	100%	100%	100%	100%
P09	100%	80%	90%	80%
P10	100%	100%	100%	100%
P12	100%	80%	100%	90%
P13	100%	100%	100%	100%

Note: Each test block contained 9 test trials for a total of 36. The criterion for displaying successful equivalence responding was 90% accurate responding in each of the four blocks.

demonstrated equivalence responding. However, due to the novelty of the procedure and the fact that it's the first study of its kind, the participants who did not successfully complete training should also be accounted for. As a result, it was found that 64% of the participants recruited (8 out of 13) met the criterion for equivalence responding. P02 was unable to progress past the first training phase, which was the initial ReTMTS training phase, whereas P04 and P11, although successful in demonstrating this first relation, were unable to demonstrate the second relation, which had been trained via an exclusion variation of the procedure. Although the extent of the success of the procedure was limited, nevertheless there was a clear indication that this procedure can be effective. It is notable that the two participants who did not reach the criterion for equivalence responding despite reaching Phase 4 were each one correct response below threshold (80% accurate responding) in at least one of the four test blocks, as seen in Table 2. P09 was below threshold in two test blocks (C–A symmetry and C–B equivalence), however in both blocks they were one accurate response short of the criterion. As such, their accuracy in responding was much higher than what could be achieved simply by chance.

One of the noteworthy findings is the relatively low number of training trials needed to establish equivalence responding. As can be seen in Table 1, whereas only two participants required exposure to the minimum amount of training trials, five were only retrained once, with P07 being exposed to the most training trials at 63. In comparison, the training phases of Plazas (2021) study on university undergraduates, which established equivalence responding through the use of traditional operant conditional discrimination procedures, presented 66 training trials (not counting the initial pretraining phases). Therefore, this current experiment has shown that exclusion can be trained successfully in a relatively short amount of time, around 10 min had the participants not been retrained or were retrained once. That being said, it could be assumed that more exposures to the baseline relations would have led to more successful participants, and also that a pretraining phase or instructional video would have perhaps resulted in a fewer number of participants undergoing retraining in Phase 1. Perhaps a longer intertrial interval (ITI) may also have increased the number of successful participants, because Leader et al. (1996) found that a longer ITI relative to the interstimulus interval increases the success rate of the respondent-type. However, this was with the more traditional respondent-type procedure, and given how that the timings used in this experiment were the same as those used by Delgado and Rodriguez (2020) and Todd et al. (2023), both of which were successful in establishing equivalence responding in the majority of their tested participants, perhaps the short ITI is not a major issue, in fact, perhaps, one could argue given the sequential design of the training procedure, the shorter ITI may have actually increased the salience of perhaps not the individual trials, but the relations being presented on screen.

The findings of this study corroborate what Minster et al. (2011) have suggested; that emergent relations depend more on environmental stimulus pairings, otherwise known as respondent-type relations, rather than established reinforcement contingencies. Their experiment found that four of their five participants were able to respond in accordance with their criteria for three 5-member equivalence classes, despite two members of each class (G and H) having an explicit history of extinction. The two stimuli had been used as class-specific negative comparisons for the B stimuli during training (as in, if B1 was presented as the comparison, G1 and H1 were the negative comparisons; if B2 was presented, G2 and H2 were presented as well; if B3 presented, then G3 and H3 were both presented alongside it). This suggested that environmental correlations played a bigger role in the establishment of the emergent relations than operant reinforcement or extinction. Their discussion also briefly touched on exclusion, as they hypothesized that exclusion is not due to rejecting a comparison because it is incorrect for the sample presently on screen, but instead rejecting it because it is correct for another sample. Perhaps these conclusions of Minster et al. (2011) applies to the current study; the participants were not explicitly told that relations between the samples and the negative comparisons were incorrect, they were simply shown that a negative comparison for one sample was subsequently related to a different sample stimulus.

The findings of the current study also support the work of Hayes (1992) as well as Tonneau (2001, 2002), who both emphasized the influence stimulus pairings have on the development of equivalence responding. As previously mentioned, research into exclusion has been entirely conducted using operant procedures (examples include Dixon, 1977; Plazas & Villamil, 2018; Schenk et al., 2021; Tomonaga, 1993). The current study has taken the first step in plugging this gap in exclusion literature in regard to respondent-type procedures. Although the number of successful participants was relatively low, it is worth noting that this initial study has more in common with the Todd et al. (2023) procedure than any exclusion procedures, using the same stimuli and overall design, with the obvious exception of establishing A–C relations using exclusion. Perhaps further alterations to the ReTMTS procedure, to bring it more in line with the procedures used in other exclusion literature, would lead to a higher success rate. For example, a procedure could be used that is like the one used in Plazas and Villamil's (2018) study. Their study involved using exclusion training to establish equivalence relations within a third class of stimuli following the successful establishment of two equivalence classes using the MTS procedure, and it could easily be conducted with the ReTMTS procedure.

Although it is assumed that the selection relations between the A and C stimuli in this experiment were controlled by the rejection of the previously related comparisons, one could also argue that this selection was in actuality controlled by novelty, something that has been suggested in experiments with operant procedures (Plazas & Villamil, 2018). It could be argued that the relation between the A and C stimuli was established because the C stimuli was a new, previously unseen symbol that did not resemble the other stimuli on screen, not because previous trials had trained reject relations between the sample stimulus and the unrelated B comparisons. For example, Dysart et al. (2016), in their study on referent selection using operant procedures, found that young children are more likely to favor and select novel labels and objects when presented with a "super-novel" object alongside two objects they had previously been exposed to. That being said, Wilkinson and McIlvane (1997) suggested that both forms of control can influence performance simultaneously. It is possible that this control by novelty and/ or control by rejection can also occur in a respondent-type exclusion experiment such as the current study. Unfortunately, it is not clear from the procedure used in this experiment which control was influencing the relations. Perhaps a future ReTMTS experiment might combine this procedure with the blank comparison method (Plazas, 2021; Wilkinson & McIlvane, 1997) which involves hiding one of the comparison stimuli by placing a blank comparison (such as a black box that is not related in any way to any samples) over the S- stimulus in some trials, and over the S+ stimulus in others. This method would clearly demonstrate select and reject relations, as the participant would be expected to select the S+ when the S- comparison is hidden and reject the S- when the S+ is hidden by selecting the blank comparison. The consistently high scores obtained by the participants in the equivalence test blocks also highlight the fact that a relation had been established between the B and C stimuli without any prior training. Even the two participants who failed to reach the criterion in the C-A symmetry block displayed high levels of accurate responding in the subsequent test blocks for equivalence relations, well above chance levels in both cases and in the case of P12, above criterion in both blocks. This may be due to the C stimuli replacing the related B stimulus in the training trials, in effect training the participant to recognize these two stimuli as substitutable for one another, leading to equivalence relations being more readily generated.

A final note on the nature of the ReTMTS procedure itself is worth mentioning. This study, Delgado and Rodriguez (2020) and Todd et al. (2023) refer to this procedure as a respondent procedure, due to its use of simultaneous stimulus pairing during training. However, as the related stimuli were not the only stimuli on screen, a prompt in the form of red boxes around the related sample and comparison stimuli was required, though potentially the prompt could also have been in the form of arrows or the use of different colors of the related stimuli. This raises the question, is this truly a respondent-type procedure? Although it is true that the presence of the red boxes function as orienting stimuli, it is still a respondent process, albeit one that has required a prior learning history to establish that boxes around the two stimuli signify a relation between them. Perhaps the red boxes also function as a shared stimulus feature that is delayed in its appearance, and simply function as an extension of the stimulus-pairing procedure? Whatever the case may be, this procedure, although arguably not truly respondent, is certainly not operant. The participants received no feedback at any point in the training, and no responses on their part were required during training except during the probe trials, where again, no feedback was given. It is also worth noting, on the A–C exclusion trials in Phases 2 and 3, red boxes were not present on screen, with the A–C relations established not by prompts, but by the previously established reject relations (or potentially the novelty of the C stimuli or a combination of both).

To conclude, the present study has opened up opportunities for further experiments on exclusion using the Respondent-type Matching-to-Sample Procedure. As exclusion is of interest to researchers in applied settings, the exclusion ReTMTS procedure presents a new pathway for research with participants other than verbal adults such as children (e.g., de Rose et al., 1996; Plazas & Maldonado, 2018; Schenk et al., 2021).The success of the ReTMTS procedure described here also opens up the possibility for research opportunities in other areas of interest in equivalence research, such as transfer of function, blocking, and investigating complex relations.

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Data Availability The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval All procedures in the current study were in accordance with the ethical standards of the institutional research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval was approved by the School of Psychology Staff and Postgraduate Research Ethics Filter Committee, Ulster University, Northern Ireland, UK. Research involved human participants from non-vulnerable populations. Informed consent was obtained for all participants.

References

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods, 52*, 388–407. https://doi.org/10.3758/s13428-019-01237-x

Arantes, A., & de Rose, J. C. (2015). High probability of equivalence class formation with both Sample-S+ and Sample-S-controlling relations in baseline. *The Psychological Record, 65*(4), 743–748. https://doi.org/10.1007/s40732-015-0143-2

Brown, K., Rosales, R., Garcia, Y., & Schneggenburger, S. (2023). A review of applied research on pairing procedures to facilitate emergent language. *The Psychological Record, 73*, 221–236. https://doi.org/10.1007/s40732-023-00543-3

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Proceedings of the Stanford Child Language Conference, 15*, 17–29.

Carrigan, P. F., Jr., & Sidman, M. (1992). Conditional discrimination and equivalence relations: A theoretical analysis of control by negative stimuli. *Journal of the Experimental Analysis of Behavior, 58*(1), 183–204. https://doi.org/10.1901/jeab.1992.58-183

Cumming, W. W., & Berryman, R. (1965). The complex discriminated operant: Studies of matching-to-sample and related problems. In D. I. Mostofsky (Ed.), *Stimulus generalization* (pp. 284–330). Stanford University Press.

Delgado, D., & Rodríguez, A. (2020). Stimulus equivalence using a respondent matching-to-sample procedure with verification trials. *The Psychological Record, 72*, 1–9. https://doi.org/10.1007/s40732-020-00438-7

de Rose, J. C., de Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Exclusion and stimulus equivalence. *Journal of Applied Behavior Analysis, 29*(4), 451–469. https://doi.org/10.1901/jaba.1996.29-451

de Rose, J. C., de Souza, D. G., Rossito, A. L., & de Rose, T. M. S. (1992). Stimulus equivalence and generalization in reading after matching-to-sample by exclusion. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 69–82). Context Press.

de Rose, J. C., Hidalgo, M., & Vasconcellos, M. (2013). Controlling relations in baseline conditional discriminations as determinants of stimulus equivalence. *The Psychological Record*, *63*(1), 85–98. https://doi.org/10.11133/j.tpr.2013.63.1.007

Dixon, L. S. (1977). The nature of control by spoken words over visual stimulus selection. *Journal of the Experimental Analysis of Behavior, 27*, 433–442. https://doi.org/10.1901/jeab.1977.27-433

Dysart, E. L., Mather, E., & Riggs, K. J. (2016). Young children's referent selection is guided by novelty for both words and actions. *Journal of Experimental Child Psychology, 146*, 231–237. https://doi.org/10.1016/j.jecp.2016.01.003

Fields, L., & Verhave, T. (1987). The structure of equivalence classes. *Journal of the Experimental Analysis of Behavior, 48*(2), 317–332. https://doi.org/10.1901/jeab.1987.48-317

Fields, L., Verhave, T., & Fath, S. (1984). Stimulus equivalence and transitive associations: A methodological analysis. *Journal of the Experimental Analysis of behavior, 42*(1), 143–157. https://doi.org/10.1901/jeab.1984.42-143

Green, G., & Saunders, R. R. (1998). Stimulus equivalence. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 229–262). Springer.

Hayes, L. J. (1992). Equivalence as process. In S. C. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 97–108). Context Press.

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: evidence for "fast mapping." *Science, 304*(5677), 1682–1683. https://doi.org/10.1126/science.1097859

Leader, G., Barnes, D., & Smeets, P. M. (1996). Establishing equivalence relations using a respondent-type training procedure. *The Psychological Record, 46*, 685–706. https://doi.org/10.1007/BF03395192

McIlvane, W. J., Kledaras, J. B., Munson, L. C., King, K. A., Rose, J. C. D., & Stoddard, L. T. (1987). Controlling relations in conditional discrimination and matching by exclusion. *Journal of the Experimental Analysis of Behavior, 48*(2), 187–208. https://doi.org/10.1901/jeab.1987.48-187

Minster, S. T., Elliffe, D., & Muthukumaraswamy, S. D. (2011). Emergent stimulus relations depend on stimulus correlation and not on reinforcement contingencies. *Journal of the Experimental Analysis of Behavior, 95*(3), 327–342. https://doi.org/10.1901/jeab.2011.95-327

Plazas, E. A. (2021). Formation of stimulus equivalence relations by exclusion: evidence using the blank comparison stimulus procedure. *The Psychological Record, 71*(1), 1–15. https://doi.org/10.1007/s40732-020-00433-y

Plazas, E. A., & Maldonado, P. M. (2018). Emergence of new stimulus classes by exclusion in children and adolescents. *The Psychological Record, 68*, 451–460. https://doi.org/10.1007/s40732-018-0289-9

Plazas, E. A., & Villamil, C. W. (2018). Formation of new stimulus equivalence classes by exclusion. *Journal of the Experimental Analysis of Behavior, 109*(2), 380–393. https://doi.org/10.1002/jeab.322

Rodewald, H. K. (1974). Symbolic matching-to-sample by pigeons. *Psychological Reports, 34*(3), 987–990. https://doi.org/10.2466/pr0.1974.34.3.987

Rosales, R., Rehfeldt, R. A., & Huffman, N. (2013). Examining the utility of the stimulus pairing observation procedure with preschool children learning a second language. *Journal of Applied Behavior Analysis, 45*(1), 173–177. https://doi.org/10.1901/jaba.2012.45-173

Schenk, J. J., Keenan, M., Boelens, H. H., Dymond, S., & Smeets, P. M. (2021). Children's emergent relations of equivalence using stimuli with opposite verbal labels: Exclusion and minimal training conditions. *Behavioural Processes*, *185*, article 104341. https://doi.org/10.1016/j.beproc.2021.104341

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech & Hearing Research, 14*(1), 5–13. https://doi.org/10.1044/jshr.1401.05

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Authors Cooperative.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, *37*(1), 5–22. https://doi.org/10.1901/jeab.1982.37-5

Sidman, M., Willson-Morris, M., & Kirk, B. (1986). Matching-to-sample procedures and the development of equivalence relations: The role of naming. *Analysis & Intervention in Developmental Disabilities, 6*(1–2), 1–19. https://doi.org/10.1016/0270-4684(86)90003-0

Stromer, R. (1989). Symmetry of control by exclusion in humans' arbitrary matching to sample. *Psychological Reports, 64*(3), 915–922. https://doi.org/10.2466/pr0.1989.64.3.915

Stromer, R., & Stromer, J. B. (1989). Children's identity matching and oddity: Assessing control by specific and general sample-comparison relations. *Journal of the Experimental Analysis of Behavior, 51*(1), 47–64. https://doi.org/10.1901/jeab.1989.51-47

Todd, J., Keenan, M., & Gallagher, S. (2023). The respondent-type matching-to-sample procedure: A comparison of one-to-many and linear procedure for establishing equivalence responding. *The Psychological Record, 1–12*. https://doi.org/10.1007/s40732-023-00558-w

Tomonaga, M. (1993). Tests for control by exclusion and negative stimulus relations of arbitrary matching to sample in a "symmetry-emergent" chimpanzee. *Journal of the Experimental Analysis of Behavior, 59*(1), 215–229. https://doi.org/10.1901/jeab.1993.59-215

Tonneau, F. (2001). Equivalence relations: A critical analysis. *European Journal of Behavior Analysis, 2*(1), 1–33. https://doi.org/10.1080/15021149.2001.11434165

Tonneau, F. (2002). Who can understand relational frame theory? A reply to Barnes-Holmes and Hayes. *European Journal of Behavior Analysis, 3*(2), 95–102. https://doi.org/10.1080/15021149.2002.11434209

Watt, A., Keenan, M., Barnes, D., & Cairns, E. (1991). Social categorization and stimulus equivalence. *The Psychological Record, 41*(1), 33–50. https://doi.org/10.1007/BF03395092

Wilkinson, K. M., Dube, W. V., & McIlvane, W. J. (1998). Fast mapping and exclusion (emergent matching) in developmental language, behavior analysis, and animal cognition research. *The Psychological Record, 48*, 407–422. https://doi.org/10.1007/BF03395281

Wilkinson, K. M., & McIlvane, W. J. (1997). Blank comparison analysis of emergent symbolic mapping by young children. *Journal of Experimental Child Psychology, 67*(2), 115–130. https://doi.org/10.1006/jecp.1997.2402