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Instrução Baseada em Equivalência no Ensino de Relações de Tamanho a uma Criança com Autismo

Effects of Equivalence-Based Instruction to Teach Size Relations to a Child with Autism

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Resumo

Diversos estudos sugerem que a Instrução Baseadas em Equivalência (IBE) é uma tecnologia efetiva para ensinar uma ampla variedade de habilidades acadêmicas para pessoas diagnosticadas com Transtorno do Espectro Autista (TEA). No entanto, a eficácia da IBE para ensinar relações de equivalência envolvendo o comportamento de selecionar estímulos sob controle da sua dimensão física (tamanho), os símbolos matemáticos de maior que (>) e menor que (<) e as palavras ditadas correspondentes ("maior que" e "menor que") ainda não foi investigada. O objetivo do estudo foi verificar os efeitos da IBE na emergência de relações entre símbolos matemáticos e o tamanho físico de diferentes estímulos tridimensionais. Uma criança de 7 anos, do sexo masculino e diagnosticada com autismo participou do estudo. Um delineamento pré/pós-teste foi utilizado para avaliar a emergência das relações CB (símbolo-tamanho) após o ensino das relações AC (palavras ditadas-símbolo) e AB (palavras ditadas-tamanho). Os resultados indicaram aquisição das relações de linha de base e emergência das relações CB, sugerindo efetividade da IBE para ensinar relações simbólicas entre palavras ditadas, tamanho de objetos e símbolos matemáticos.

Palavras-chave: Equivalência de estímulos, formação de conceito, matemática, autismo.

Abstract

Several studies suggest that Equivalence-Based Instruction (EBI) is an effective method for teaching a variety of academic skills to individuals with autism. However, the efficacy of EBI for teaching equivalence relations involving the behavior of selecting a stimulus according to its physical size, the mathematical symbols for "larger than" (>) and "smaller than" (<) and their corresponding dictated words has not yet been investigated. The study aimed to verify the effects of EBI on the emergence of relations between the mathematical symbols and the sizes of 3D objects. A 7-year-old boy diagnosed with autism participated in the study. A pretest/posttest design was used to verify the emergence of CB relations (symbols-size) after training AC (dictated words-symbols) and AB (dictated words-size) baseline relations. The results indicated acquisition of baseline relations and emergence of CB relations, suggesting that EBI is effective for teaching relations between dictated words, object sizes and mathematical symbols.

Keywords: Stimulus equivalence, concept learning, mathematics, autism.

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Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder (American Psychiatric Association, 2013) that affects social communication in children. Individuals diagnosed with ASD often have difficulties in developing language and cognitive skills, requiring specific interventions to learn those repertoires. Given that ASD affects a high number of children worldwide and may represent a relevant concern for public health (Araujo et al., 2019), the improvement and development of effective practices is needed.

Equivalence-Based Instruction (EBI) has been used to teach a wide variety of skills, including reading (Millan & Postalli, 2019), language (Neves et al., 2018) and also musical skills (Griffith et al., 2018). Typically, in EBI protocols, relations among three or more stimulus sets are directly taught via matching-to-sample procedures, followed by tests to assess the emergence of novel relations. For instance, after AB and AC baseline training, the emergence of BC, CB, BA and CA relations can be assessed as a product of such training. As novel relations may emerge without direct training, EBI is considered an efficient method for teaching skills with less instructional time (Zinn et al., 2015).

Several studies have shown that EBI could also be effective for teaching skills to individuals diagnosed with ASD; most of these studies refer to reading skills (e.g., Rehfeldt, 2011; Varella & de Souza, 2015), but applied studies focusing on math skills in this population have been gaining more attention recently (e.g., Dixon et al., 2016; Stanley et al., 2018). Nonetheless, studies investigating the acquisition of equivalence relations involving basic mathematical concepts such as larger than/smaller than and their corresponding mathematical symbols have not yet been conducted, despite such acquisition's relevance to learning other complex mathematical skills (e.g., math facts). Furthermore, the mathematical concepts of "larger than" and "smaller than" could be challenging for individuals with developmental disabilities, considering that such concepts are relational concepts (Zentall et al., 2002), in the sense that judging an object as larger than or smaller than another depends on what stimuli are exhibited together (for instance, one could say that the size of a soccer ball is larger than that of a golf ball, whereas the size of the same soccer ball would be smaller than that of a basketball).

The present study sought to investigate the effects of EBI on the emergence of relations between the relative physical size of a stimulus and its corresponding mathematical symbols (">" and "<"). Initially, baseline training established the auditory-visual relations between dictated words "larger than"/ "smaller than" and the mathematical symbols, followed by training the relations between the dictated words and the relative physical size of the stimulus (i.e., the behavior of selecting one of two stimuli of different sizes under control of the dictated words "larger than" and "smaller than"). Finally, emergent probes assessed whether the mathematical symbols controlled the selection of a stimulus based on its relative size.

Method

Participant, Setting and Materials

Edson was a 7-year-old boy diagnosed with ASD, with an age equivalent of 3 years and 6 months measured on the Peabody Picture Vocabulary Test: Revised (PPTV-R, Dunn & Dunn, 1981). He attended a special school five days a week, 4 hours a day, and had previous learning experience with matching-to-sample tasks. He communicated using two to three-word phrases and achieved Level 6 on the Assessment of Basic Learning Abilities-Revised test (ABLA-R, DeWiele et al., 2011), indicating ease in learning arbitrary visual and auditory-visual conditional discriminations (Varella et al., 2017).

Sessions lasting approximately ten minutes were conducted one to three times a week at the school in a quiet room with a table and chairs. The experimental stimuli consisted of three stimulus sets. Set A comprised the dictated Portuguese words corresponding to "larger than" (A1) and "smaller than" (A2). Set B was made up of 18 pairs of quasi-identical stimuli (e.g., spoons, boxes, soda bottles and toys) that differed only in their physical size, with B1 designating the larger comparison; and B2, the smaller comparison. Furthermore, Set B was subdivided into three six-pair subsets: B, B' and B''. B was exhibited during pretests and baseline training; B', in the generalization test and CB' Posttest 1; and B'', during CB'' Posttest 2. Set C consisted of two printed cards (8cm x 12cm): one with the "larger than" mathematical symbol (B1, >) and one with the "smaller than" symbol (B2, <). Additionally, six printed cards (8cm x 12cm) containing two copies of three pictures of familiar stimuli (a dog, a ball and a motorcycle) were employed in identity-matching tasks, which were conducted during the pretraining and Posttest 2 phases (see description below). Materials also included a video camera, a pen and paper for recording the data.

Dependent Measures, Interobserver Agreement and Procedural Integrity

A correct response was defined as selecting the target comparison from a two-stimulus array in the presence of a spoken sample (auditory-visual) or a visual sample (visual-visual) in a matching-to-sample task. A total of 44% of the sessions were video recorded to collect the Interobserver Agreement (IOA) and Procedural Integrity (PI) data. For IOA, a second, trained observer analyzed the recordings and scored the participant's correct and incorrect responses in the protocol. IOA was calculated by dividing the total number of agreements by the total number of trials (agreements plus disagreements) and multiplying by 100%. The IOA was 99% across all trials. For PI data collection, the observer filled out a checklist assessing whether trials were implemented as indicated in the protocol. A trial was scored as correct if the experimenter (1) presented the specified stimuli in the correct position, (2) provided the instruction with the specified sample stimulus and (3) provided the programmed consequences for correct or incorrect responses. The PI was calculated by dividing the total number of correct trials by the sum of correct and incorrect trials, multiplied by 100%. The PI was 93%.

Experimental Design and Procedures

The experimental protocol was approved by the Federal University of São Carlos Ethics Committee (CAAE# 16038513.0.0000.5504). A pretest-training-posttest sequence was used to evaluate the effects of training AC (dictated names-symbols) and AB (dictated names-sizes) relations on the emergence of CB (symbols-sizes) relations. The symmetric BA and CA relations were not assessed due to procedural limitations in simultaneously presenting auditory stimuli (Set A) as comparisons. Also, methodological difficulties in presenting the relative size as samples (B stimuli) precluded testing for BC and BA relations. Therefore, equivalence relations between dictated words, relative size and the mathematical symbols were inferred based exclusively on the emergence of CB relations.

Before the beginning of a session, a preference assessment (Brief Multiple Stimulus Without Replacement; Carr et al., 2000) was conducted to identify potential reinforcers. Relations were trained and tested in a 2-choice matching-to-sample (MTS) procedure, in a tabletop format. Blocks consisted of 12 trials of auditory-visual or visual-visual MTS, except in CB'' Posttest 2, in which 20-trial blocks were employed (detailed below). The experimenter sat beside the participant; a trial began with the experimenter gaining the child's attention and presenting the two comparison stimuli (3D objects or cards), and then exhibiting the sample. Correct responses were followed by praise and the edible selected in the preference assessment. Incorrect responses were followed by removal of the comparison stimuli, a neutral "no" and restatement of the instruction with a gestural prompt by the experimenter. The position of the comparison stimuli and the order in which the sample was presented varied unsystematically across trials. The inter-trial interval was approximately 5s. The criterion for all the experimental phases was 91% accuracy (11 out of 12 correct responses) within a block.

Pretraining. Prior to the pretests, the participant was taught to perform both types of matching tasks (auditory-visual and visual-visual) in blocks of 12 trials with familiar stimuli. Along the auditory-visual trial block, three comparison stimuli were presented and the instruction "point to" was given (e.g., "point to the dog"). The same was done in the visual identity-matching trial block, except that the procedure consisted of presenting a card identical to one of the three comparisons and then giving the instruction "match."

Pretests. AB, AC and CB relations were individually assessed in blocks of 12 trials without programmed consequences (extinction). After the 12-trial block, the participant had access to the previously identified reinforcers, in an attempt to reinforce compliance during the test block.

AC and AB Baseline Training. AC relations were trained first, followed by AB training. Each pair of stimuli appeared twice in a 12-trial block.

Posttests. In order to check whether the participant's responses during AB trials were under the control of the stimulus relative size, a generalization test was conducted subsequent to achieving the criterion in AB training. The AB' generalization test was identical to AB baseline training, except that trials were not reinforced (i.e., extinction) and six other pairs were presented as comparisons (Subset B'). Prior to each CB test block, a 12-trial full baseline block was presented, consisting of 6 AC trials interspersed with 6 AB trials. This was done to ensure a stable baseline before testing for the emergence of CB relations.

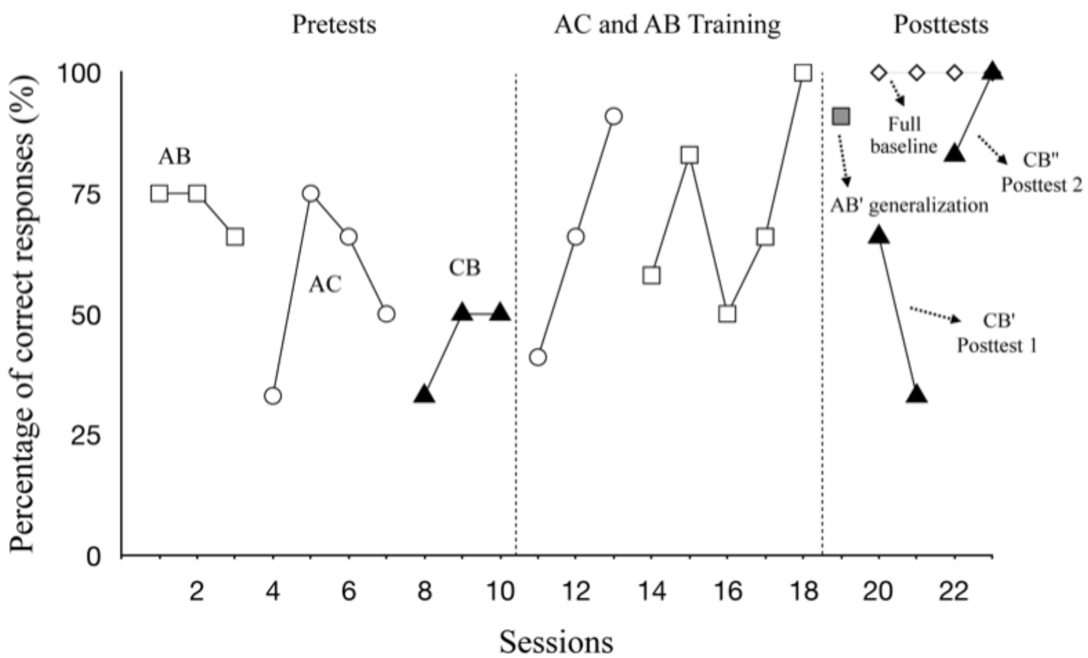
Two types of posttest blocks were conducted. In CB' Posttest 1, blocks were identical to pretest blocks, except that the comparison stimuli presented were obtained from Subset B'. In CB'' Posttest 2, the comparison stimuli were obtained from Subset B'' and the trial block consisted of 20 trials: 12 trials of CB relations in extinction, interspersed with 8 trials of reinforced identity-matching relations (with the same stimuli used during the pretraining phase).

Results

Figure 1 shows Edson's data in the pretest, training and posttest phases. In the pretests, his AB performance (open squares) was slightly above chance in three test blocks, with accuracy ranging from 66 to 75% of correct responses. With respect to AC (open circles) and CB (black triangles) relations, Edson scored at chance levels (varying between 33 and 75%). During baseline training, he mastered the criterion for AC relations in three sessions, achieving 41%, 66% and 91% of correct responses, respectively. In AB trials, he mastered the criterion after five sessions, with performance ranging from 50 to 100% accuracy.

Figure 1.

Percentage of correct responses per session.



Note: Percentage of correct responses for AB (open squares), AC (open circles) and CB (black triangles) relations during pretest, training and posttest phases. The grey square depicts performance in AB generalization probes, whereas open diamonds depict accuracy in full baseline trials (AC and AB) conducted before each CB probe block.

Regarding the posttest results, the data we obtained were consistent with generalization of AB relations (grey square), suggesting that the AB baseline training was successful in establishing conditional relations between the dictated words "larger than" and "smaller than" and the stimulus relative size. Edson achieved 91% of correct responses in the generalization test. Moreover, performance on CB Posttest 2 indicated the emergence of CB relations. Edson was subjected to four CB-relations test blocks, two blocks for each type of posttest, with all full baseline blocks (open diamonds, see Figure 1) with 100% of accuracy. In Posttest 1, he responded at 66% in the first block, but accuracy declined to 33%. However, his performance improved in CB Posttest 2, with 83% and 100% of correct trials in the two test blocks, respectively. The results thus indicate emergence of CB relations, with a possible enhancing effect of interspersing identity matching trials with test trials. Considering that the identity trials were visual-visual and that different arrangements of teaching and testing procedures could affect performance (Kelly, Green & Sidman, 1998), it is likely that the identity trials in the test block provided a clear context for matching visual stimuli in CB trials

Discussion

The positive results obtained in CB testing could suggest that the relations between dictated words ("larger than" and "smaller than"), relative physical size and mathematical symbols were equivalence relations (Sidman, 2000). These results are noteworthy for two reasons. First, they demonstrate the emergence of complex visual-visual relations in which symbols control a relational conceptual behavior (i.e., selecting objects under the control of their relative size). In relational concepts (Zentall et al., 2002), the relevant stimulus property that controls behavior is not a static physical feature (such as color or shape), but rather a relative feature that depends on a stimulus-stimulus relation. In the present study, Edson learned to match the mathematical symbols ">"and "<" to the largest and smallest comparisons exhibited, respectively. The sample ">" controlled the selection of a 67.6 oz. bottle (when presented along with a 20 oz. bottle) and the selection of a 12 oz. cup (smaller than the mentioned bottles) when presented with a 4 oz. cup.

Second, the present study extends, to the "larger than" and "smaller than" concepts, previous studies showing equivalence class formation involving quantities (Green, 1992; Kennedy & Serna, 1995). For instance, in Green's study, two participants with developmental disabilities learned equivalence relations between dictated numerals, printed numerals and quantities of dots. In equivalence probes, participants accurately related printed numerals to cards displaying quantities of dots; their performance was also accurate even when new stimuli such as coins or apples were exhibited. Therefore, EBI could be used for teaching equivalence relations involving the mathematical concepts of "larger than" and "smaller than" and their corresponding mathematical symbols (an important mathematical skill previously unaddressed in the stimulus equivalence literature) to individuals with autism.

Teaching such equivalence relations could also lead to developing increasingly complex derived relational responses (such as comparative relations) in children with autism (e.g., Gorham et al., 2009). According to the Relational Frame Theory (RFT, Hughes & Barnes-Holmes, 2016), a history of multiple exemplars with non-arbitrary relational training (for instance, selecting a stimulus based on its physical size) would be critical for learning that "a gold medal is larger than a silver medal" (even if both medals are of the same size). RFT proposes that contextual cues are needed to indicate what type of relation would be brought to bear on a given stimulus array. Thus, a procedure such as the one described herein, which establishes non-arbitrary relational responses (a conceptual behavior) under the control of equivalence classes (symbols and/or words that would control a specific pattern of relational responding), could be significant for developing effective RFT interventions for individuals with autism and other developmental disabilities. Future studies should investigate the extent to which teaching equivalence relations involving conceptual behaviors (non-arbitrary relational responses) enhances performance in tasks involving other relational frames (e.g., comparison, distinction and opposition).

The present study has some limitations. First of all, although the emergence of CB relations may suggest equivalence class formation, this inference should be viewed with caution due to the fact that emergence of the other relations needed to substantiate equivalence relations (such as BC, CA and BA relations) was not assessed. As previously stated, methodological difficulties in simultaneously presenting sizes as samples and auditory stimuli as comparisons precluded testing the abovementioned relations. A second limitation refers to the fact that the data were obtained with single participant with a pretest/posttest design. One cannot completely rule out the hypothesis that the emergence of CB relations was not a product of the procedure. Notwithstanding, this hypothesis seems unlikely, because learning CB relations outside the context of the study would require several sessions of multiple-exemplar training and emerging relations were not observed until the change of the testing procedure (CB Posttest 2, see Figure 1). Moreover, to our knowledge, the participant was not exposed to similar tasks in school or in home. Though, future replications could benefit from employing a larger sample, with a more robust design (e.g., multiple baselines across participants) and investigate whether teaching "larger than/smaller than" concepts would generalize to physical dimension other than stimulus size (for example, physical space).

Overall, our findings add to the literature, showing that a child diagnosed with autism can establish emergent relations between mathematical symbols and relative sizes, suggesting that EBI could be effective for teaching this mathematical skill in applied settings.

Declaração de conflito de interesses

Os autores declaram que não há conflito de interesses relativos à publicação deste artigo.

Contribuição de cada autor

Certificamos que todos os autores participaram suficientemente do trabalho para tornar pública sua responsabilidade pelo conteúdo.

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