Establishing Derived Equivalence Relations of Basic Geography Skills in Children with Autism

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Abstract The present study evaluated the efficacy of a stimulus-equivalence training procedure in teaching basic geography skills to two children with autism. The procedures were taken directly from a standardized training curriculum based in stimulus equivalence theory called *Promoting the Emergence of Advanced Knowledge Equivalence Module* (PEAK-E). Results suggest that the procedures were efficacious in directly training several geographical relations, as well as promoting the derivation of several untrained relations for three countries and their corresponding continents. In addition, responding generalized from selecting countries on a tabletop paper map to selecting countries on an interactive touchscreen map.

Keywords Autism · Geography · PEAK · Stimulus equivalence · Verbal behavior

Parent requests and legislative mandates have produced an increase in the inclusion of children with autism and related disabilities in general education classrooms, even when these children lack social and academic skills necessary to be successful in such environments (Fuchs & Fuchs, 1994; Kasari, Freeman, Bauminger, & Alkin, 1999). The No Child Left Behind Act (2002), for example, requires schools to use the grade-level standards for students without disabilities as the basis for IEP objectives of students with disabilities. Advances in the development of applied technologies generated from stimulus equivalence theory (Sidman & Tailby, 1982) may be efficacious in directly training academic skills and also in promoting the emergence of academic skills in the absence of direct training (i.e., derived stimulus relations).

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LeBlanc, Miguel, Cummings, Goldsmith, and Carr (2003) demonstrated how equivalence training of US geographical relations could promote the emergence of derived stimulus relations with two children with autism. In their study, participants learned to relate state names (A) to state shapes (B) (A–B) and to relate state shapes (B) to state capital names (C) (B–C). Results suggested that direct training of A–B and B–C relations resulted in the emergence of untrained symmetrical, transitive, and equivalence relations across three testing conditions (i.e., extinction for correct and incorrect responses, continuous reinforcement for correct and incorrect responses, and extinction for correct and incorrect responses with interspersed trials of previously mastered responses). The target relations in LeBlanc et al. were socially relevant because basic geography skills are an item (i.e., CCSS.ELA-Literacy.RH.6–8.7) within the Common Core Standards (2014) on which children with autism and related disabilities are assessed (NCLBA, 2002). A potential limitation in the study conducted by LeBlanc et al., however, was that the equivalence classes targeted had only three class members (state names, shapes, and capitals) and investigators did not assess generalization.

The purpose of the present study was to expand on research conducted by LeBlanc et al. (2003) and other authors (e.g., Dixon et al., 2017; Lynch & Cuvo, 1995) on the application of stimulus equivalence technologies to academic skills of children with autism. Previous research suggests that the probability of stimulus equivalence decreases as nodal distance increases (Fields, Verhave, & Fath, 1984). The present study expands upon the study conducted by LeBlanc et al. by increasing the number of class members from 3 to 4 (country names, locations, flags, and continents) where one class member required participants to select a stimulus on a world map (i.e., location). Thus, we evaluated if results of LeBlanc et al. could be replicated with increased nodal distance between stimuli. Increasing the number of class members from 3 to 4 members also has the potential benefit of increasing the number of emergent relations from 4 to a total of 9 relations, allowing for greater efficiency. Finally, the present study extends on previous research by assessing generalization of participants' selection responses from a tabletop map to an interactive map on a touchscreen.

Method

Participants, Setting, and Materials

One male and one female participated in the current study: Parker (12 years old; male) and Lily (9 years old; female). Both participants were diagnosed with autism and attended a special school for children with autism. The participants were selected for the study for two reasons: they had similar educational goals to learn geography skills and they demonstrated similar verbal abilities prior to the study. Specifically, participants exhibited advanced verbal repertoires (i.e., tacts, mands, intraverbals) and a history of demonstrating reflexive, symmetrical, transitive and equivalence relations, per their PEAK-Equivalence Pre-Assessment scores (Dixon, 2015).

All sessions were conducted in the participants' home classrooms or in a separate room at the school. Sessions lasted between 20 and 30 min, with 2–3 sessions occurring each day. Sessions were conducted 2 days per week over 4 weeks. Materials were adopted from the *Promoting the Emergence of Advanced Knowledge Equivalence*

Module (PEAK-E) program 13 V – Equivalence: Countries and Continents (Dixon, 2015). Stimuli included vocal country names spoken by the experimenter (e.g., Argentina, Kenya, and Mongolia), a paper world map, 5.08×5.08 cm paper country flags, and continent names spoken by the participant. Materials also included touchscreen laptop computer that display an interactive globe.

Dependent Variable, Interobserver Agreement, and Procedural Integrity

The dependent variable was the percentage of correct responses for each trial block. The percentage correct was calculated by dividing the number of correct responses by the total number of responses in a five-trial block then multiplying by 100. The mastery criterion was 100% correct responding across three consecutive blocks. Interobserver agreement (IOA) was collected on 41% of sessions by two trained, independent observers. Trial-by-trial IOA was calculated by dividing the number of agreements by the total number of agreements and disagreements and multiplying by 100. Mean agreement was 100% for Lily and 98% for Parker.

Procedural fidelity was assessed for 16% of the trials by using the PEAK Implementation Checklist (Belisle, Rowsey, & Dixon, 2016). A trained observer tallied the number of steps performed correctly and incorrectly by the researchers for each trial. The number of steps performed correctly was then divided by the total number of steps (i.e., 11 steps per trial) and multiplied by 100. Procedural fidelity was 100% for each participant across all phases of this investigation.

Experimental Design

Training was evaluated using a multiple-probe design across subjects. A total of six relations were tested throughout the study (i.e., A–B, B–C, C–D, D–A, C–A, and D–B), three of which were directly trained (i.e., A–B, B–C, and C–D). The three relations that were exclusively tested in the absence of direct training (i.e., D–A, C–A, and D–B) were selected out of a possible nine untrained relations because they represent derived equivalence relations, or the most complex derivations possible in the present study. The study proceeded as follows: 1) baseline, 2) A–B training, 3) B–C training, and 4) C–D training. A set of test probes identical to those in baseline were conducted following each of the training phases.

Procedure

During baseline, probes were conducted in five-trial blocks across each of the six relations. Prompting and reinforcers were not used during test probes. The country name to country location (A–B) training phase involved presenting a spoken country name (A) and a map (B), and asking the participant, “Where is (A)?” If the participant provided the correct response by pointing to the country location on a world map, the experimenter praised the response. If the participant did not respond, or provided the incorrect answer, the experimenter pointed to the correct country and said, “This is (A).” All remaining relations (i.e. B–C, C–D, D–A, C–A, and D–B) were probed following the phase. In the country location to country flag (B–C) training phase the experimenter pointed to a country on a world map, and asked, “What is this country’s

flag?” and the participant was required to select the corresponding flag from an array. If the participant responded by selecting the correct flag, the experimenter praised the response. If the participant emitted an incorrect response, the experimenter pointed to the correct flag and advanced to the next trial. All other relations were probed following this phase. The country flag to continent name (C–D) training phase involved the experimenter presenting a country flag (C), and asking, “In which continent is this country?” If the participant provided the correct spoken name of the continent, the experimenter praised the response. If the participant provided an incorrect answer, the experimenter said the correct response and advanced to the next trial. All remaining relations were probed following the phase. For the continent name to country name (D–A) test relation, the experimenter asked, “What country is in (D)?” and the participant was required to say the correct country. For the flag to country (C–A) relation, the experimenter provided a sample flag that was placed on the table directly in front of the participant and asked, “What country is this?” and the participant was required to say the correct country. For the continent to location relation (D–B), the experimenter provided the participant with a world map and asked, “What country is in (D)?” The participant was required to point to the correct country location on the map.

Generalization probes were conducted following each set of baseline probes for all relations containing the map (A–B, B–C, and D–B relations). Generalization probes were conducted in a similar fashion for each relation except that the paper map of the world was replaced with an interactive globe displayed on a touchscreen laptop. The experimenters turned off all country name labels to ensure the participant would not respond based on the textual name of the country. All country borders on the globe remained visible for the participant to see. At the beginning of each trial, the globe was positioned so North America was displayed in the center of the computer screen. This ensured a consistent starting location prior to each trial and minimized any variables potentially associated with a random starting position. After the experimenter presented the vocal discriminative stimulus, participants were required to use their finger to navigate the globe (i.e., spinning the globe; moving it up or down) and find the correct country or continent. The experimenter did not prompt or praise responses during generalization probes.

Results and Discussion

Figure 1 displays the results for both participants. Data suggest that neither participant had mastered target relations prior to training based on performance below 20% for Lily and below 40% for Parker. During A–B training, Lily demonstrated an increase in correct responding for the A–B relation during training that reached 100% correct within 16 trial blocks. For the set of probes following A–B training, Lily responded with 100% accuracy on the A–B relation and achieved 60% accuracy for the A–B generalization probes. All other relations for Lily remained at baseline levels. During B–C training, Lily’s correct responding for the B–C relation increased to 100% within 3 trial blocks. For the set of probes following B–C training, Lily’s responding occurred at 100% accuracy for A–B and B–C relations, and her performance was 80% correct for the untrained C–A relation. During C–D training, Lily’s responding was variable, but increased to 100% accuracy with additional training. For the final set of baseline

Fig. 1 Correct responses across conditions for both participants for PEAK-E program 7E – *Transitivity: Countries and Continents*. Closed symbols represent the A-B, B-C, and C-D train stimuli and open symbols represent the D-A, C-A, and D-B test stimuli

probes, Lily responding occurred at 100% accuracy for the B-C, C-D, D-A, and D-B relations, and she achieved 80% accuracy for the A-B and D-A relations. Generalization probes occurred at 60%, 80%, and 100% for the A-B, B-C, and D-B relations, respectively.

During A-B training, Parker's correct responding reached 100% within 13 trial blocks. Parker's percentage correct responding for the A-B relation remained at 100%, with all other relations remaining at similar levels to that in baseline. Parker also showed an increase in correct responding for the A-B generalization probe, which occurred at 80%. Parker demonstrated 100% correct responding for the A-B and B-C relation and 60% correct responding for the C-A relation. Parker's responding for the C-D relation also increased to 100% in this phase. Parker demonstrated 100% correct for all relations except the C-D and C-A relations, which occurred at 80% accuracy. Parker's responding on generalization probes occurred at 100% accuracy for A-B and B-C relations and 80% accuracy for the D-B relation. The percentage of nonoverlapping data for the final set of baseline probes relative to the first set of baseline probes was 100% for both participants across all relations.

Results of this study, which are consistent with prior research, demonstrate that a training procedure grounded in stimulus equivalence can be efficacious for teaching academically relevant skills to individuals with autism. These findings expand on the outcomes of LeBlanc et al. (2003) by promoting the emergence of untrained relations within four-member equivalence classes. Results also demonstrate the generalizability of trained and derived skills (i.e., D-B relation), which suggests a change in the response topography from a paper map to an interactive map on a touchscreen computer. Because procedures and many training stimuli (e.g. example countries, discriminative stimuli, etc.) were taken from the standardized curriculum of PEAK, an added benefit may be the utility of the protocol to therapists or teachers with limited prior exposure to equivalence procedures. Although the current study provides support

for the effectiveness of the procedures, further research is needed regarding the relative portability of the procedures in usual care settings involving non-technically trained caregivers (e.g., Schoenwald & Hoagwood, 2001). Research should also assess the social validity for both teachers and parent-consumers of the procedures outlined in the present study. Taken together, results suggest stimulus equivalence procedures can be efficacious for training and facilitating generalization of academically relevant skills for some children with autism.

Compliance with Ethical Standards

Disclosure First author receives small royalties from sales of the PEAK curriculum.

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