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Using the Stimulus Equivalence Paradigm to Teach Coin Discrimination to Visually Impaired Children

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by

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Abstract

The ability to purchase goods and services independently requires a complex set of discriminations among paper and coin currency. In regards to coins, a complete discrimination skill set includes the ability to name coins, to state the value of a coin, to identify coins given their names, to identify coins given their values, to state the name of a coin given its value, and to state the value of a coin given its name. Due to their loss of sight, individuals with visual impairment must rely on tactile cues, such as ridges and comparative size, to discriminate between monetary coins. Previous research has taught coin discrimination to disabled populations; however, none have evaluated training procedures for individuals with visual impairments. In the current study, we specifically taught children with visual impairment to select a coin using tactile cues upon hearing its name and then to select a coin upon hearing its value. In accordance with a stimulus equivalence paradigm, we also assessed the emergence of coin-name, coin-value, name-value, and value-name relations. After training, all three participants correct responding increased from baseline levels with the emergence of the predicted relations.

Using the Stimulus Equivalence Paradigm to Teach Coin Discrimination to Visually Impaired Children

Being independent in one's community involves a specific set of skills, including navigating transportation routes, communicating well with others, and purchasing items of necessity. Individuals who possess these functional skills, particularly those with disabilities, are able to reach only a certain level of independence. Those who develop the skills necessary to engage in monetary exchanges are capable of more efficiently and independently operating in their community (Xin, Grasso, Dipipi-Hoy, & Jitendra, 2005).

Successful monetary exchanges involve a number of skills including identifying the cost of a good or service and identifying the relevant monetary units necessary to achieve that amount. This latter portion involves identifying the value of individual denominations of currency, as well as addition and subtraction. The relevant identification of currency would involve developing a relation between the actual bill or coin, the spoken word or name of the coin, and the representative value of the coin. (Edge & Burton, 2001).

Several researchers have evaluated procedures to teach monetary skills to individuals with developmental disabilities. Trace, Cuvo, and Criswell (1977) taught fourteen mentally handicapped participants to create coin combinations equivalent to a numerical value displayed on a machine and to then deposit these coins into the machine via a response chaining procedure. In another study, Lowe and Cuvo (1977) taught mentally handicapped participants who had previously acquired simple arithmetic skills to count and then sum coins. The researchers used a coin hierarchy (i.e., taught coins in increasing multiples of 5), modeling procedures, and physical guidance to teach the participants. In addition to these techniques, the researchers also instructed the participants to place a finger, corresponding to its divisibility by 5 (nickel = one finger, dime = two fingers), next to the target coin in order to facilitate counting.

Miller, Cuvo, and Borakove (1977) also taught monetary skills to fourteen mentally handicapped adolescents; specifically, they taught participants to state the value of a selected coin and to also select a target coin after hearing the value. The results showed that that those participants who they exclusively taught to state the target coin's value required fewer trials to reach mastery than those participants taught to select the target coin after hearing the value in addition to verbally producing the value. Their study determined that the participants generalized the comprehension of coin values after only being taught to verbally produce them.

These research studies have used teaching methods based upon visual discrimination of coins (Trace & Cuvo, 1977; Lowe & Cuvo, 1977; Miller & Cuvo, 1977). Honor and Comstock (2005) determined that Americans use visual characteristics of coins including both gross features, such as size and color, and defining details, such as ridges and president displayed on the coin, to identify the specific coin. However, such procedures are unlikely to be successful in teaching individuals with visual impairments to make coin discriminations.

Children with visual impairments may present a unique challenge to teaching monetary skills in that they will need to be trained to discriminate based upon tactual features of the coins, specifically the presence vs. absence of ridges and the relative size of the coin. Despite the importance of this skill to individuals with visual impairments, we have not identified any research demonstrating an empirically-based teaching procedure to develop these tactual discriminations. We set out to do so in the current study by teaching these discrimination skills and arranging instruction in a manner that would promote the formation of a stimulus-equivalence relation between the coin, its spoken name, and its spoken value.

Stimulus equivalence is typically assessed within a matching to sample arrangement in which in the presence of one stimulus (A), an individual is taught to select a second stimulus (B), and in the presence of stimulus (B) the participant is taught to select stimulus (C). An equivalence class is demonstrated when following this training, three stimulus relations emerge without direct training; these relations are referred to as reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982). In a reflexive relation, a participant is able to match a stimulus to itself. For instance, a participant would be able to select a quarter from an array of coins when presented with a quarter. In a symmetric relation, the reverse of a trained relation emerges without additional training. For instance, if a participant was taught to select a quarter when presented with the stated word “quarter”, the symmetric relation would be demonstrated by naming a quarter when presented with the coin. In a transitive relation, a participant would be directly taught to select stimuli B when presented with stimuli A and then to select stimuli C when presented with stimuli B. The emergent transitive relation would appear when the participant could then select stimuli C when presented with stimuli A or vice versa. For example, when taught to select the target coin after hearing the name of the coin and also being taught to select the target coin after hearing the value of the coin, the participant could then verbally produce the value of the coin after just hearing the name of the coin and vice versa.

Stimulus equivalence may be beneficial in teaching monetary discriminations because it increases the efficiency of instruction in that we can directly teach a small number of skills that will result in the emergence of a number of additional relations. Stimulus equivalence has been successfully used in teaching individuals functional skills such as reading (de Rose et al., 1996; Connell & Witt, 2004) and emotional recognition (Guercio et al., 2004). Therefore, using a stimulus equivalence class to teach coin discrimination would enable a greater number of these skills to be acquired, without teaching each skill subset individually (Trace & Cuvo, 1977; Lowe & Cuvo, 1977; Miller & Cuvo, 1977).

Previous research has been conducted using stimulus equivalence teaching techniques with coin discrimination (McDonagh, 1984); however, no studies have involved participants with visual impairments. The purposes of this study were to (a) evaluate a training procedure to establish coin identification skills when presented with the name and the value of the coin and (b) to assess the emergence of an equivalence class among the name, value, and tactual properties of coins.

Method

Participants

We recruited referrals for 3 students' participation from a state school for the visually impaired via interviews with teachers and school administrators with the criteria that the students be (a) enrolled in either Kindergarten or 1st grade, (b) had been diagnosed with no more than minimal intellectual disability, (c) demonstrated minimal prior coin discrimination skills, and (d) had a visual impairment to a degree that prevented them from recognizing coins by sight alone. The first three students who met these criteria and who returned consent forms participated.

Riley was a 9-year-old boy of typical cognitive development with complete blindness. His teachers described him as hard-working, particularly in his study of Braille, and a good listener. Maddie was a 6-year-old female of typical cognitive development, diagnosed with Oculocutaneous Albinism with horizontal nystagmaus, as well as photophobia, an extreme sensitivity to light. Her teachers reported her strengths in social interactions and communication with students and teachers. Christopher was an 8-year-old male with mild developmental delays; he was diagnosed with retinal detachment in both eyes, specifically retinopathy of prematurity, a dense cataract in his left eye, and no light perception in his right eye. Christophers' teachers reported he typically required individualized instruction in all academic tasks; however, they also reported that he had demonstrated increased improvements in his communication skills over the past academic year. We do not have any formal developmental assessments of the participants beyond any indication on each child's Individualized Education Plan.

Materials

The training took place in either an empty therapy observation room at the school or, with the permission of the participants' teacher, a designated area in her classroom secluded from the other children and ongoing activities to limit distractions. We used the following American coin currency: the quarter, the dime, the nickel, and the penny. Both the quarter and the dime have ridges on the side of the coin, while the nickel and the penny have smooth edges. In order to ensure the discriminability of these marks by touch, we used relatively uncirculated coins designated for classroom instruction. We then presented these coins along with a verbal prompt to each participant.

A paired-item preference assessment was conducted with each child in order to identify highly preferred leisure items to deliver as reinforcers during the study. A list of potential reinforcers was generated from interviews with the participants' teacher and the children directly. We presented the items in paired arrays and asked each child to choose between the presented items. Each item was paired with every other item once, and the items were then ranked in order based upon the percentage of trials they were selected. Access to the top three items were arranged as reinforcers throughout the remainder of the study. Riley chose a slinky, coloring, and a book; Maddie chose a slinky, a keyboard, and a Spongebob video; and Christopher chose a slinky, a ball, and a SpongeBob video. When a reinforcer was earned during the experiment, the teacher dropped a marble into a plastic cup to signal the reinforcer was earned along with verbal praise. Marbles were then exchanged for 30-s access to a choice of leisure items at the conclusion of each training trial.

Procedures Overview

We initially conducted a pretest to determine the presence of a pre-existing repertoire of coin-related skills. Next, we assessed the child's ability to discriminate larger vs. smaller coins and ridges vs. no ridges and if necessary, teach these skills. We then conducted an additional baseline probe for the coin relations before finally sequentially teaching 2 coin relations. After conducting booster sessions upon completion of training, we then assessed the emergence of untrained coin relations as a result of this training. Sessions during each phase utilized a matching-to-sample arrangement in which students were presented with a sample stimulus (i.e., a coin, the stated name of the coin, or the stated value of the coin) and selected the corresponding stimulus from an array (i.e., the coin) or vocally stated the correct name or value.

Coin Relations Baseline

We conducted baseline probes to assess six coin relations for each of the four American coins (penny, nickel, dime, and quarter). Specifically, we assessed the children's abilities to state the name of a coin given the coin as a sample stimulus (coin-name relation), to state the value of a coin given the coin (coin-value relation), to state the value of a coin given the name (name-value relation), to select a coin given its name (name-coin relation), to select a coin given its value (value-coin relation) and to state the name of a coin given its value (value-name relation). We assessed each relation during an individual session that consisted of eight trials in which each coin was presented as the target two times. Students who correctly responded to 7 out of 8 targets on any given test were to be excluded from the study. Since Riley met this criterion for the name-coin relation, we only directly trained him in the value-coin relation; whereas, Maddie and Christopher did not meet this criterion for any relation.

Discrimination Skills Assessment and Training

Tactile discriminations between American coins require students to discriminate larger from smaller (from largest to smallest; quarter, nickel, penny, dime) as well as the presence or absence of ridges along the sides of the coins. Prior to directly training coin discriminations, we conducted a pretest to ensure students had these prerequisite skills. During larger vs. smaller discrimination pretests, we presented the child with two randomly selected coins and instructed him or her to choose the larger or smaller coin. Each larger/smaller pretest session was 12 trials, so that we presented every coin with every other coin twice per session (once in which we requested the larger and once in which we requested the smaller coin). The teacher did not provide any programmed consequences for correct or incorrect responding.

During the ridges vs. no ridges pretest, the teacher presented the children with two coins on each trial (one with ridges and one without) and were asked to hand the teacher the coin either with or without ridges. This pretest consisted of 8 trials in which each ridged coin was presented with each non-ridged coin two times (once in which the ridged coin and once in which the non-ridged coin were requested). Again, the teacher did not deliver any programmed consequences for correct or incorrect responding.

We directly taught students who did not demonstrate accuracy criterion (correctly responding to 7 out of 8 targets or higher or 11 out of 12 targets or higher) during the size and ridge discrimination pretests. Training sessions for the larger/smaller discrimination were similar to baseline except that the children were prompted to (a) place both coins next to each other in their hands, (b) to touch the edge of the smaller coin, and (c) hand the larger/smaller coin to the therapist. Correct responding at each step in the sequence resulted in teacher praise, and completion of the terminal step resulted in the delivery of a marble. Incorrect responses or a failure to respond at any step resulted in the delivery of physical guidance from the teacher.

Training sessions for the ridges/no-ridges discrimination were similar to baseline except that children were prompted to (a) pick up each coin individually, (b) drag their finger nail along the side of the coin, (c) vocally label the coin as having or not having ridges, and (d) hand the coin with or without ridges to the teacher. Correct responding at each step in the sequence resulted in teacher praise, and completion of the terminal step resulted in the delivery of a marble. Incorrect responses or a failure to respond at any step resulted in the delivery of physical guidance from the teacher.

Training sessions continued until the participant met the 7 out 8 trials correct-responding criterion during training sessions and during an additional post-test session completed the following day. This session was conducted identical to the pretest to ensure these discrimination skills maintained in the absence of reinforcement. Once the child exceeded 7 out of 8 targets correct on a post-test for these two discrimination skills, we repeated coin relation pretests to ensure that teaching the larger/smaller and ridges/no ridges discrimination did not directly result in coin-relation acquisition.

Coin Relation Training

Based on the stimulus equivalence paradigm, we directly trained two coin relations and expected four emergent relations. Specifically, we sequentially trained the name-coin and value-coin relations. The sample was the spoken name of the coin and the spoken value of the coin, while the target response for both relations was handing the physical coin to the teacher from an array consisting of all four American coins. We assessed four emergent relations that we expected to appear following the acquisition of the directly trained relations, specifically the:

coin-name (symmetric), coin-value (symmetric), name-value (transitive), and value-name (transitive). Each session consisted of eight trials.

We then used an errorless teaching method during our name-coin and value-coin training. During the first session of the name-coin relation training sessions, one coin was initially targeted and only one comparison coin was presented in the array (e.g., the penny). At the beginning of each trial we provided the prompt, “Find the (name)” and the child had 5-s to respond independently. Across all training phases, correct independent responses resulted in the delivery of praise and a marble. If they did not engage in a correct independent response, we physically prompted the child to (a) pick up the coin, (b) to drag their finger nail along the outer rim of the coin and (c) to hand the coin to the teacher. Correct prompted responses resulted in praise only. Following one session in which the child completed these three steps independently on 7 out of 8 trials, we introduced one additional comparison that differed in the presence or absence of ridges (e.g., the dime). Training was similar except that we prompted the participant to (a) stack the coins in their hands to identify size differences, (b) drag their fingernail along the outer rim of each coin, and (c) to hand the target coin to the teacher. Following one session in which the child correctly and independently identified the target coin on 7 out of 8 trials, we introduced a third coin. The same training steps and criteria were used to add in a fourth coin. Following training and meeting criteria with a comparison array of four coins, we then introduced the next coin as the target and repeated the previous training steps, until all four coins were selected with at least 7 out of 8 correct trials given their name as a sample stimulus.

Following completion of this training we again probed all six coin-name-value relations prior to conducting value-to-coin training. Value-coin relation training used an identical errorless training procedure as described for name-coin training except the initial prompt during this training was “Find the (value).” The effects of name-coin relation training and value-coin relation training were assessed in a multiple baseline design across participants.

Emergent-Relations Probes

We implemented 2 different emergent relation probe procedures across participants. During Riley’s and the first few post-training probes of Maddie’s assessment, we assessed the emergence of targeted relations during probe sessions similar to baseline probes. That is, during individual sessions, we presented each coin as a sample stimulus twice and assessed each relation in individual sessions; we did not deliver any programmed consequences for correct or incorrect responding. In between each session we conducted a *booster training* session, identical to previous training sessions, in which all trained relations were represented and correct responding resulted in reinforcement. Similar to the prior condition we required 7 out of 8 trials with correct responding to move beyond the booster session. We included these boosters to ensure the trained relations remained at strength given the periods of time that elapsed between training and the completion of all probes (typically we conducted one or two probe sessions per day, and thus several days could elapse between training and probing).

During Maddie and Christopher’s assessments, we interspersed unreinforced probe trials with reinforced training trials within each session. Specifically, each session included 16 trials of which 8 involved presentations of the trained relations and resulted in reinforcement or corrective feedback and 8 unreinforced probes (an equal ratio of unreinforced probe trials to reinforced probe trials). We evaluated only those data from the unreinforced probe trials as the dependent variable. This procedure prevented prolonged periods of non-reinforcement for responding, which were characteristic of the probe procedure used with Riley.

Measurement and Interobserver Agreement

For relations that required the participant to identify a particular coin, we defined correct responding as placing the target coin in the teacher's hand; we defined incorrect responding as placing any other coin in the teacher's hand or failing to respond within 10-s. During trials that required a vocal response, we defined correct responding as vocalizing the target coin's name (or value); we defined incorrect responding as vocalizing any other coin's name (or value) or failing to respond within 10-s.

In order to assess interobserver agreement (IOA), a second observer simultaneously but independently collected data during 100% of Riley's sessions, 81% of Maddie's sessions, and 85% of Christopher's sessions. We compared observers' records on a trial by trial basis and scored each trial in agreement if both observers recorded a response as correct or if both recorded a response as incorrect; we scored all other trials in disagreement. The number of trials in agreement then summed and divided by the total number of trials and converted into a percentage yielding a mean agreement of 99.6% for Riley's evaluation, 97.2% for Maddie's evaluation, and 95.8% for Christopher's evaluation (session range, 75% to 100% across participants).

Results

We present results for Riley's evaluation in Figure 1. Riley engaged in perfect responding during the first 4 baseline probes of the name-coin relation (top left panel of Figure 1; as well as the coin-name relation, top middle panel of Figure 1). Therefore, we did not directly train this relation. Rather, we initiated training of the value-coin relation (*M* = 17.5% correct during pre-training baseline; bottom left panel of Figure 1). Riley met mastery criteria following 18 sessions during training (Table 1); and continued to respond at high levels during post-training probes (*M* = 87.5%). This training was also associated with increases in accuracy of the emergent relations (i.e., those relations not directly taught) during baseline probes. Specifically, accuracy increased from means of 15% in pre-training to 91% in post-training probes the name-value (i.e., transitive) relation, 45% to 81% in probes of the coin-value (symmetric), and 12.5% to 81% correct in probes of the value-name relation (transitive).

In Figure 2, we display Maddie's results. During initial pre-training baseline probes for Maddie, her responding was below mastery criterion for both name-coin (*M* = 29%; top left panel of Figure 2) and value-coin (*M* = 20.8%; bottom left panel of Figure 2) relations across three sessions; therefore, we directly trained her in both relations. In Table 3 we present Maddie's results for the discrimination skills assessment in which she displayed mastery for size difference. However, she did not meet the criterion for presence or absence of ridges; therefore, we trained her in this discrimination skill until she met mastery criterion after 2 sessions (Table 3).

After 16 sessions (Table 2) of name-coin relation training Maddie met mastery criterion and consistently responded at greater than baseline levels during 3 sessions of post-training probes (*M* = 83.3%). This increase in correct responding resulted in a large increase in accuracy for the emergent, symmetric coin-name relation, specifically from a mean of 25% pre-training to 87.5% post-training (top middle panel of Figure 2). During the name-coin post-training probes, the untrained relation of value-coin remained at a similar to baseline level (*M* = 20.8%), as did the emergent relations of coin-value, name-value, and value-name (*Ms* = 8%, 12.5%, and 12.5%, respectively).

After 16 sessions (Table 1) of value-coin relation training, we began post-training probes with Maddie in which her correct responding remained at a high accuracy level across 5 sessions (*M* = 97.5%; bottom left panel of Figure 2). Maddie also showed high levels of accurate responding in the previously trained name-coin relation during post-training probes (*M* = 82.5%), as well as the symmetric coin-name relation (*M* = 72.5%). This value-coin training was also related to increases in accuracy of the untrained emergent relations. However, initially the first post-training probe of the emergent relations showed unexpected low levels of accuracy. Due to these results, we implemented a new procedure in which booster trials with reinforcement were intermixed with probe trials with no reinforcement (indicated on Figures 2 and 3 across emergent relation panels). After the implementation of this new post-training probing procedure, accuracy increased from overall means of 10% in pre-training to 72% in post-training probes of the name-value (i.e., transitive) relation (bottom middle panel of Figure 2), 8.3% to 100% in probes of the coin-value (symmetric; top right panel), and 12.5% to 78% correct in probes of the value-name relation (bottom right panel).

In Figure 3, we present Christopher's results. During initial pre-training baseline probes for Christopher, his responding was the lowest out of the 3 participants for name-coin (*M* = 8%; top left panel of Figure 3) and value-coin (*M* = 12.5%; bottom left panel of Figure 3) relations across three sessions, thus meeting criterion for relation training. Christopher also met the criterion for discrimination training in both size difference and presence or absence of ridges and therefore we trained him in these skills until he reached mastery criterion after 2 sessions (Table 3).

After we directly trained Christopher in the name-coin relation in 21 sessions, Christopher's results for increased from pre-training to 70.8% at post-training across three sessions (top left panel of Figure 3). We conducted the post-training probes with the same procedure used with Maddie. The value-coin training was also associated with an increase in accuracy levels of the emergent symmetric relation (*M* = 50%; top middle panel of Figure 3).

During the name-coin post-training probes, the untrained relation of value-coin remained at a similar to baseline level (*M* = 8%), as did the emergent relations of coin-value, name-value, and value-name (*Ms* = 8%, 0%, and 0%, respectively).

In 17 sessions (Table 1) Christopher met mastery criterion for value-coin training. His post-training probes showed consistently high levels of accuracy across 7 sessions (*M* = 89%; bottom left panel of Figure 3). Higher levels of accurate responding continued for the previously trained name-coin relation at 62.5% and the emergent, symmetric coin-name relation at 52%. This value-coin training was associated with increased accuracy of the untrained emergent relations, specifically from overall means of 0% in pre-training to 29% in post-training probes of the name-value (i.e., transitive) relation (bottom middle panel of Figure 3), 2% to 36% in probes of the coin-value (symmetric; top right panel), and 0% to 36% correct in probes of the value-name relation (bottom right panel).

Discussion

We taught three children with visual impairments to accurately select among the four American coins given both the coin name and the coin value as a relevant sample stimulus. We taught this discriminated performance based upon tactual cues, specifically the relative size of each coin and the presence or absence of ridges. In addition to these targeted relations, we observed the formation of an equivalence class via the emergence of the coin-name (symmetric), coin-value (symmetric), name-value (transitive), and value-name (transitive) relations. Previous research has demonstrated a number of training procedures to teach coin usage repertoires (Miller, Cuvo, & Borakove, 1977) and similar relations as those targeted in this study using a stimulus equivalence paradigm (Trace & Cuvo, 1977; Lowe & Cuvo, 1977; Miller & Cuvo, 1977). However, this study was unique by extending these teaching procedures to a novel population (i.e., individuals with visual impairment) and in doing so, relied upon a novel stimulus feature, tactual cues.

From a conceptual perspective, this study is also interesting in that it involved the cross-modal transfer of stimulus control within a stimulus equivalence framework. That is, typically stimulus equivalence is assessed using topographically similar responses (e.g., selections) and assessing the formation of classes around presented and selected stimuli (e.g., given instruction to select A given B, the assessed symmetric relation would be select B given A). The current study differed in that the stimulus equivalence class facilitated generalization across response topographies (e.g., selection and vocal responding) and is one of the few studies to demonstrate this cross modal transfer of stimulus control (see also Bush, 1993 and Toussaint & Tiger, 2010).

From a methodological perspective, the design of the current study allowed for the assessment of equivalence relations at different points in training. That is, the multiple probe design allowed us to determine that training the name-coin relation resulted in the development of the symmetric coin-name relation, but the value-coin and coin-value relations emerged only following name-coin *and* value-coin training. Thus, this experimental design allowed for a determination of experimental control of both the direct and indirect effects of instruction.

From a practical perspective, the development of monetary skills are essential in fostering independence among individuals with visual impairments, allowing these individuals to purchase actual needed or wanted personal items (Edge & Burton, 2001; Xin, Grasso, Dipipi-Hoy, & Jitendra, 2005). However, coin name and value recognition is not sufficient to develop the level of independence desired for these children. The development of arithmetic skills is also essential so that these children may accurately count and spend their money accurately and should be the focus of future research.

It is also apparent that a focus solely on coin discrimination is not sufficient to generate independence as most American consumer spending will involve paper money (not considering check or credit card transactions). American paper currency cannot be discriminated based upon tactual features alone as each bill is the same size, shape, and texture. Vision Aware (2010) recommends visually impaired individuals arrange their own SD’s to discriminate bills (likely with the assistance of a sighted individual) by keeping $1 bills flat, folding $5 bills in half vertically, folding $10 bills in half horizontally, and folding $20 bills in half horizontally and then again vertically; they provide no recommendations for larger denominations. Although these recommendations allow for tactual discrimination, again there are no specific recommendations for teaching these discriminations. Once these monetary skills are developed, researchers can then begin to address the development of other consumerism skills (e.g., teaching how to find items in a store, how to purchase items from a vending machine, how to pay at a cash register).

Despite the large visually impaired population and the challenges they face, the needs of individuals with visual impairments have rarely been addressed in the educational and psychological literature. The teaching of visually impaired students is left to tradition and superstition in lieu of empirically validated practices. Although the current study does not address all of the needs of students with visual impairments, we see this training procedure to be the first step in the development of an empirically based monetary-skills curriculum and hopefully a change in the expectations for evidence for educating this population.

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Table 1.
Value-Coin Training: Number of Trials to Mastery vs. Errors Made

	Riley		Maddie		Christopher	
Penny	8	0	8	0	8	0
Penny + Quarter	8	0	8	0	8	0
Penny + Quarter + Nickel	8	0	8	0	8	0
All	8	0	8	0	8	0
Nickel	8	0	8	0	8	0
Nickel + Quarter	16	2	8	0	8	0
Nickel + Quarter + Penny	8	0	8	0	16	3
All	8	0	8	0	8	0
Dime	8	0	8	0	8	0
Dime + Quarter	8	0	8	0	8	0
Dime + Quarter + Nickel	8	0	8	0	8	0
All	8	0	8	0	8	0
Quarter	8	0	8	0	8	0
Quarter + Penny	8	0	8	0	8	0
Quarter + Penny + Nickel	8	0	8	0	8	0
All	16	2	8	0	8	0
Total	144	4	128	0	136	3

Table 2.

Number of Name-Coin Training: Number of Trials to Mastery vs. Errors Made

	Maddie		Christopher	
Penny	8	0	8	0
Penny + Quarter	8	0	8	0
Penny + Quarter + Nickel	8	0	8	0
All	8	0	8	0
Nickel	8	0	8	0
Nickel + Quarter	8	0	8	0
Nickel + Quarter + Penny	8	0	16	3
All	8	0	24	5
Dime	8	0	8	0
Dime + Quarter	8	0	8	0
Dime + Quarter + Nickel	8	0	8	0
All	8	0	24	5
Quarter	8	0	8	0
Quarter + Penny	8	0	8	0
Quarter + Penny + Nickel	8	0	8	0
All	8	0	8	0
Total	128	0	168	13

Table 2.
Number of Booster Sessions

	Riley	Maddie	Christopher
Name-Coin	N/A	4	10
Value-Coin	1	2	15

Table 3.
Number of Discrimination Skills Training Sessions

	Riley	Maddie	Christopher
Size Comparison	N/A	N/A	2
Presence or Absence of Ridges	N/A	2	2

Figure 1. Trained and emergent relations for Riley.

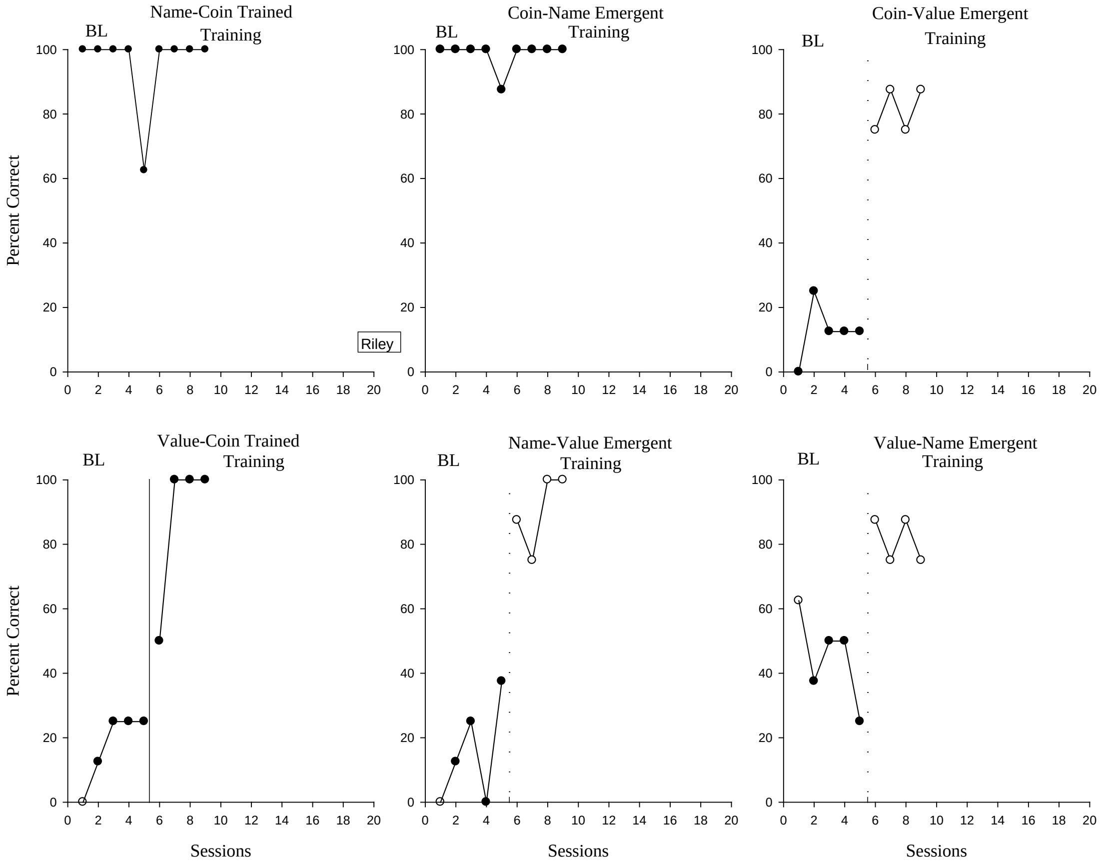

Figure 2. Trained and emergent relations for Maddie.

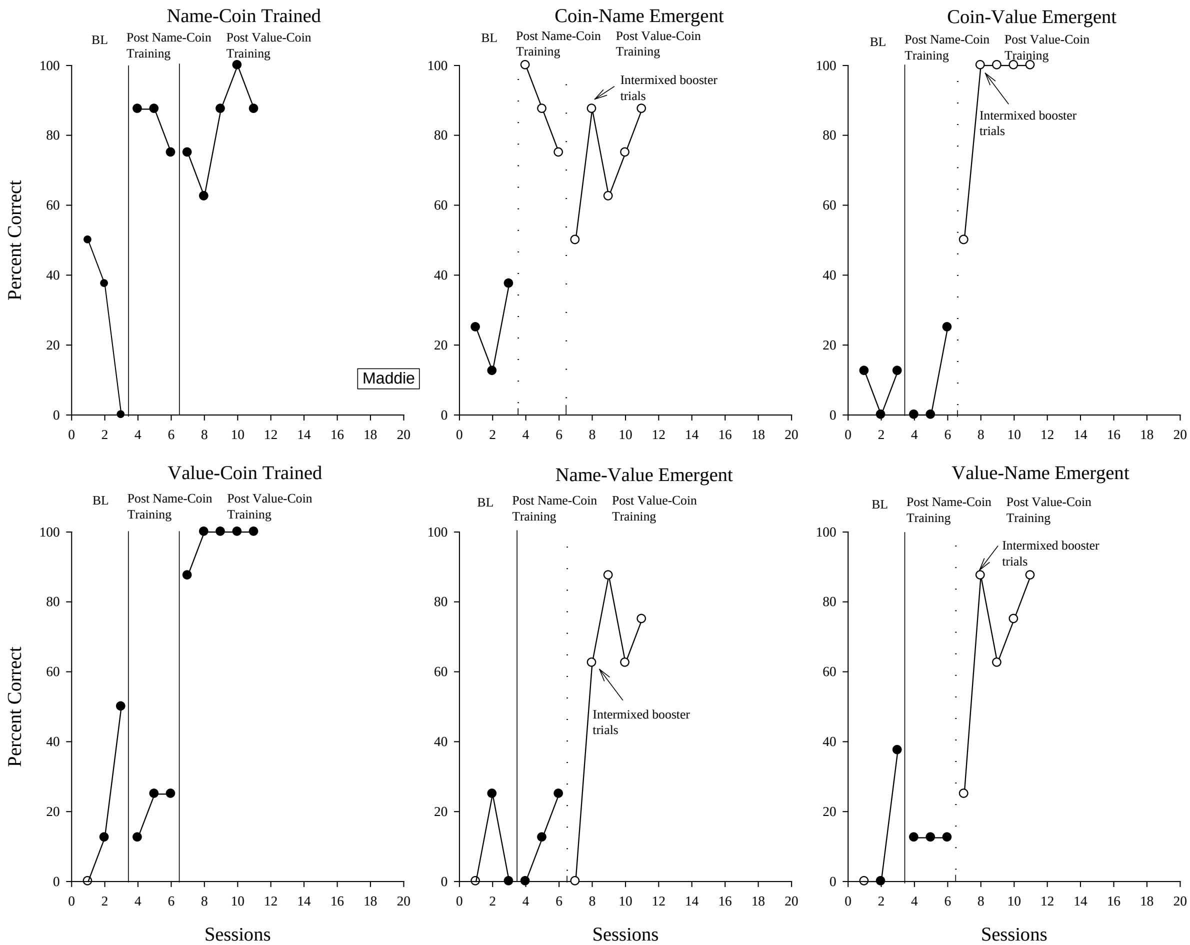

Figure 3. Trained and emergent relations for Christopher.