The Psychological Record, 2011, 61, 000–14

CONDITIONAL DISCRIMINATIONS BY PREVERBAL CHILDREN IN AN IDENTITY MATCHING-TO-SAMPLE TASK

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This study sought to develop methodology for assessing whether children aged 16–21 months could learn to match stimuli on the basis of physical identity in conditional discrimination procedures routinely used in stimulus equivalence research with older participants. The study was conducted in a private room at a daycare center for children and toddlers. Simple discrimination and discrimination-reversal trials were programmed. In the initial training, S+ and S– toys were displayed within the 2 windows. When the child touched the window containing the toy defined as S+ on a given trial, she or he was allowed to manipulate/play with that toy. Selections of the S– toy ended the trial without a play opportunity. The study provides evidence that preverbal children can master simple and conditional discrimination performances via such procedures perhaps setting the stage for subsequent studies needed to assess the stimulus equivalence potential of children in this age range.

Key words: simple discrimination, discrimination reversal, conditional discrimination, identity matching to sample, preverbal children, toy manipulation

Sidman's classic work on the problem of stimulus equivalence has inspired a generation of behavior analytic research to define symbolic behavior in operational terms and to establish the necessary and sufficient conditions under which symbolic behavior is demonstrable in various populations (see Sidman, 1994, 2000, for coverage of the most salient

This research was supported by grants from FAPESP (01/05178-5), CNPq (551845/02-3, 1415832003-7), and CAPES. Initial methods development and manuscript preparation were supported by HD04147 and HD39816. We appreciate and thank Deisy das Graças de Souza, Júlio Cesar C. de Rose, and Gerson Y. Tomanari for their comments on the work. Correspondence concerning this article may be sent to Maria Stella C. de Alcantara Gil, Via Washington Luis, Km 235, São Carlos, SP – ZIP CODE 13565-905 (e-mail: mscagil@ufscar.br).

contributions). The wide scope of Sidman's original vision is evident in subsequent extensions to address the symbolic capacity of nonhumans (e.g., Schusterman & Kastak, 1993), the very complex symbolic behavior of highly verbal humans (e.g., Hayes, Barnes-Holmes, & Roche, 2001), and, since the inception of stimulus equivalence work, symbolic functioning in persons with neurodevelopmental disabilities (Rehfeldt & Barnes-Holmes, 2009; Sidman, 1971).

One curious feature in the evolution of stimulus equivalence work by behavior analysts is the relative neglect of populations of humans who are minimally verbal or nonverbal due to very young age or intellectual disability (cf. O´Donnell & Saunders, 2003). The topic has not been neglected entirely (e.g., Carr, Wilkinson, Blackman, & McIlvane, 2000; Lionello-DeNolf et al., 2008; Lipkens, Hayes, & Hayes, 1993; Horne & Lowe, 1996;;), but examples are scarce indeed in comparison to the voluminous work conducted with other populations. Given the manifest importance of a comprehensive account of the development of symbolic behavior within a behavior analytic framework, the relative neglect of minimally verbal/nonverbal populations is somewhat difficult to explain.

Perhaps the most likely explanation for the paucity of work in this critical area is the time, expense, logistical support, and, perhaps, methodological insufficiency involved when verbal instructions are virtually entirely precluded. Relevant to our last suggestion, Lipkens et al. (1993) studied a developing child in its second year of life and showed that simple differential reinforcement and prompting methods were largely ineffective by themselves in establishing simple and conditional discriminations. Such methods also tend to produce highly variable responses and frequent learning failures in frankly nonverbal persons with autism spectrum disorders (Lionello-DeNolf et al., 2008). Children who are more verbal (e.g., aged 24+ months) seem to pose somewhat less of a challenge to behavior analytic researchers using methods such as matching to sample (Boelens, Groek, & Klarenbosh, 2000; Jordan, Pilgrim, & Galizio, 2001; Pilgrim, Jackson, & Galizio, 2000), but these individuals tend to have already acquired substantial verbal skills as speaker and listener.

Commenting on the problem of developing necessary performance baselines in preverbal children, O´Donnell and Saunders (2003) pointed out the seeming mismatch between the procedures and time course of model behavioral analytic methods used with nonhumans (precluding all verbal prompting, of course). Such methods require frequent sessions composed of many discrimination trials with establishing operations such as food restriction to increase reinforcer potency. By contrast, typically developing children in the critical age range (i.e., approximately 14–21 months) are not usually available for, and/or do not tolerate, lengthy individual sessions over a protracted training course. Permissible establishing operations to enhance potency of consequences are very limited in scope (happily and appropriately), and there has yet to be a comprehensive analysis of generalized reinforcers—other than the evanescent effects of stimulus novelty—that might be used effectively within the targeted age range.

The available research with typically developing children seems to have converged on teaching identity matching-to-sample with familiar figures or

nonrepresentative forms as an important step in establishing the procedural control of discrimination baselines that is needed to document stimulus equivalence relations. While such baselines have virtually always been established or assumed in studies of older, verbal humans, their development in young children, especially minimally verbal or nonverbal children, remains a methodological challenge for behavior analytic researchers. No one has yet answered the question of whether methods *can be* developed that will bring minimally verbal and/or nonverbal typically developing children within the methodological scope of current stimulus equivalence methodology. The present study took a step toward answering this fundamental question.

The methods of the study reported in this article were inspired by those of a long-term program of methodological research conducted at the UMMS Shriver Center with humans with severe intellectual disabilities (Dube & Serna, 1998; Serna, Dube, & McIlvane, 1997). This research program analyzed training contingencies necessary to establish identity-matching baselines, beginning with simple simultaneous and successive discriminations (cf. Saunders & Spradlin, 1989, 1990). As training progressed, discrimination function reversals were introduced gradually, initially in simple discrimination; later in the program, the simple discrimination baseline was systematically transformed into conditional discrimination, and generalized identity matching was established with virtually all who participated, including many individuals who were minimally verbal or nonverbal.

In pursuing the Shriver methodological approach, we found it necessary to adapt the methods to preverbal but otherwise typically developing children. Whereas the Shriver group has typically been able to employ generalized reinforcers, such as tokens, identifying effective consequences for preverbal children was a challenge. Necessary adaptations related principally to the difficulty of maintaining the child in experimental situations (Kagan, 1981) and measuring stimulus features to which the preverbal child attends (O'Donnell & Saunders, 2003; Wilkinson & McIlvane, 2001).

Creating opportunities for the child to manipulate or produce changes in the environment seemed to be an appropriate tactic, inspired in part by work relating to other analyses of aspects of the behavior of preverbal children (e.g., Weisberg & Rovee-Collier, 1998). Our goal was to use environmental manipulation opportunities to assess whether a method based on progressive expansion of simple-to-conditional discrimination could be an appropriate route to identity matching-to-sample performances in preverbal children. If such methodology could be established, it might lead ultimately to the capacity to assess generalized identity matching and thus to test for the relational property of *reflexivity*, one of the three defining properties of equivalence relations (Sidman & Tailby, 1982).

In pursuing our study, we thought it critical to employ an experimental setting with the most natural characteristics possible (i.e., similar to those already experienced by the child). Within this environment, we also thought it critical to familiarize him or her so as to ensure that the child was calm, relaxed, and free to act without restrictions other than those always employed with children (caretakers in immediate proximity; ability to touch and otherwise interact with adults in the immediate vicinity [i.e., the experimenter]); freedom to crawl, stand up, and/or walk around the room, etc.).

Method

Participants

The participants were one girl and two boys aged 16, 17, and 21 months, respectively. All were recruited from a local daycare center.

Stimuli

Table 1 describes each stimulus used—six sets of small stuffed toys (6 each, 36 in all), termed "pigs" because they somewhat resembled such animals. The pigs were sized such that a child could hold and manipulate them readily. They were made of polka-dotted, striped, or mono-colored cloth. The pigs were designed such that they could be stacked one on top of the other. Three stacked pigs made of cloth with the same pattern constituted the stimuli to be discriminated. Each pig had a battery-powered integrated circuit and a sensor system within it. When a stacked pig was touched or otherwise manipulated, melodies and flashing lights were presented by embedded speakers and five LEDs, respectively. Each melody lasted 6 s and could be reinitiated by the researcher. Thus, manipulating a pig produced auditory, visual, and tactile stimulation.

Table 1
Description of the Stimuli Used in the Study

Stimuli	Description/characteristics
Polka-dotted	Toys made of white cloth background. Dot colors were mixed: red, yellow, blue, and green.
Striped	Toys made of white cloth background. Stripe colors were mixed: red, yellow, blue, and green.
Mono-colored	Toys made of a single one-color cloth. There were four sets: red, yellow, blue, and green.

Apparatus

The apparatus was designed to emulate one employed by McIlvane and Stoddard (1981) to study exclusion learning in old nonverbal individuals with profound intellectual disabilities. It consisted of a box measuring .80 × .56 × .80 m, with two side-by-side cutouts in the front containing window openings. Each window was .25 × .25 m, and the distance between them was .15 m. The child and researcher sat in front of the box, facing the windows. The top of the box had a cover with two parallel slots. One slot allowed transparent acrylic panels to be inserted to block access to the interior of the box. The other held two neutral-colored panels, one that covered one window and another that covered both of them. The entire back of the box was open, to permit a researcher to perform necessary experimental operations (placing stimuli to be discriminated, moving panels, etc.).

Setting

Sessions were conducted in a 7-m² room in the daycare center. The room was divided in half by a neutral-colored curtain, which ran across its entire

length (2 m). Only the half of the room in front of the curtain was visible when entering it. The apparatus was located in the center of the room, behind the curtain, with the windows facing the room entrance. An opening was cut in the middle of the curtain to display the windows. Two experimenters were present during all sessions: One remained seated on the floor with the child, facing the windows; the second, out of view behind the curtain, manipulated the apparatus and stimuli.

A fixed-mount digital camera was focused on the front of the apparatus, facing the windows. A built-in SVHS camera was set flush with the curtain and focused on the child's face. Because of the distance between the windows of the apparatus, the child had to select one or the other, and this could be recorded. The view also allowed observing and recording of the experimenter's behavior.

Procedure

Table 2 summarizes the sequence of procedures. Data collection occurred over 14 weeks. Each session lasted approximately 10 min; two sessions were typically conducted each week. Intervals between trials varied from approximately 15 to 20 s. The maximum number of trials per session was 12. Sessions were interrupted immediately if the child showed any signs of irritability or tiredness, regardless of any other established criteria. Initial sessions were preceded by a familiarization period in which the researchers interacted with the children while participating in the daily routine of the daycare center.

Table 2
Training Sequence Throughout the Study

	Stimuli			
Training	Sample	S+	S−	Criterion
Simple discrimination 1	—	S1	S2	Four consecutive corrects
Reversal 1	—	S2	S1	
Simple discrimination 2	—	S3	S4	
Reversal 2	—	S4	S3	
Identity MTS	S4	S4	S5	Four consecutive corrects
Same sample[a]	S5	S5	S4	
Identity MTS	S2	S2	S6	Four consecutive corrects
Alternating samples[b]	S6	S6	S2	

Note. Pig sets: S1 = red; S2 = striped; S3 = yellow; S4= polka-dotted; S5 = blue; S6 = green.
[a] For this training, the change of sample stimulus depended on achieving the criterion.
[b] Sample stimuli were alternated irregularly over trials.

Simple Discrimination and Reversal

During all sessions, the researcher was seated on the floor with the child, facing the windows of the apparatus. Every trial began with the opening of the windows displaying the stimuli—two different sets of three identical toy pigs displayed with one on top of the other. On the first trial of

a given simple discrimination problem, the child was permitted to choose freely between the two discriminative stimuli. The researcher said "Which do you want?," "Take the one you want," or something similar. The child chose by touching one of the transparent acrylic panels. When she or he did so, that panel was raised, the child was given access to the set of pigs behind it, and she or he was permitted to play with them for about 12 s, which set off the sound/light display when the pigs were separated. After the play period, the researcher gently removed the toys and pushed them under the curtain and out of view.

Whichever set of pigs the child chose was designated S+ for the remaining trials of that problem. If the child did not immediately choose a window, the experimenter modeled the required response before proceeding. If the child selected the stimulus designated S– on a subsequent trial, the opaque panel immediately was lowered to cover both windows until the next trial.

Criterion to master a given discrimination problem was at least four successive S+ selections. Thereafter, a discrimination reversal was initiated, and the mastery criterion was also at least four successive selections of the former S–. Each child completed training on two simple discrimination and two reversal problems with two different pairs of stimuli (red/striped and yellow/polka-dotted cloth; see Table 2).

Identity Matching-to-sample (IDMTS)

This training was initiated after the children completed simple discrimination and reversal training with two different sets of stimuli. The identity-matching procedure differed from the simple discrimination procedure in that trials commenced with presenting the child with a sample pig with sounds and lights deactivated. The child was allowed to play with the sample for a few seconds. Thereafter, comparison stimuli were presented in the two windows. To gain access to the comparison set of pigs, the child was required to select the ones that were identical to the sample that she or he had just been given. If the child did so, he or she was given access to the comparison pigs and could then play with both the sample and the comparison pigs for a few seconds more. The identity-matching procedure was noncorrection: If the child chose the S– comparison, then the experimenter gently removed the sample pig from the child's grasp (as necessary) and placed it out of view behind the curtain.

The IDMTS procedure had two training phases: In a Phase 1 "introduction" procedure, trials were arranged initially such that the same sample was presented over a minimum of four successive trials before a different sample was presented, also for a minimum of four successive trials. For the sample stimulus to be changed to another type of pig, the child had to meet a criterion of four successive correct selections. This "same sample" procedure was intended merely to introduce the child to the sequence of the IDMTS trials. True sample-matching was not required, in the sense that selections on trials N+1, N+2, and N+3 could have reflected only simple discrimination.

In Phase 2, however, the procedure was changed to a conventional IDMTS procedure in which the identity of the sample and correct

comparison stimulus alternated irregularly across trials in a six-trial block, thus requiring true conditional discrimination in order to make consistently correct selections sufficient to meet the mastery criterion (six consecutive correct IDMTS selections, e.g., with samples in an order such as S6, S2, S6, S2, S2, S6). In the service of promoting mastery of conditional discrimination, Phase 2 employed a procedure in which less-than-criterion performances were followed by presentation of another six-trial block that presented different combinations of stimuli and different sequences of sample stimuli.

Results

Figures 1, 2, and 3 present the individual participant data throughout the procedure. These figures are trial-by-trial cumulative records in which selection of either S+ or S– steps the corresponding record up. If neither the S+ nor the S– steps up on a given trial, then the child made no response on that selection opportunity. In overview, these records show that all children mastered simple discrimination, discrimination reversals, and ultimately identity matching to sample with alternating samples via the training. Because details of the training procedure differed slightly across the three participants, we will present each participant's data separately.

Participant So

Figure 1 shows that this participant completed the simple discrimination and discrimination-reversal phases very quickly. Regarding the IDMTS performance, this child was the only one who received the "same sample" procedure on two different IDMTS problems prior to the alternating-sample procedure. This child's rapid acquisition of conventional conditional discrimination suggested that training on two different same-sample IDMTS problems might not be important, and the procedure was not used with the other two children.

Participant Ad

By contrast with child So, Figure 2 shows that Participant Ad showed slower acquisition of initial simple discrimination, discrimination reversal, and same-sample IDMTS. After these discriminations were mastered, however, alternating-sample IDMTS performance was acquired quickly. One possibility potentially accounting for initially less accurate discrimination performance was this child's session behavior. He got up frequently and was clearly attentive to other aspects of the environment in the room (e.g., the light switch), as well as to stimuli outside it (e.g., sounds coming from the next room).

Participant Pe

Figure 3 shows that this child also displayed somewhat more protracted acquisition of simple discrimination and discrimination reversal, similar to that shown by Participant Ad. Unlike Ad, however, training with both same-sample and alternating-sample IDMTS proceeded quickly.

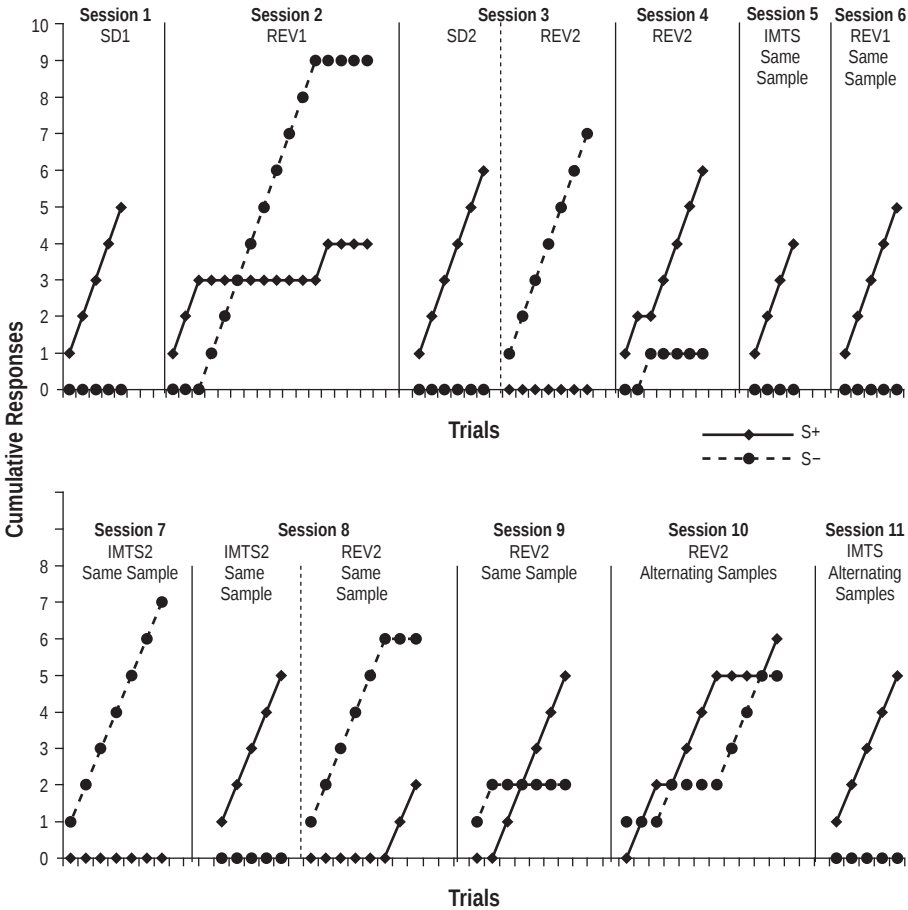

Figure 1. Cumulative selections of S+ and S– throughout the sequence of sessions for participant So. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 – S+ striped/S– red; REV1 – S+ red /S– striped ; SD2 – S+ yellow/S– polka dotted; REV2 – S+ polka-dotted /S– yellow; Same sample (IDMTS1 – S+ green/S– striped; REV1 – S+ striped /S– green; IDMTS2 – S+ blue/S– polka dotted; REV2 – S+ polka dotted /S– blue); Alternating samples – stimuli green/striped.

Discussion

The results of this study show clearly that preverbal children can master conditional discrimination within the context of an identity matching-to-sample task that was similar procedurally to tasks used routinely in stimulus equivalence research. The results suggest that procedures modeled after those used with older children and adults may be within the capabilities of preverbal children, despite the unique problems that have long been acknowledged with this population (Weisberg & Rovee-Collier, 1998). Methodology of the type reported here may find applicability beyond merely the search for stimulus equivalence potential in preverbal children.

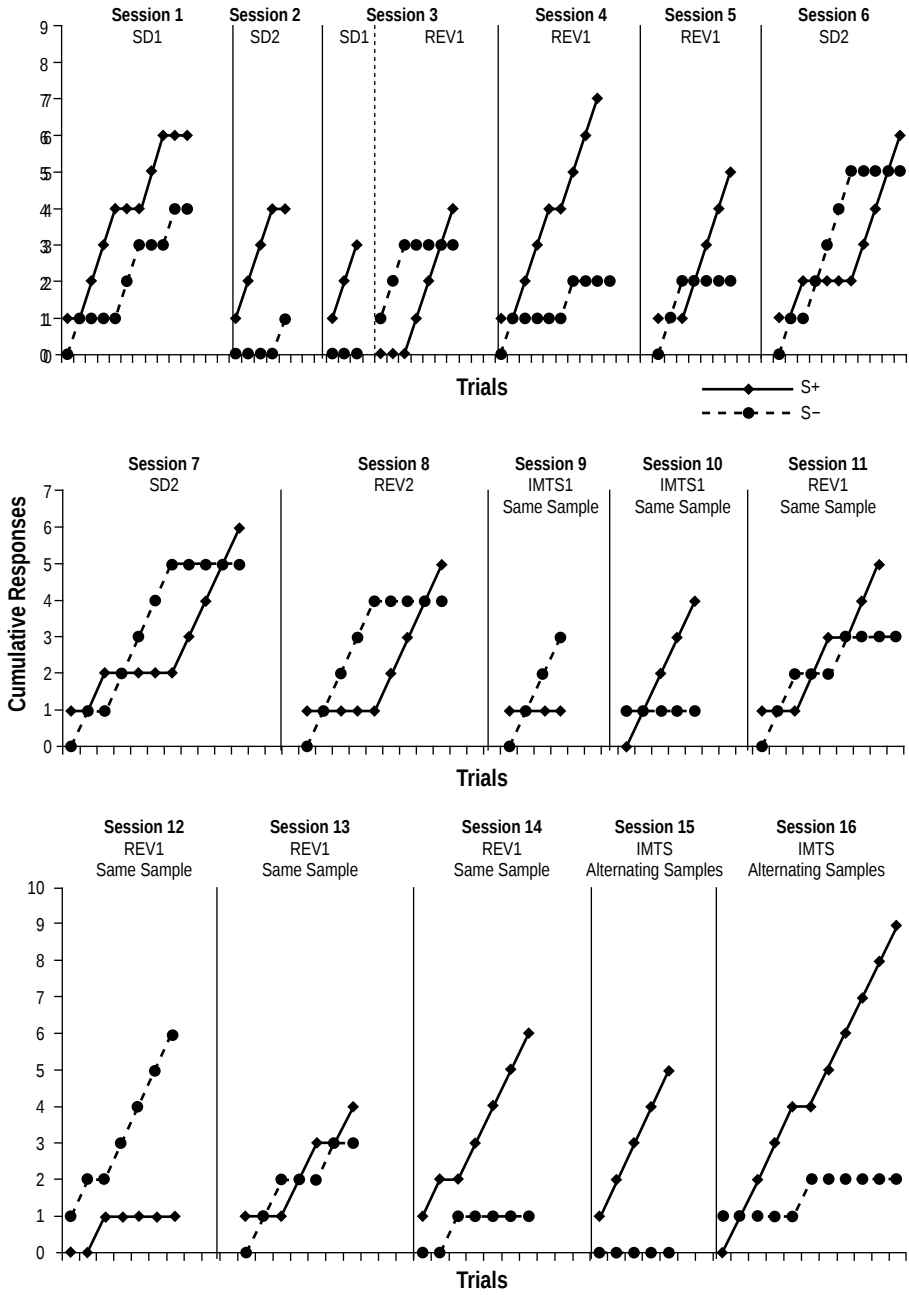

Figure 2. Cumulative selections of S+ and S− throughout the sequence of sessions for participant Ad. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 – S+ striped/S− red; REV1 – S+ red /S− striped; SD2 – S+ yellow/S− polka-dotted; REV2 - S+ polka dotted /S− yellow; Same sample (IDMTS1 – S+ green/S− striped; REV1 – S+ striped /S− green); Alternating samples – stimuli green/ striped.

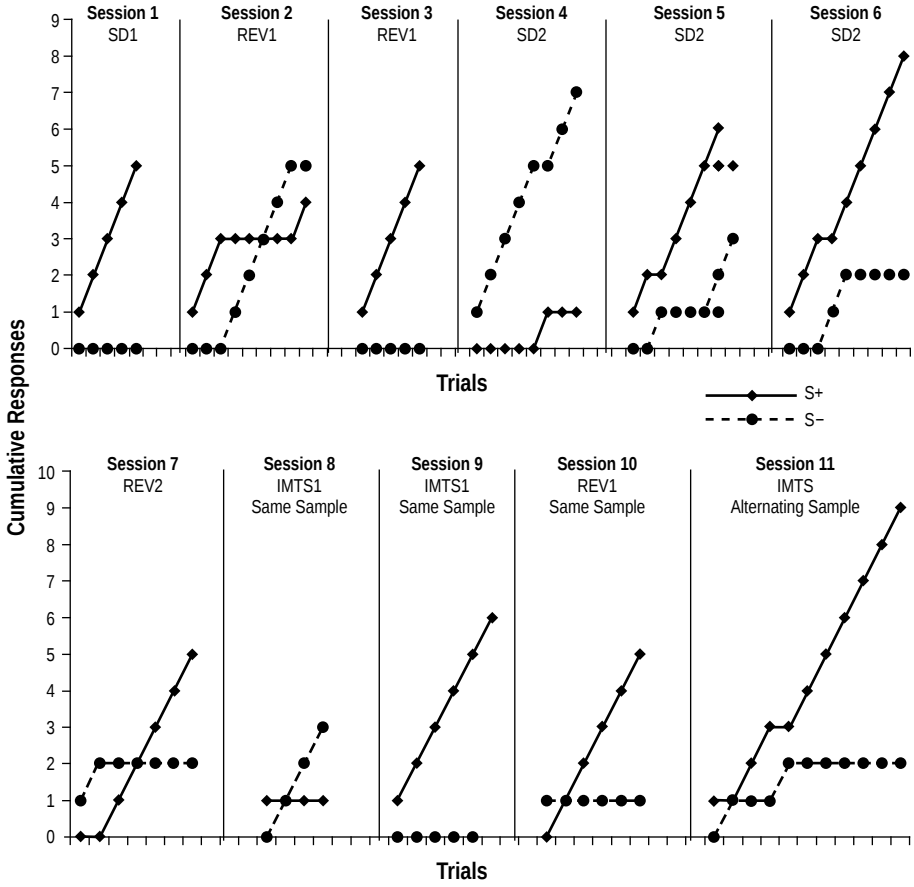

Figure 3. Cumulative selections of S+ and S– throughout the sequence of sessions for participant Pe. SD = simple discrimination; REV = reversal; IDMTS = identity matching-to-sample. Stimuli: SD1 – S+ yellow/S– polka-dotted ; REV1 – S+ polka dotted /S– yellow; SD2 – S+ red/S– striped; REV2 – S+ striped/S– red; Same sample (IDMTS1 – S+ blue/S– polka dotted; REV1 – S+ polka dotted /S– blue; Alternating samples – stimuli green/ striped.

Procedures for assessing and teaching conditional relations between/among stimuli have been used successfully in basic and applied research on learning, memory and perception in both general education and special education (Saunders & Spradlin, 1989, 1993). The development of efficient, effective procedures for teaching discrimination skills in preverbal children can, concomitantly, lead to methodological advances for investigating aspects of child behavior and capabilities, assist in analysis of how complex discrimination repertoires such as symbolic behavior are acquired, and, perhaps as a consequence, lead to improvements in methodology for teaching these repertoires to both typically and atypically developing individuals.

An important aspect of methodological development may be an effort to render the procedure a good match for naturally operating contingencies, as

we did in adapting our methodology to resemble a play session in the children's day-care setting. As in such settings, we sought to attend carefully to individual differences, both in day-to-day variability and across children, in terms of variables such as the amount of time individuals seemed willing to engage with the procedures, the number of trials that could be implemented without tiring the children, the degree of distractibility to outside events, and so on. The procedures that evolved in the course of designing and conducting our study thus seemed to achieve a good match with the children's needs in relationship to such variables.

The positive results of the procedures notwithstanding, certain methodological aspects still need refinement to render the methodology broadly applicable and routinely replicable. Further analysis is likely to be necessary of variables such as the adequacy of criteria for assessing learning/learning set, the optimum lengths of sessions, intertrial periods, intersession intervals, and perhaps other variables.

To conclude, earlier empirical analyses of the behavioral requirements for conditional discrimination in older persons with disabilities (Dube, 1996; Dube & Serna, 1998; McIlvane, Dube, Kledaras, Iennaco & Stoddard, 1990;) informed our study with preverbal children. As in that work, our procedures systematically managed the transition from simple discrimination and simple discrimination reversal through to conditional discrimination. Interestingly, we saw that our seeming well-matched procedures led to a fairly rapid transition process in our children—protracted training was not needed as it frequently has been with older nonverbal children with intellectual disabilities. Might the speed of the transition seen in studies of the type reported here serve as an early predictor of the developmental trajectory when intellectual disability is suspected? Might development of such skills through early intervention play a pivotal role in altering the developmental trajectory? If so, it seems likely that we may be better positioned to ask and answer theoretical questions such as whether equivalence class formation is a basic behavioral process that is not reducible to other processes (Sidman, 1994, 2000) and that might be managed effectively via procedures that help the learner attend to the relevant environmental cues that lead to the development of conventional symbolic functioning.

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