Published in final edited form as:

Psychol Rec. 2015 March ; 65(1): 41–47. doi:10.1007/s40732-014-0084-1.

Discrimination and Reversal Learning by Toddlers Aged 15–23 Months

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Abstract

Few studies have investigated simple discrimination and discrimination reversal learning by children younger than 2 years. Extant research has shown that teaching discrimination reversals may be challenging with this population. We used social reinforcement and correction procedures to teach simple simultaneous discrimination and discrimination reversal tasks involving three pairs of animal pictures displayed in a paper notebook. Participants were eight typically-developing toddlers aged 15–23 months. All learned at least one simple discrimination/discrimination reversal problem. Four children learned all problems and showed evidence of learning set formation. Perhaps surprisingly, discrimination reversals were sometimes learned more rapidly than original discriminations. The procedures suggest a potentially efficient methodology for investigating more complex aspects of relational learning in toddlers.

Simple discrimination and discrimination reversal learning involve basic processes that are behavioral prerequisites for development of stimulus equivalence classes (Saunders & Green, 1999; Sidman, 1994; Smeets & Barnes, 1997). Research on these processes has been conducted for decades with a variety of nonhuman and human populations (Kastak, Schusterman, & Kastak, 2001; Iversen, 1998; Sidman & Stoddard, 1967; Terrace, 1963).

Much behavior analytic research on children's discrimination learning has focused on preschool children aged three years and above using tabletop or computer-based procedures (Lionello-DeNolf, McIlvane, Canovas, de Souza, & Barros, 2008; Smeets, Barnes, & Luciano, 1995). By contrast, few such studies have been conducted with toddler-aged children. Most of these have concerned auditory-visual conditional discrimination (Horne, Lowe, & Randle, 2004; Lipkens, Hayes, & Hayes, 1993; Luciano, Becerra, & Valverde,

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2007), perhaps because such tasks resembled natural interactions between toddlers and their verbal communities (Bruner, 1983). Even fewer have focused on simple discrimination and/or reversal learning by infants and toddlers (Gil, Oliveira, & McIlvane, 2011; Gil, Oliveira, Sousa, & Faleiros, 2006; Gil, Sousa, & de Souza, 2011; Overman, Bachevalier, Turner, & Peuster, 1992; Silva & Souza, 2009).

In recent years, we have been focusing on refining the operant methodology for teaching discrimination to children. Many of our experimental questions and procedures derive from an earlier program of research focusing on methods for teaching identity and arbitrary matching to sample to older nonverbal children (Dube & Serna, 1998; Serna, Dube, & McIlvane, 1997). One key feature of those programs was establishing rapid acquisition of simple visual discriminations and discrimination reversal – because frequent discrimination reversals are a characteristic of conditional matching to sample (Saunders & Green, 1999).

Results of preliminary studies (Gil et al., 2006) revealed methodological challenges that pertained specifically to application of simple discrimination and discrimination reversal procedures with very young children (e.g., error proliferation, failures to respond, premature session termination by the child, etc.). These required solutions before going on to address more advanced conditional discrimination tasks (cf. Gil, Oliveira, et al., 2011). Summarizing the results of our previous studies, eleven children aged 10 to 21 months learned simple simultaneous discriminations via procedures that presented toys to be discriminated in a three comparison MTS format. Training sessions were brief (i.e., up to ten minutes), presented a maximum of 12 trials, and required 3–4 consecutive correct choices to meet learning criteria. Reinforcing consequences were opportunities for social play with the stimulus selected and the adult.

Our overall program sought to determine if infants and toddlers could show greater capabilities in simple discrimination and reversal learning than have been reported to date. For example, Gil, Oliveira and colleagues (2011) used custom-fabricated three-dimensional toys (somewhat resembling stuffed piglets). The piglets were constructed using fabrics with different, highly discriminable patterns. When a piglet was selected correctly, embedded battery-powered circuits caused exterior light-emitting diodes (LEDs) to begin flashing to confirm the child's response. In addition, the child was allowed to play with the piglet after his/her selection as a potentially reinforcing consequence. Three participants aged 16, 17 and 21 months learned two simple discriminations and two discrimination reversals prior to mastering identity matching to sample.

In another study, Silva and Souza (2009) displayed attractive animated images on a touch-sensitive computer screen. If the child touched the correct image on a trial, that response was followed by 5 s of a cartoon and social interactions. This study also used an atypical discrimination reversal procedure after a child met learning criteria with one stimulus pair (e.g., A1+/A2–). Rather than reversing both positive and negative stimulus functions (e.g., A2+/A1–) as is typically done, only one stimulus function was reversed: the former negative stimulus became the positive stimulus and a different stimulus was introduced as the negative stimulus (e.g., A2+/B1–). Three children aged 10, 12 and 14 months learned up to

six simple discrimination problems via this procedure. There was no evidence of increased learning efficiency (i.e., learning set; Harlow, 1949) across discrimination problems.

Overman and colleagues (1992) reported the only comprehensive study of simple discrimination that used three-dimensional objects to be discriminated with toddler-aged children. The objects were presented in a Wisconsin General Testing Apparatus (WGTA); correct responses were followed by food and praise. Three stimulus pairs were presented in succession (i.e., A1 vs. A2, B1 vs. B2, C1 vs. C2). To control for initial stimulus preferences, the first stimulus chosen of each pair was arbitrarily designated as incorrect, and thus the child had to overcome any pre-potent stimulus preferences in order to master each simple discrimination problem. Daily 15-trial sessions continued until children met a criterion of 13 correct choices for two consecutive days. Mean trials to criterion on the three simple discriminations were 83, 72, and 79 for a 12-month-old group and 60, 14, and 7 for an 18-month-old group, thus demonstrating learning set outcomes (Harlow, 1949) with the latter group but not the former. Overman and his colleagues did not address discrimination reversal with either group.

The study we report here asked whether children aged 15–23 month could demonstrate simple discrimination, discrimination reversal, and learning set with static two-dimensional stimuli. The training procedures did not entail use of procedures to enhance stimulus salience (i.e., flashing LEDs, animation, food reinforcement, etc.). Technical aspects could be simplified with use of the 2-D stimuli. For example, the inter-stimulus intervals could be shorter due to the less complex physical manipulations required (Gil & Oliveria, 2006; Gil, Oliveira & at al., 2008). We hypothesized that discrimination of static 2-D stimuli could be facilitated if we used materials such as those encountered in the children's familiar environment (pictures in a paper book as in typical book reading by adults to children). The materials and tasks resembling those to which toddlers are exposed in their typical environments (see Luciano et al., 2007) and may have been more familiar than those presented using unfamiliar tabletop or automated apparatus (Gil et al., 2006; Gil, Oliveira et al., 2011; Gil, Sousa et al., 2011). We also sought to forestall any habituation effects (cf. McSweeney, 2004) such as those that we observed previously with 3D stimuli (Gil, Oliveira et al., 2011; Gil, Sousa et al., 2011; Sousa, Garcia, & Gil, submitted; Silva & Souza, 2009). As in our prior studies, the stimuli to be discriminated also functioned as both discriminative and reinforcing stimuli. While manipulation possibilities are more limited for 2D than for 3D stimuli, their potency as reinforcers would be enhanced by supplementary verbal interactions with the experimenter. Moreover, the task format (book reading) has been extensively and successfully used in investigations with young children (e.g. Ganea, Pickard, & DeLoache, 2008).

Method

Participants

Four female and four male typically-developing toddlers were recruited from a local day-care center and assessed by the Denver Developmental Screening Test II (Frankenburg, Dodds, Archer, & Bresnick, 1990), translated and adapted for presentation in Portuguese (Pedromônico, Bragatto, & Strobilus, 1999). Each toddler will be referred to by the letter P

followed by his/her age in months: P15, P17, P18, P19, P21a, P21b, P22, and P23. The research adhered to relevant ethical guidelines, and all of the participants' parents signed a consent form after the procedures were explained.

Setting and Materials

Sessions were conducted in a 9 m² unfurnished room adjacent to the nursery. The child was seated on the floor with the experimenter immediately behind.

Six animal photos (15 cm wide × 10 cm high) were organized in pairs to be discriminated: (1) sheep, toucan; (2) pig, owl; (3) capybara, stork. Pairs were mounted on six black cardboard sheets (45.5 cm × 27 cm) with Velcro and separated by five blank sheets within a spiral-bound notebook. A fixed-mount digital camera was focused on the notebook, the experimenter, and the toddler.

During an initial three-week familiarization period, the experimenter played briefly with all the children in the nursery. Within the experimental room, individual play periods were initiated to accustom the child to the environment and to make his/her continued presence there reinforcing. During such periods, the experimenter and child played with commercially-available toys that belonged to the daycare facility.

Discrimination Procedures

Each stimulus pair was used successively in simple simultaneous discrimination and discrimination reversal tasks. The task sequence was discrimination training with pair 1 (SD1), discrimination reversal with pair 1 (REV1) followed by SD2/REV2 and SD3/REV3. Data were collected over two weeks during mornings and afternoons. Typical sessions lasted about two minutes and programmed six discrimination trials. That number was extended by up to four more trials if the child appeared about to meet criterion. Initially one session and later two sessions were conducted during each morning and afternoon period. Sessions were interrupted if (a) criterion was reached, (b) the child emitted four consecutive incorrect responses, or (c) the child showed irritability or fatigue (e.g., closing the eyes and frowning, rubbing the eyes with the back of the hand[s], etc.) that might lead to crying. Each session ended with five minutes of free play. Learning criterion for each discrimination task was either (a) four consecutive correct choices in a single session or (b) five consecutive correct choices across two consecutive sessions.

Response training—The response – touching one of two photos on notebook pages – was trained in one session. Photos were one boy and one girl. Trials began when the experimenter presented one page displaying two stimuli and said: “Look! Take one!”. If the child touched either photo, the experimenter delivered praise (e.g., “Well done!”), detached the photo selected, and initiated about 20 s of play with the photo and the child. If the child did not touch a photo within 10 s, however, the experimenter manually guided him/her to touch. The mastery criterion for this phase was three independent selections of either photo by the child.

Simple simultaneous discrimination training—The consequences for selecting a positive stimulus (S+) were immediate praise, photo detachment, and play as just described. During play, the experimenter vocalized the animal name and actions that she or the child performed with the photo (e.g., “Look at the toucan! It is flying.”; “Are you going to feed the sheep?”). Thereafter, the experimenter completed the trial by placing the S+ photo under the notebook and turning to an empty page initiating a 5 s intertrial interval.

Consequences for selections of negative stimuli (S–) were gently removing the child’s hand from the photo, either in silence or saying “We are going to see it again.” A 5 s intertrial interval then ensued.

The child’s first selection with each stimulus pair defined the S– (i.e., whichever photo chosen was arbitrarily defined as incorrect) and led to the specified consequences. The S– and S+ stimuli functions of each stimulus in the pair remained the same for the subsequent training trials until the task was learned. Our rationale for this procedure was the same as that reported by Overman and colleagues (1992). Given the possibility and unpredictability of pre-potent stimulus preferences, we reasoned that it would be best practice to demonstrate that our training procedures could overcome such preferences by “training against initial preference.” The alternative – leaving possible preference unmeasured and uncontrolled – could introduce a source of behavioral variability that could complicate interpretation of our findings.

Discrimination reversal training occurred after each original simple simultaneous discrimination had been mastered. It was similar to the original training except that S+ and S– functions were reversed. For example, if the sheep was S+ and the toucan S– during the first simple discrimination training (SD1), the the toucan was S+ and the sheep S– in reversal training (REV1). Reversed contingencies were in place on the first trial of reversal training.

A correction procedure was used in three situations: (a) three consecutive incorrect selections within a session; (b) three consecutive selections of either the left or right position within a session; or (c) following a session that ended with four non-consecutive incorrect responses or four same-position responses. In such situations, the experimenter gently removed the toddler’s hand from the incorrect stimulus and positioned his/her hand on the correct stimulus. Thereafter, the differential consequences for correct choices were presented. Such corrected response were counted separately from independent correct and incorrect responses.

Experimental Design and Data analysis

A single-subject design was utilized. Data were analyzed in terms of the total of responses – correct, incorrect, and corrected – until reaching the learning criteria in each task. Reliability of experimenter-collected data was assessed on 28.5% of sessions by an independent observer. Interobserver agreement was 100% and was calculated by the formula $IOA = (\text{agreement} / (\text{agreement} + \text{disagreement})) \times 100$.

Results

Five children mastered all six tasks – P15, P18, P21a, P21b and P23. The youngest child (P15) required more training trials than the others. For all but P15, we observed a decreasing trend in trials-to-criterion across tasks (i.e., learning set). Figure 1 shows the total of number of responses for each training task prior to those that fulfilled the learning criterion for each one.

Notably, one-trial discrimination learning occurred once during simple discrimination training (SD1 for P18), and errorless learning occurred three times in discrimination reversal training (REV1 for P19; REV2 for P21a; REV1 for P23). While the latter finding may seem surprising on its face, we think that it has an explanation in our procedures that we will address in the Discussion.

As shown by black sections of the bars in Figure 1, the correction procedure was implemented with all the participants during both simple discrimination and discrimination reversal tasks. The proportion of corrected trials was roughly comparable on both task types.

Figure 2 depicts the total of training trials until learning criterion achievement of the simple discrimination and discrimination reversal tasks separately. A decreasing trend in trials-to-criterion across tasks (i.e., learning set) was observed for P23 in simple discrimination learning. Similarly, participants P18 and P21b learned the discrimination reversal task within a decreasing number of training trials.

Discussion

All eight participants learned at least one simple discrimination and one discrimination reversal. Five learned the six tasks, including the youngest one (15-months-old). Some participants demonstrated errorless learning and learning set formation.

We think that the most important contribution of our study was showing rapid simple discrimination learning and discrimination reversal learning by children as young as 15 months. Unlike our prior studies, we used static 2-D stimuli to be discriminated rather than specially designed 3-D stimuli or animations designed to attract attention. Also, we used entirely social reinforcement procedures rather than food reinforcement as did Overman and colleagues (1992). Our data compare favorably with those of the 1992 study; comparable children in their study required about twice as much training in order to master 3-D simple discriminations. Thus, we think that our procedures have much to recommend themselves for replication by others.

With respect to reversal learning specifically: (a) all toddlers learned one reversal; (b) some learned three discrimination reversals, one more than in our previous studies (Gil et al., 2006; Gil, Oliveira et al., 2011) and thus allowing a more complete assessment of learning set possibilities, and (c) reversal learning was achieved without special procedures designed to bypass the challenges of reversal following immediately after discrimination acquisition (cf. Lionello-DeNolf et al., 2008; Silva & Souza, 2009). To our knowledge, our study is the

first to report such facile simple discrimination and reversal learning by children of this age range without the use of special procedures to enhance responding

Taking the present work and earlier studies together, our research program has succeeded in overcoming certain challenges of conducting experimental investigation with toddlers (Lipkens et al., 1993), thus contributing to resolution of perceived ‘methodological insufficiency’ (Gil, Oliveira et al., 2011) of prior investigations. We think that an important feature of the procedures may well have been use of materials and tasks resembling ones that toddlers are exposed in their typical environments (Luciano et al., 2007). That is, our “book reading” situation may have been more familiar than tasks presented using unfamiliar tabletop or automated apparatus (Gil et al., 2006; Gil, Oliveira et al., 2011; Gil, Sousa et al., 2011).

To suggest one reason why reversal learning proved unexpectedly easy (sometimes even errorless), recall that the stimulus designated S– on each simple discrimination problem (and thus S+ on the corresponding reversal) was the one selected on the first exposure. Thus, the child had to inhibit any initial stimulus preference to learn the simple discrimination task (cf. Diamond, 1990). When a child was exposed to the reversal task, perhaps pre-potent stimulus preference re-emerged on the first such trial – resulting in reinforcement that would be expected to make further selections of that stimulus even more probable. If this was the explanation considered for the subtle changes in responding across sessions that would be a limitation of the present study, especially when analyzing performances as the one of participant P19 in REV1.

As an alternative to a pre-potent preference account, one might suggest that repeated selections of the same stimulus during simple discrimination training culminated in some form of satiation with that photo. If so, one might expect the emergence of “exploratory tendencies” (cf. Harlow, 1949) that would lead to occasional S– selections despite the programmed reinforcement procedures. While further research will be needed to disentangle these two possibilities, considering them further is likely to have benefit in understanding the sources of behavioral variability that are often reported with very young and/or nonverbal participants (e.g., Lionello-DeNolf et al., 2008).

Investigating the influence of 3D or 2D stimuli on these two possibilities would be relevant since subtle changes in choices across sessions were also observed in previous studies employing 3D stimuli (e. g., Gil, Oliveira et al., 2011; see sessions 1 and 2 for participant So, sessions 7 and 8 for participant Ad and sessions 1 and 2 for participant Pe). Similarly, contributions for understanding the sources of behavioral variability in discrimination and reversal learning of this population could be made by investigating the relative effects of defining the child’s first choice as S+ (Gil, Oliveira et al., 2011) or S– (present study) in further subtle changes during.

We think that the correction procedure was likely an important contributor also to the children’s facile simple discrimination and discrimination reversal learning. We speculate that correction supplemented effects of extinction that might not – by itself – have proven sufficient for changing the children’s stimulus choices. Not only did the correction

procedure lead to immediately reinforced stimulus choices but perhaps also blocked development of error patterns and their known deleterious effect on discrimination learning (e.g., Stoddard & Sidman, 1967).

A question for future research is whether the present procedures or other “naturalistic” methods are virtually essential for demonstrations of facile simple discrimination and discrimination reversal learning set. To our knowledge, procedures like those used by Overman et al. (1992) have been used successfully to produce simple discrimination – but not discrimination reversal – learning set in 18-month-old toddlers. Moreover, as we just noted, the present procedures did not involve any food deprivation/reinforcement of the type employed by Overman et al. (1992). If such procedures are not necessary for and produce no better or even inferior contingency learning in infants and toddlers, then why use them? Future studies could employ this general approach to investigate more complex repertoires in infants and toddlers, for example, exclusion responding during conditional discrimination training (Lipkens et al., 1993; McIlvane, Munson, & Stoddard, 1988). Perhaps methodology of the present type will reveal that such capabilities develop at an earlier age than previously thought.

Acknowledgments

This research was supported by the Foundation for Research Support in the State of São Paulo for the first author's doctoral dissertation (FAPESP, Grant # 10/15602-8). All authors are affiliated with the Instituto Nacional de Ciência e Tecnologia sobre Comportamento, Cognição e Ensino, supported by FAPESP (Grant # 08/57705-8) and CNPq (Grant # 573972/2008-7) which supported the prepublication activity. William J. McIlvane's participation was supported additionally by NIH grants HD04147 and MH90272 and by the Commonwealth Medicine Division of the University of Massachusetts Medical School. A previous version of these data was presented at the 6th Conference of the European Association for Behavior Analysis, Lisbon, Portugal, September, 2012.

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Figure 1.

Total of number of responses for each training task prior to those that fulfilled the learning criterion for each task.

Figure 2.
Total of trials until learning criterion achievement of the three simple discrimination (SD) and three discrimination reversal (DR) tasks.