Learner Preference Between Massed- and Alternating-Trial Sequencing when Teaching Stimulus Relations to Children with Autism

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Abstract Two children with autism were assessed for preference between intersession distribution of mastered and unknown instructional trials on a computerized matching-to-sample task consisting of 12 total learning opportunities. Choice responses yielded presentation of either massed-trial sequencing (six unknown/six mastered stimuli relations or vice-versa) or alternating-trial sequencing delivery (alternation of unknown and mastered stimuli relations) followed by reinforcement for correct responses. An extinction condition served as an experimental control. Both children demonstrated a preference for the alternating-trial sequencing condition, and implications for instructional programming and possible effects to delays to higher rates of reinforcement are discussed.

Keywords Preference · Matching-to-sample · Choice · Massed trials · Alternating trials · Acquisition

In an era of increasing demands for behavior analytic intervention services for children with autism, there appears to remain considerable debate about the precise ways in which the delivery method is to occur. Within the parameters of discrete trial training (Smith, 2001), or sometimes simply called applied behavior analysis (ABA therapy) (Weiss, 2001; Reichow, 2012), caregivers may encounter contradictory advice related to what exactly to teach (Leaf, Leaf, McEachin, Taubman, Ala'i-Rosales, Ross, Smith, & Weiss, 2015) and how specifically to teach it (Roll-Pettersson, Alai-

Rosales, Keenan, & Dillenburger, 2010; Sarokoff & Sturmey, 2004). Topics of debate include the nuances of intervention such as prompting (Leaf, Sheldon, & Sherman, 2010; Schreibman, 1975; Windsor, Piche, & Locke, 1994), selecting reinforcers (Cote, Thompson, Hanley, & McKerchar, 2007; DeLeon & Iwata, 1996; Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin, 1992; Green, Reid, White, Halford, Brittain, & Gardner, 1988), sequencing of high versus low compliance probability demands (Mace, Hock, Lalli, West, Belfiore, Pinter, & Brown, 1988), and the exact sequencing of unknown versus mastered tasks to facilitate learning (Browder & Shear, 1996; Dunlap, 1984; Neef, Iwata, & Page, 1977; Rowan & Pear, 1985).

In terms of the timeline of task introduction to a child with autism, a variety of behavior analytic principles may be at work, each of which serves as the justification for a specific yet different rationale for the type of task sequencing. For example, when a child is given a series of mastered tasks first, prior to the introduction of an unknown task, it is possible that a recent history of reinforcement serves as a motivator to increase the probability of more difficult task completion (Lee, 2006). However, it is also the case that a child may simply prefer such an arrangement because the delay to reinforcement is minimal at session onset, thus suggesting that delay discounting may be a controlling variable (Demurie, Roeyers, Baeyens, & Sonuga-Barke, 2012). A contrary argument could be made in which an alternation or variation of the specific task presentations (different types of learning trials) could be of greater reinforcing value to the child, as each different trial places demands on a different dimension of the behavioral repertoire, some of which may be of less effort than the others (Dunlap & Koegel, 1980). Finally, alternation of mastered and unknown tasks, and thus response effort, may be akin to a fixed (or variable) interval schedule of reinforcement whereby each unknown task serves a discriminative function for an upcoming mastered task (and lower effort

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response), which reliably produces a reinforcer. The mastered task itself may also take on conditioned reinforcement properties.

While arguments have been promulgated regarding the clinical rationales for selecting instructional arrangements, none of these have looked at learner preference for arrangements of instructional sequences. Choice making has been demonstrated to be associated with “a decrease in problem behaviors in instructional contexts” (Brown, 1991; Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Dunlap & Kern, 1993; Dyer, Dunlap & Winterling, 1990; Vaughn & Horner, 1995). Additionally, an extensive literature has emerged around choice making in the context of selecting reinforcers (Graff & Karsten, 2012; Tullis, Cannella-Malone, Basbigill, Yeager, Fleming, Payne & Pei-Fang, 2011). The focus of previous research has largely been on the choice of reinforcers and tasks themselves. Preference for the structure of how tasks are presented has not been the subject of previous investigations. Therefore, the purpose of the present study was to more carefully explore preference for the sequencing of tasks within a discrete trial arrangement for children with autism whereby mastered and unknown stimulus relations were presented to the student either in massed-trial or alternating-trial sequential delivery.

Method

Participants, Setting, and Materials

Mary was an 11-year-old girl diagnosed with PDD-NOS (DSM-IV) and Dravet syndrome. Mary was on several medications for epilepsy and hypothyroidism, which included Clobazam, Depakote, Vimpat, Diastat, and Levoxyl. Mary was placed on a full-day sub-separate classroom 5 days per week. The classroom was a specialized service classroom within the public school system with peers who also required special education services. As part of her Individualized Educational Plan (IEP), she received weekly services from a physical therapist, occupational therapist, and speech pathologist.

Ronald was a 5-year-old boy diagnosed with ASD (DSM-V). Ronald was not receiving any medications and attended a full-day typical general education classroom 5 days per week. Ronald received weekly services from a speech pathologist as part of his IEP. Both participants received in-home Applied Behavior Analysis Services consisting of 6 h per week and 3 h per week for Mary and Ronald, respectively. Both participants received their diagnosis by their respective pediatric neurologist.

Sessions were conducted in different locations in the participant's home and lasted between 1.6 and 31.1 min, and a maximum of nine sessions were conducted per day (typically between two and four sessions per day). The experimental procedures were consistent and presented on an HP Pro Book 4540 s 16-in. laptop with Core i3 processor,

1366 × 768 resolution screen running Windows 7. A customized software program programmed in Matlab (Mathworks, Inc.) and Psychophysical Toolbox (Brainard, 1997; Pelli, 1997) allowed for the presentation of stimuli on the screen, recorded participants' responses to the stimuli, and delivered virtual tokens for every correct response, while the experimenter typically stood behind the child. No verbal instructions were provided prior to or during the session. Verbal praise was delivered at the completion of the three token deliveries that resulted in a 5-min pause in session for a trade-in for a preferred activity.

Procedure

Sessions consisted of the presentation of six matching-to-sample trials of arbitrary (text-picture) and six identical (picture-picture) stimuli. The text-picture stimuli relations were unknown to the participants and were trained in sets of three stimuli at a time. In order for any stimuli to be considered unknown, the participant obtained a score of 0 % following three presentations of that stimuli, and for mastered was that the child had a history of high response accuracy on identical matching tasks as indicated by scores above 90 % during a pre-test session. The identical pictures in each set matched the pictures being trained on the text-stimuli relations. Two conditions differed in the sequence in which the unknown and mastered trials were presented. A third condition did not involve reinforcement and was used as a control condition. Once participants showed accuracy above 89 % across the three sessions of training in the word-picture stimuli (regardless of the conditions), a new set of stimuli was introduced.

Condition 1: Massed-Trial Sequencing

At the beginning of the session, the presentation of the first six trials could consist of either unknown stimuli relations (text-picture) that were unknown to the child and the last six trials consisted of stimuli that the child had previously mastered (picture-picture) or the first six trials could consist of stimuli that the child had previously mastered and the last six trials consisted of stimuli relations that were unknown to the child. Whether the first six trials consisted of unknown or mastered trials was determined by chance (probability of 0.5), that is, once the participant chose this condition in any particular session, the computer determined which block of six-trial types were presented first. A trial began with the presentation of a sample stimulus centered in the top 50 % of the computer screen along with the three comparison stimuli positioned in the bottom 50 % of the screen. During the first session, the child was physically prompted to click the mouse pointer on the sample stimulus (observing response). The observing response produced the immediate appearance of the comparison stimuli. For unknown stimuli relations, the sample stimulus

was the text of the word that corresponded with one of the comparison stimuli, all of which were pictures. For example, a sample stimulus may have been “C-A-T” while the comparisons were the pictures of a cat, a dog, and a pig. For mastered stimuli relations, the sample stimulus was the identical picture to one of the comparison pictures.

When the child made a correct response to a comparison stimulus for both unknown and mastered stimuli relations at the prescribed prompt level, the computer displayed the addition of a yellow circle approximately 5 mm in diameter on the bottom right corner of the screen to functionally serve as a “token.” Correct responses were defined as a mouse click on the correct comparison. No time limit was specified. After the delivery of three such tokens, backup reinforcers were provided for the child. Figure 1 displays a graphical representation of the task and virtual token display. Mary’s reinforcers were access to a DVD player and music on iPhone, and Ronald’s were a variety of toys. Reinforcers for both participants were assessed through an informal presentation of different items that were conducted prior to each session. Unknown word-picture relations were taught following a prompting hierarchy sequence that was embedded in the computer program. First providing the full word (e.g., “Cat”), then the consonant-vowel (e.g., “Ca”), followed by the consonant (e.g., “C”) as the comparisons were presented on the screen. Each prompt from the hierarchy sequence was provided for every unknown word-picture relations for at least three consecutive sessions. The prompt moved along the continuum (most-to-least) if the participant met a criterion of 80 % accuracy for the three sessions. Error responses were defined as a mouse click response to one of the two incorrect comparison stimuli. Errors resulted in no token delivery and immediate end of the trial. A session with less than 80 % accuracy for unknown relations resulted in the prompting sequence reversed to the prior level in the prompt hierarchy. Following every terminal response,

the child was provided a 3-s pause before the presentation of the next trial (i.e., intertrial interval). The mastered stimuli were always the picture used to teach the unknown word-picture relations. Stimuli consisted of cat, dog, and pig for set 1 (Mary and Ronald); hat, mat, and fan for set 2 (Ronald); and bus, tub, and sun for set 3 (Ronald).

Condition 2: Alternating-Trial Sequence

In contrast to massed-trial sequencing, the order of 12 trials in this condition was alternated between mastered and unknown stimuli relations. If the participant chose this condition, whether the first trials consisted of unknown or mastered stimuli relations was determined by chance, also with probability 0.5. Once the first trial was determined, the remaining trials alternated between unknown and mastered trials. All other contingencies were identical to those described above.

Condition 3: Extinction

All elements of this condition were identical to condition 2, except for the withholding of all delivery of tokens following correct responses. Prompt and prompt hierarchy were followed accordingly.

Preference Assessment

Since the interest of the experiment was to determine the preference for trial sequence instructional procedures, each session began with the presentation of three colored squares (200 pixels in length and width) randomly located on the computer screen. A single click of the computer mouse resulted in one of three training conditions being presented, two of which differed in the sequence at which trials were presented, massed- and alternating-trial sequencing, and a third control

Fig. 1 Representation of the task and virtual token display on the computer screen

Fig. 2 Preference assessment results for Mary (*top panels*) and Ronald (*bottom panels*)

condition, extinction. The color chosen, subsequently, served as the screen background color for that experimental condition. Prior to the availability of the choices among the conditions, the participants were pre-exposed to each condition using a full physical prompt for each selection. This pre-exposure occurred during the first session every time there was a change in the colors associated with each condition.

After preference was established, a new set of colors was introduced and the development of preference measured. Once preference was established for the new set of colors, the previous set of colors were re-introduced. These alternations between the two sets of colors provided greater confidence that preference was related to a history with the current versus previous reinforcement histories with the colors used. If preference for massed- and alternating-trial sequencing did not emerge, it would be impossible to determine whether differences between the conditions of interest were irrelevant or the participant did not discriminate the task. Because of the absence of the arbitrary reinforcement (the “token”) in the extinction condition, it was expected that participants would drift away from choosing this condition over the other alternatives.

Results and Discussion

Figure 2 displays both Mary and Ronald’s response choices for the trial sequencing options. Response choice, a measure of preference, is shown as the cumulative number of times the participant chose one of the three conditions on each color reassignment. Overall, participants most often chose the alternating-trial sequencing condition relative to both massed-trial sequencing and extinction conditions. Mary showed exclusive preference (three out of three exposures) for alternating-trial sequencing conditions, and Ronald

Table 1 Mean overall accuracy (% correct) for the three conditions for unknown and mastered stimuli relations for Mary (*M*) and Ronald (*R*)

	Unknown	Mastered
Massed	<i>M</i> = 76.39 <i>R</i> = 93.66	<i>M</i> = 100.00 <i>R</i> = 97.73
Alternating	<i>M</i> = 69.61 <i>R</i> = 91.27	<i>M</i> = 100.00 <i>R</i> = 97.75
Extinction	<i>M</i> = 49.27 <i>R</i> = 97.22	<i>M</i> = 99.27 <i>R</i> = 100.00

showed preference for alternating-trial sequencing in two out of three exposures to choice assessments.

Regardless of sequencing of trials, response accuracy (a predictor of reinforcement rate) remained unaffected thus suggesting preference did not have an interactive effect with learning. Instead, it appears that both children opted for the more frequently alternating task nature provided by our alternating-trial sequencing condition. However, it should be noted that Mary's accuracy for unknown instructions varied across conditions of training (e.g., 76, 69, and 49 % for the massed, alternated, and extinction conditions, respectively).

There are many possible explanations for this finding, one of which may be that alternating-trial sequencing provided more consistent rate of reinforcement throughout the session as opposed to an unpredictable possibility of having a sequence of trials with a lower reinforcement rate. This is supported by the fact that accuracy measures were affected by whether the trials were mastered and unknown to the participant as shown in Table 1. Higher mean accuracy for mastered trials was observed and was consistent across all sequencing conditions and participants. Since the beginning of massed-trial sequencing condition had a probability of 50 % of having unknown trial sequence (lower reinforcement rate), it is also possible that the massed-trial sequencing condition may have had acquired an aversive function despite the fact that its reinforcement rate was overall higher. This possibility could have created an aversive response history to this condition in contrast to an appetitive response history created to the alternating-trial sequencing condition in which the reinforcement rate was balanced across session. This last point is somewhat strengthened by the absolutely no relative preference for the extinction condition.

Our current data suggest that as caregivers seek out to provide the most optimal discrete trial training environment, they might consider assessing for preference between interspersing unknown and mastered stimulus-response demands within a single block of trials, or at least within a larger therapy session. Furthermore, leaving all mastered or "easy" skills to the end of a session may be set the occasion for escape-maintained behavior challenges, if a child finds such an arrangement aversive. Future research should consider if additional variations of these experimental procedures are warranted. For example, it remains unknown if massed-trial sequencing whereby mastered skills are presented prior to unknown skills has the same delay to the reinforcement effect shown here. Additionally, the word-picture and picture-word tasks of our experiment were potentially of uncontrolled dissimilarity and could be improved by using all word-picture relations, some of which were simply unknown to the child. In conclusion, the present data speak to the need for more attention being made to the subtle nuances of ABA therapy delivery for children with autism.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from parents of all participants included in the study.

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