Preference and Stimulus Reinforcing Values in Preference Assessment: Do They Follow the Matching Law?

Siu Hung May Lee

University of Manitoba

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BY

Siu Hung May Lee

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirement of the degree

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Abstract

Using stimulus preference assessments to identify reinforcers for persons with severe and profound developmental disabilities assumes that preferences are positively correlated with the stimuli's reinforcing values. I examined (a) whether preferences were positively correlated with the reinforcing values of stimuli, (b) whether preferences varied in proportion to the reinforcing values of the stimuli according to the matching law (Herrnstein, 1970), and (c) whether stimulus interactions among the stimuli were present during paired-stimulus preference assessments. Participants were three adults with severe to profound mental retardation and with limited or no communication skills. Reinforcer tests were first conducted for each participant using an ABAB design. The reinforcing value of a stimulus was defined by the mean percent increase in the rate of responding from baseline phases (A) to reinforcement phases (B). One stimulus was tested at a time until 6 stimuli were identified for each participant, 2 weak reinforcers, 2 moderate reinforcers, and 2 strong reinforcers. Preferences among the 6 stimuli were then assessed using a paired-stimulus procedure and two different selection responses. Participants selected their preferred item by pressing a micro-switch during one assessment and by pointing to or touching the item in another. Participant 1 was assessed first using the switch, then without the switch, and then again with the switch. Participants 2 and 3 were assessed once for each selection response and in different orders. Preferences and stimulus reinforcing values were found to be correlated positively in all but one of the 7 preference assessments, with Spearman rank correlations ranging from –.2 to .83. However, undermatching was observed in Participant 1 and overmatching was observed in Participant 3 only during the preference assessments without a micro-switch. No matching was found in all other preference assessments. Lastly, moderately reinforcing stimuli were chosen less frequently than expected based on their reinforcing values

when they were paired with less reinforcing stimuli. However, no consistent stimulus interactions were observed in other stimulus pairings. Overall, the paired-stimulus preference assessment method with the pointing/touching selection response consistently detected the most reinforcing stimuli in two of the three participants, but the procedure did not reliably discriminate between moderate and weak reinforcers.

Preference and Stimulus Reinforcing Values in Preference Assessments: Do They Follow the Matching Law?

Preference assessments are often used to identify reinforcers for persons with severe and profound developmental disabilities who are unable to verbally communicate what they like and dislike. Identification of reinforcers is important because they can be used in training programs to strengthen adaptive behaviors. In addition, arranging the environment to provide preferred items or activities is one way to implement self-determination, which is considered to be an important dimension of quality of life (Hughes, Hwang, Kim, Eisenman, & Killian, 1995).

Other things being equal, the effectiveness of preference assessments in identifying reinforcers rests on the assumption that more preferred stimuli are likely to be reinforcers and that they will be stronger reinforcers than less preferred stimuli. This assumption may be described by the *matching law* (Herrnstein, 1970), which states that the proportion of responses occurring to one stimulus relative to another will equal the relative proportion of reinforcements associated with the two stimuli. Although the matching law has been shown to be highly robust with animals and humans (Baum, 1979), its application in the context of preference assessments has not been tested. Does the relationship between preference for stimuli and the reinforcing values of those stimuli follow the matching law? This study addressed this question. The extent to which preference and stimulus reinforcing values follow the matching law has implications for the interpretation of preference assessments results.

Preference Assessment

A preference assessment, also called stimulus preference assessment, involves systematically presenting an array of stimuli and directly observing a person's responses toward those stimuli. The person receives a stimulus as a consequence for approaching or choosing it.

Preference is then defined in terms of the relative frequency of approach responses among the presented stimuli – the more frequently a stimulus is approached, the more preferred it is relative to other presented stimuli. Three common ways to assess preference have been examined. Stimuli can be presented one at a time (single-stimulus or SS), two at a time (paired-stimulus or PS), or more than two at a time (multiple-stimulus or MS).

During the SS procedure, stimuli are presented individually in a randomized order and each stimulus is presented for the same number of trials. When a stimulus is presented, the person is given the opportunity to approach the stimulus (e.g., reaching for or pointing to the stimulus within 10 s). If an approach response occurred, the person would receive the stimulus for a period of time (e.g., 30 s) if it was an activity or for consumption if it was a food item. The preference score for a stimulus is the number of trials it has been approached divided by the number of trials that the stimulus was available. A highly preferred stimulus is one that has been approached on at least 80% of the trials (Pace, Ivancic, Edwards, Iwata, & Page, 1985).

During the PS procedure, two stimuli are presented concurrently on each trial and each stimulus is paired with every other stimulus for the same number of trials. Order and positions of the stimuli are counterbalanced across trials. On each trial, the participant is asked to select one of the two stimuli and the experimenter records which stimulus, if any, has been chosen. The preference score for a stimulus is calculated the same way as described above for the SS procedure (Fisher et al., 1992; Piazza, Fisher, Hagopian, Bowman, & Toole, 1996).

During the MS procedure, more than two stimuli (usually 6 to 8) are presented on each trial. In MS *with* replacement, all stimuli are presented on every trial and the participant is asked to select one stimulus on each trial (Windsor, Piché, & Locke, 1994). In MS *without* replacement, all stimuli are presented on the first trial and the participant is asked to select one stimulus. On the next trial, the previously chosen stimulus is removed and the remaining stimuli are presented. This is repeated on subsequent trials until all stimuli have been selected (DeLeon & Iwata, 1996). The preference score for a stimulus is calculated in the same way as described in the above procedures.

The SS procedure has been recommended for individuals who may have difficulty in scanning multiple stimuli (Logan et al., 2001). A limitation of the SS procedure is that individuals tend to approach all stimuli at a high frequency during the assessment (Hagopian, Rush, Lewin, & Long, 2001; Thomson, Czarnecki, Martin, Yu, & Martin, 2007). The PS procedure has been shown to be more sensitive than the SS procedure in differentiating preferences and more accurate in predicting the relative preference of the stimuli (Fisher et al., 1992; Piazza et al., 1996). Lastly, the MS without-replacement procedure is better than the MS with-replacement procedure in yielding consistent preference rankings (DeLeon & Iwata, 1996). Although the MS without-replacement and PS procedures appear to be equally effective in differentiating preferences, the PS procedure is more commonly used because the former requires individuals to scan a large number of stimuli on every trial and this behavior may not be well developed for individuals with severe and profound developmental disabilities. Therefore, this study focused on the PS procedure.

Reinforcer Assessment

Although a preferred stimulus identified through preference assessment is often assumed to be a reinforcer, whether it is a reinforcer requires verification that is independent of the preference assessment. This verification is completed through a reinforcer assessment.

A reinforcer is defined as a stimulus that, when presented immediately following a response, will increase the probability of that response (e.g., rate of responding) occurring in the presence of the same antecedent stimulus and under a similar state of deprivation (Martin & Pear, 2007). A common test of a reinforcer usually involves establishing a baseline phase by observing the frequency of a target response in the presence of a specific stimulus, with either no programmed consequences or a specific consequence (e.g., praise) following the behavior. After a stable rate of responding is observed, the reinforcement phase is introduced by applying the stimulus in question as an immediate consequence following each instance of the target response. Replications of the baseline and reinforcement phases (e.g., in an ABAB design where A = baseline and B = reinforcement) are conducted to increase our confidence about any observed effects. If higher rates of responding occur during the reinforcement phases than during the baseline phases, then the stimulus would be a reinforcer. If the rates of responding between baseline phases and reinforcement phases are similar, then the stimulus would not be a reinforcer. If lower rates of responding occur during the "reinforcement" phases than during the baseline phases, then the stimulus would be a punisher rather than a reinforcer.

The extent to which a reinforcer assessment was conducted and how it was conducted vary across studies in preference assessments. Some studies conducted reinforcer assessments using an ABAB design, as described above, for their most preferred stimuli (e.g., Graff & Ciccone, 2002; Higbee, Carr, & Harrison, 2000; Logan et al., 2001; Roane, Vollmer, Ringdahl, & Marcus, 1998). Some studies compared the relative reinforcing effects of the most and the least preferred stimuli (e.g., Spevack, Yu, Lee, & Martin, 2006). Lastly, some preference assessment studies conducted no reinforcer assessments (e.g., Bojak & Carr, 1999).

Most studies have found that the identified preferred stimuli did function as reinforcers during reinforcer assessments (Green, Reid, Canipe, & Gardner, 1991, Higbee et al., 2000; Piazza et al., 1996). Some studies, however, have reported failures to discern preferences or to identify reinforcers (e.g., Ivancic & Bailey, 1996; Ivancic, Barrett, Simonow, & Kimberly, 1997). The failure to identify reinforcers has been attributed to limitations in the selection of the approach response or in the discrimination skills of the participant. For example, Hagopian, Long, and Rush (2004) stated that preference assessment procedures that used approach responses such as pointing to or reaching for a stimulus are not suitable for persons with developmental and physical disabilities. Spevack et al. (2006) showed that preferred stimuli functioned as reinforcers for a more passive response (i.e., looking at the stimulus), but not for a more active response (i.e., switch-pressing) for persons with profound multiple disabilities. Logan et al. (2001) pointed out that persons with profound multiple disabilities may have poor scanning and discrimination skills.

While these are important considerations and may account for some of the discrepant results, another possibility is that none of the stimuli were reinforcers even though a preference hierarchy was observed. In all studies where reinforcer assessments were conducted, none have conducted reinforcer assessments *before* the preference assessments and none have tested the reinforcing values of *all* stimuli in the preference hierarchy. The reinforcing values of the stimuli were therefore unknown prior to the preference assessment. If none of the stimuli used in a preference assessment were reinforcers, this might result in either a failure to discern a preference hierarchy or the emergence of a preference hierarchy based on other characteristics of the stimuli or processes (e.g., interactions among the stimuli during the preference assessment), rather than the reinforcing values of the stimuli.

Stimulus Interactions in Preference Assessments

Several studies have shown that stimuli with different reinforcing values do interact during preference assessments. DeLeon, Iwata, and Roscoe (1997) measured the preferences of 13 persons with a diagnosis of profound mental retardation and 1 person with moderate mental retardation. They conducted three preference assessments for each participant using an MS without replacement procedure, which included: (1) an assessment with 7 food items; (2) an assessment with 7 non-food items; and (3) a combined assessment with 7 items made up of top ranked food and non-food items from the preceding assessments. Differential preferences were evident when the food and non-food items were assessed separately. During the combined assessment, however, the food items displaced the non-food items downward either completely or to a large extent for 12 of the 14 participants. Reinforcer assessments conducted with two participants following the preference assessments using their top ranked non-food items showed that the stimuli functioned as reinforcers for both participants. The authors suggested that food as a stimulus class may be more reinforcing than non-food items because it requires less response effort to extract reinforcement from food than from non-food reinforcers. Although this seemed to be a reasonable assumption, no direct comparisons were made between food and non-food items during the reinforcer assessments.

Bojak and Carr (1999) replicated the results of DeLeon et al. (1997) with four participants with severe mental retardation. They conducted the combined preference assessment before and after meals, and showed that meals, as a naturally occurring everyday event that affects deprivation, did not affect the observed displacement between food and non-food stimuli. However, no reinforcer assessments were conducted in this study.

Taravella, Lerman, Contrucci, and Roane (2000) observed similar results to DeLeon et al. (1997) when they examined non-food stimuli with different preference values. After using a PS procedure to assess 10 leisure items, the 5 lowest ranked items were presented in a second assessment, but without the higher ranked items. The second assessment produced more differentiated preference scores than the first assessment among the 5 items, and the most preferred item from the second assessment also functioned as a reinforcer during subsequent reinforcer assessments.

The above studies suggested that preference for a stimulus decreased when it was presented with another more reinforcing stimulus, even though both stimuli could be reinforcers for increasing behaviors. In this case, the less preferred stimulus could be overlooked as a reinforcer (false negative). The reverse, however, has a more serious implication. If preference for a stimulus increases during a preference assessment as a result of it being paired with a less reinforcing stimulus, this may lead to a higher preference score for an otherwise weak reinforcer (false positive). In this case, the preferred stimulus may not function as a reinforcer.

Matching Law

In a concurrent choice situation where two simultaneously available stimuli are associated with different schedules of reinforcement, the matching law states that the proportion or ratio of responses occurring to one stimulus relative to another will equal the proportion or ratio of reinforcements associated with each stimulus (Herrnstein, 1970; McDowell, 1989). For example, suppose a pigeon can peck at either a red or a blue key to receive food. Pecking the blue key is reinforced on a variable interval 20 s schedule (i.e., reinforcement occurs for the first response after an interval has elapsed, and that interval varies from one reinforcement to the next, with an average of 20 s across intervals) and pecking the red key is reinforced on a variable interval 10 s schedule (i.e., reinforcement occurs twice as often as on the red key than on the blue key on average). Over time, the pigeon will peck the red key twice as often as the blue key. The relationship can be expressed mathematically as

$$b1/b2 = r1/r2 \qquad (1)$$

where b1 and b2 refer to the rates of behavior (pecking) to each stimulus, respectively, and r1 and r2 refer to the rates of reinforcements associated with each alternative, respectively. Perfect matching occurs when the ratio on the response side of the equation (b1/b2) is equal to the ratio on the reinforcement side of the equation (r1/r2).

A generalized form of the equation expressed in terms of a power function has been recommended when the reinforcers associated with each stimulus differ qualitatively (McDowell, 1989). The equation can be expressed as

$$\log (b1/b2) = a \times \log (r1/r2) + \log k \qquad (2)$$

where a is the slope of the linear regression fitted to the data and k, the y-intercept, represents bias towards a response alternative. When both a and k equal 1, equation (2) is equivalent to (1). Undermatching and overmatching are said to occur if a is less than or greater than 1, respectively. The extent k deviates from 1 reflects the degree of bias, for example, by favoring one alternative over another. The matching law has been shown to apply equally well for rate of responding or time spent responding (McDowell, 1989).

Matching Law Research in Developmental Disabilities

The matching law has been shown consistently with rats and pigeons (Davison, 1982; McSweeney, 1975), and in studies with humans including persons with developmental disabilities. Neef, Mace, Shea, and Shade (1992) examined the effects of rate and quality of reinforcement with three students in a special education program. During the baseline phase, two sets of cards with identical math problems were given to the students. Picking a card and answering the math question correctly from one set was reinforced on a variable interval 30 s (VI 30) schedule and picking a card and solving the problem from another set was reinforced on a variable interval 120 s (VI 120) schedule. Two sets of math problems were simultaneously available and reinforcers with the same qualities (either high or low quality) were used in this phase. During the next phase, a reinforcer with high quality was provided under the VI 120 schedule whereas a reinforcer with low quality was provided under the VI 30 schedule. Neef et al. observed that percentage of time allocated to each set of math problems closely matched the reinforcement obtained under each schedule of reinforcement during the baseline phase. However, when different qualities of reinforcers were provided for each set of math problems, two of the three students allocated more time to the VI 120 schedule with a high-quality reinforcer provided.

Neef, Mace, and Shade (1993) further examined the interaction between rate of reinforcement, quality of reinforcement and delay of reinforcement with two students in a special education program. In Experiment 1, the authors observed similar results to Neef et al. (1992) when they investigated the effects of rate of reinforcement and delay of reinforcement. Matching was observed when the reinforcers were delivered to the participants immediately in both schedules of reinforcement. However, when delay of reinforcement occurred on the richer schedule, matching was interrupted and both participants allocated most of their time to the leaner schedule of reinforcement in which they could access the reinforcers immediately. In Experiment 2, the authors investigated the effects of rate of reinforcement, quality of reinforcement and delay of reinforcement on the matching relationship. They observed that one participant spent most of the time with math problems associated with higher quality reinforcers regardless of the rate of reinforcement and delay. However, the other participant allocated most of the time to the schedule of reinforcement in which reinforcers were delivered immediately.

Neef, Shade, and Miller (1994) and Mace, Neef, Shade, and Mauro (1996) both examined the effects of rate of reinforcement, quality of reinforcement, delay of reinforcement and response effort on the matching law with persons with learning and behavior difficulties. Five of the six participants in the first study and all participants in the second study allocated most of their time to the schedule of reinforcement in which higher quality reinforcers were provided. The authors of both studies also observed that participants were least sensitive to the difficulty of the math problems.

The above studies by Neef and associates show that persons with learning difficulties are sensitive to the schedules of reinforcement, and that reinforcer quality, delays, and response effort may interact to influence matching. However, Borrero and Vollmer (2002) found no interactions among qualitatively different consequences. They examined the relationship between behaviors emitted by four persons with developmental disabilities and the rates of reinforcement provided by their caregivers, without controlling for the qualities and magnitudes of reinforcement in their study. Descriptive analysis was first conducted to identify the rate of three different types of potential reinforcers (i.e., attention, escape, and access to preferred tangible items) and the frequencies of appropriate and inappropriate behavior of the participants during their interaction. Functional analysis was then performed to identify the reinforcers that maintained each type of appropriate and inappropriate behavior. The authors observed that the relative rates of inappropriate and appropriate behavior of all participants closely matched the relative rates of reinforcement provided to the inappropriate behavior by the caregivers.

Dube and McIlvane (2002) also showed that persons with developmental disabilities are sensitive to the rate and magnitude of reinforcement under a two-choice situation. Six participants with mental retardation were required to hit one of the animated images presented on a computer screen to obtain the reinforcers. By varying the rates of reinforcement and holding the magnitudes constant in Experiment 1, and varying the magnitudes of reinforcement and holding the rates constant in Experiment 2, the authors observed that one participant was highly sensitive and another was moderately sensitive to changes in both the rate and magnitude of reinforcements. The other four participants were more sensitive to either the rate or the magnitude of the reinforcement schedules.

Statement of the Problem

The effectiveness of preference assessment in identifying reinforcers rests on the assumption that preference and stimulus reinforcing values are positively correlated. Although the matching law has been studied extensively with animals and humans, including persons with developmental disabilities, using qualitatively different reinforcers, its application in the context of preference assessment has not been investigated.

The PS preference assessment procedure is similar to the procedures used in past matching law studies in two ways. Two stimuli are concurrently available on each trial in the PS procedure and the participant can select either one of the two stimuli, and preference is defined as the relative rates of responding occurring to the presented stimuli.

However, the PS procedure also differs from past matching law studies in several ways. Studies on the matching law typically use a free operant arrangement (participants can respond at any time within a session) and intermittent reinforcement schedules, whereas preference assessments typically restrict the opportunity to respond by using discrete trials and a fixed ratio 1 reinforcement schedule (reinforcement occurs after each approach response). Another significant difference between the PS procedure and typical matching law studies is the number of stimuli used. Matching law studies typically use only two alternatives, whereas preference assessments typically involve multiple stimuli and thus many combinations of stimulus pairings. These differences may limit or influence the relationship between preference and stimulus reinforcing values during preference assessment.

A small number of published preference assessment studies have reported failure of the preferred stimuli to function as reinforcers, and others have reported stimulus interactions during preference assessments. A systematic study of how stimuli with different pre-defined reinforcing values interact during preference assessments may help us better understand and interpret preference assessment findings.

The purpose of this study was to examine the relationship between preference and stimulus reinforcing values in a preference assessment using the PS procedure. Although the stimuli were qualitatively different, their reinforcing values were predetermined through reinforcer assessments conducted before the preference assessment. During the PS preference assessment procedure, stimulus pairings were formed based on their assessed reinforcing values to systematically evaluate the matching law and stimulus interactions.

Method

Participants and Setting

Three adults with severe to profound mental retardation and with limited or no communication skills were recruited from River Road Place of St. Amant, a residential and community resource center for individuals with developmental disabilities. Selection was based on the performance on the *Assessment of Basic Learning Abilities* (ABLA) test prior to the study because a past study suggested that individuals with severe or profound developmental disabilities, who have mastered a two-choice position discrimination task (referred to as Level 2 on the ABLA test), are able to indicate their preferences during the PS preference assessment procedure (Thomson et al., 2007). All participants in the study had passed up to Level 2 but failed all higher levels on the ABLA test. Participants' characteristics were obtained from their health records, with consent, and details of which are provided in Table 1.

Table 1

Participant Characteristics

Participant	Sex	Age	Diagnosis	Communication skills
1	M	35	Severe developmental disabilities	Some vocal manding and instruction following
2	M	33	Profound developmental disabilities	No speech; some instruction following
3	F	37	Severe/profound developmental disabilities	No speech; some instruction following

All sessions were conducted in an assessment room at the St. Amant Research Centre. The experimenter sat across a table from the participant during each session, and an observer was present in some sessions to conduct reliability checks.

Instrument and Materials

The ABLA test is a well-researched, direct assessment of discrimination learning for individuals with developmental disabilities (Kerr, Meyerson, & Flora, 1977; Martin & Yu, 2000). The assessments were administered according to the procedures described by DeWiele and Martin (1998).

A list of food items (e.g., chips and candy) was identified for each participant through consultation with caregivers. Six food items were selected for each participant based on their reinforcing values following reinforcer assessments (described later).

A stopwatch was used to manage session time during reinforcer assessments. A red light, two identical round micro-switches (6 cm in diameter), and two identical transparent containers were also used during the study.

Reinforcer Assessments

Reinforcer assessments were conducted to determine the reinforcing value of each food item and to identify six food items for use in subsequent preference assessments. A reinforcer assessment was conducted for each food item using an ABAB design, where A phases consisted of *baseline* sessions and B phases, *reinforcement* sessions. A desk lamp with a red light bulb sat at the corner of the table, and it was turned on during baseline sessions and off during reinforcement sessions to facilitate discrimination between phases.

Target response. Switch pressing was the target response for all reinforcer assessments and for all participants. This behavior was selected because it had been used by each participant to activate different types of leisure activity in the classroom, it required very little effort to complete, was discrete and repeatable, and was similar to the approach response that would be used during subsequent preference assessments (described below). A switch press was defined as the participant depressing the micro-switch until it produced an audible click.

Baseline phase. Before starting each baseline session, the experimenter modeled the target response, guided the participant to engage in the response, and praised the participant immediately after the response. The session then began with a verbal instruction for the participant to engage in the target response (e.g., "*name*, press the switch") and the same instruction was repeated once after each minute. A praise statement for a behavior other than switch pressing (e.g., "nice sitting") was provided on a fixed time schedule of once per minute, and no programmed consequence was provided following a switch press. Each session was 5 minutes long and separated from the last session by at least a 5-minute break. Sessions were conducted until the rate of responding stabilized according to a modified criterion adapted from Dube and McIlvane (2002). The stability criterion for this study was defined as 3 consecutive sessions where the rate of responding for each session did not deviate from the 3-session mean by more than 20% and the 3 sessions indicated no trend in the same direction.

Reinforcement phase. The procedure during reinforcement sessions was the same as that used during baseline sessions except that the food item being evaluated was provided for consumption immediately following the occurrence of the target response. Reinforcement time was subtracted from the session time such that a participant had 5 minutes per session for responding. Sessions were conducted until the rate of responding met the stability criterion described above.

Dependent measure. The frequency of responding (switch pressing) was recorded during each session. The reinforcing value of a stimulus was defined as the mean percent change in responding from baseline phases to reinforcement phases. This was determined by: (1) taking the last 3 sessions during each of the two baseline phases and finding the mean across the 6 sessions; (2) taking the last 3 sessions during each of the two reinforcement phases and finding the mean across the 6 sessions; and (3) calculating the percent change in mean responding as follows: (mean reinforcement response rate – mean baseline response rate) / mean baseline response rate x 100%.

Reinforcer tests were conducted until six food items were identified, consisting of two food items for each of the three reinforcing levels (i.e., strong, moderate and weak reinforcers). A food item was categorized as a moderate reinforcer (MR) when its reinforcing value was approximately 2 times higher than the weak reinforcer (WR). A food item was categorized as a strong reinforcer (SR) when its reinforcing value was approximately 2 times higher than the moderate reinforcer (MR).

Preference Assessments

Stimulus pairings. Preference assessments were conducted for each participant using the PS procedure after the reinforcer assessments. In each preference assessment, there were four types of stimulus pairings based on a different combination of reinforcer values and a total of 15 unique pairings.

A. Stimuli with similar reinforcing values (MR1-MR2, SR1-SR2, and WR1-WR2).

B. Stimuli with a moderate and a strong reinforcer (MR1-SR1, MR1-SR2, MR2-SR1, MR2-SR2).

C. Stimuli with a moderate and a weak reinforcer (MR1-WR1, MR1-WR2, MR2-WR1, MR2-WR2).

D. Stimuli with a strong and a weak reinforcer (SR1-WR1, SR1-WR2, SR2-WR1, SR2-WR2).

During each preference assessment, the four types of pairings were presented in a randomized sequence in an ABCDABCD design. Each unique pairing was presented 10 times in total. All trials within each type of stimulus pairing were randomized and the positions of the stimuli were counterbalanced across trials.

PS assessment procedures. Preference assessments were conducted for each participant using two different selection responses: pressing a switch or touching/pointing to the item. The former response shared similarity with the target response used during the reinforcer assessments described above. Using a similar response during the preference assessments was thought to increase the likelihood of matching. However, the latter response was more common of preference assessments presented in the natural environment and likely to be more similar to the past experience of the participants. For preference assessment using switch pressing as the selection response, two identical micro-switches were presented side-by-side on the table concurrently. A food item was individually placed inside a transparent container which was located behind either one of the micro-switches. On each trial, the experimenter held each container, one at a time, at the participant's eye level, asked him/her to look at the food item, and then placed the container back on the table. After both containers had been shown to the participant, the experimenter asked the participant "What do you want?" On each trial, the participant was given the food item located behind the switch that was pressed. Attempts to touch both micro-switches or to touch the container(s) were blocked and the trial was repeated. If no response occurred after 10 s, the containers were removed and the next trial was then presented.

For a preference assessment using an approach response as the target response, two food items were placed on the table side-by-side without using the containers or micro-switches. The assessment procedures were similar to those mentioned above except that, instead of holding up the containers, the experimenter held each food item at the participant's eye level before the verbal prompt for the target response. If the participant pointed to or touched one of the food items, then that item was given to the participant.

The food item selected on each trial, if any, during preference assessments was recorded. The proportion of trials each food item had been selected based on its availability was calculated to determine its preference value.

Reliability Assessments

Reinforcer assessments. Interobserver reliability checks were conducted for each participant during reinforcer assessments and the percentage of sessions observed by a trained observer ranged from 31% to 49% across participants. The experimenter and the observer independently recorded the frequency of switch presses during each session. Percent agreement between the experimenter and the observer was calculated for each session by dividing the smaller number by the larger number recorded and multiplying by 100% (Martin & Pear, 2007). The mean percent agreement across participants was 99.6%, with a range of 99.4% to 99.8%.

Procedural integrity checks were conducted for each participant and the percentage of sessions observed by a trained observer ranged from 31% to 49% across participants. At the beginning of each session, the observer recorded whether the red light was presented correctly (turned on during baseline sessions, and off during reinforcement sessions), and whether the initial demonstration was conducted correctly. The mean percentage of sessions with these two steps completed correctly across participants was 100%. During each session, the observer recorded whether the verbal instructions were provided correctly (once per minute), the praise statements were provided as planned (once per minute), and whether the consequence was provided correctly following each switch press (no programmed consequence during baseline sessions and presentation of the food item during reinforcement sessions). The percentage of correct responses (all steps were completed correctly) based on available opportunities (number of switch presses by the participant) was calculated for each session. The mean percent correct responses across participants was 99.7%, with a range of 99.5% to 99.8%.

Preference assessments. Interobserver reliability checks were conducted for each participant during preference assessments and the percentage of trials observed by a trained observer ranged from 52% to 81% across participants. The experimenter and an observer independently recorded the participant's response on each trial during the assessments. A trial was scored as an agreement if the observer and the experimenter recorded the same response; otherwise, it was scored as a disagreement. Percent agreement between the observer and the experimenter was calculated for each session by dividing the number of agreements by the total number of agreements and disagreements during that session, and multiplying by 100% (Martin & Pear, 2007). The mean percent agreement across participants was 99.2%, with a range of 98% to 100%.

Procedural integrity checks were conducted for each participant and the percentage of trials observed by a trained observer ranged from 52% to 81% across participants. On each trial, the observer recorded whether: (a) the stimuli were presented in the correct positions, (b) verbal cues were provided correctly, and (c) the chosen stimulus was provided immediately following a selection response. A trial was scored as correct if no errors occurred. The mean percentage of trials delivered correctly across participants was 99.7%, with a range of 99.5% to 100%.

Results

Reinforcer and Preference Values

Figure 1 shows the mean reinforcing values (line graphs) for each stimulus against the right vertical axis and the preference values (bar graphs) for each stimulus against the left vertical axis (values are available in Appendix A). For Participant 1, the mean reinforcing value of the strong reinforcers (SRs) was 397%, approximately 2 times higher than that of the moderate reinforcers (MRs, mean = 197%), and the mean reinforcing value of the MRs was 7.5 times higher than that of the weak reinforcers (WRs, mean = 26%). Sessions data of the reinforcer tests for Participant 1 are available in Appendix B. Preference assessments for Participant 1 were administered three times first using the micro-switch (grey bars), no switch (black bar), and then again with the micro-switch. There appeared to be some correspondence between preference and reinforcer values among the SRs and MRs. However, preference for the WRs was much higher than what was expected based on their reinforcing values. Spearman rank

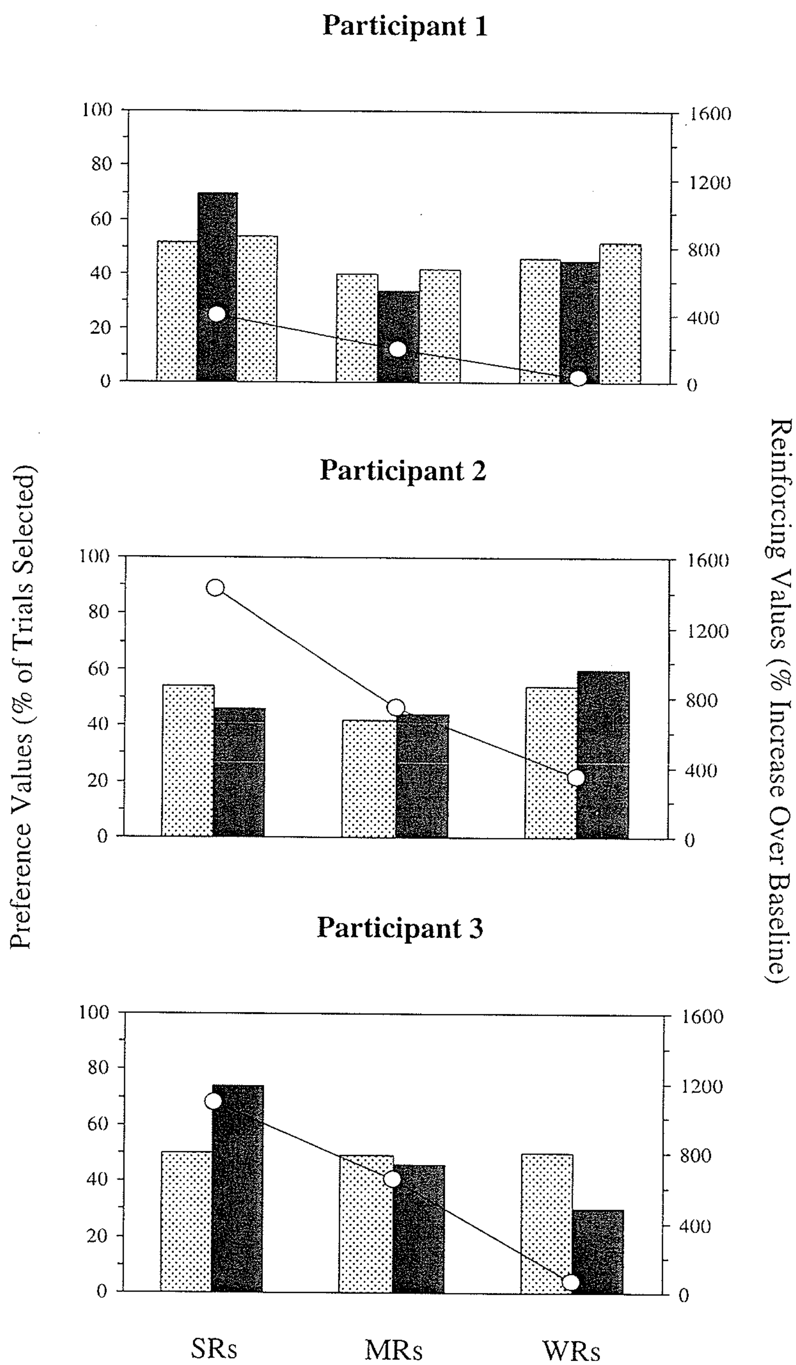

Figure 1. Reinforcer values, defined as the mean percent increase in rate of responding from baseline to reinforcement phases (right vertical axis) for each stimulus, and preference values, defined as the percentage of trials a stimulus was selected during preference assessments (left vertical axis), with and without a micro-switch (grey and black bars, respectively) for each participant.

correlations between the preference values and the reinforcing values of the stimuli were .41, .60, and .41 across the three assessments in order.

For Participant 2, the mean reinforcing value (middle line graph) of the SRs was 1419%, 1.9 times higher than that of the MRs (mean = 739%), and the mean reinforcing value of the MRs was 2.1 times higher than that of the WRs (mean = 345%). Sessions data of the reinforcer tests for Participant 2 are available in Appendix C. Preference assessments for Participant 2 were administered twice, first using the micro-switch followed by no switch. Like Participant 1, preference and reinforcer values during the preference assessment with the switch showed correspondence across the SRs and MRs, but preference for WRs was higher than expected. Spearman rank correlation was .31. Preference and reinforcer values during preference assessment without the switch, however, were negatively correlated ($r = -.2$).

For Participant 3, the mean reinforcing value of the SRs was 1087%, 1.7 times higher than that of the MRs (mean = 650%), and the mean reinforcing value of the MRs was 9.8 times higher than that of the WRs (mean = 67%; see Appendix D for sessions data for Participant 3). Like Participant 2, preference assessments were administered twice for Participant 3, although the order of assessments was reversed. When preference assessment was conducted with a micro-switch, the correspondence between preference and reinforcer values was weak ($r = .2$); when the assessment was conducted without the switch, correspondence improved significantly ($r = .83$).

Matching Law

The matching law was applied to the data to evaluate whether preference and reinforcer values varied in proportion to each other. The ratio of the preference values ($b1/b2$) was calculated for each stimulus pairing. For example, during the first preference assessment for

Participant 1, MR1 was selected on 3 of the 10 trials when it was paired with SR1. Thus the preference ratio for the MR1-SR1 pairing was 3/7 or 0.43, and log (*b1/b2*) was –.37. Next, the ratio of the derived reinforcing values for the two stimuli was calculated. The derived reinforcing values for MR1 and SR1, respectively, were 203 and 427 (see Appendix A). Thus the ratio (*r1/r2*) for this pairing was 203/427 or .48 and log (*r1/r2*) was –.32. Log (*b1/b2*) was then plotted as a function of log (*r1/r2*) for the 15 stimulus pairings. In each graph of Figure 2, the preference ratio is plotted on the vertical axis and the reinforcement ratio is plotted on the horizontal axis. A linear regression line is fitted to the data and the function, $y = ax + k$, is shown on each graph. The dash line represents unity (perfect matching).

The three graphs at the top of Figure 2 show the results of the three preference assessments for Participant 1 (with, without, and with the micro-switch, respectively). Indifferent responding was observed in the preference assessments with the switch (first and third graphs), as indicated by the almost horizontal regression lines (i.e., the slopes were near zero at –.0044 and .0439, respectively). No bias was detected in these two preference assessments as indicated by the near-zero y-intercept (–.0658 and –.0014, respectively). During the preference assessment without the switch (middle graph), however, there was a moderate positive correlation between preference and reinforcer values, although a slope of less than 1 (.4672) indicated undermatching. The regression accounted for almost 45% of the variance (R^2). In addition, a negative y-intercept (–.4512) indicated bias toward one of the response alternatives.

The two graphs in the second row of Figure 2 show the results of the preference assessments for Participant 2 with and without the micro-switch, respectively. Indifferent responding was observed in the preference assessment with the switch (i.e., slope was near zero) and no bias was detected (i.e., y-intercept was close to zero). A negative correlation between

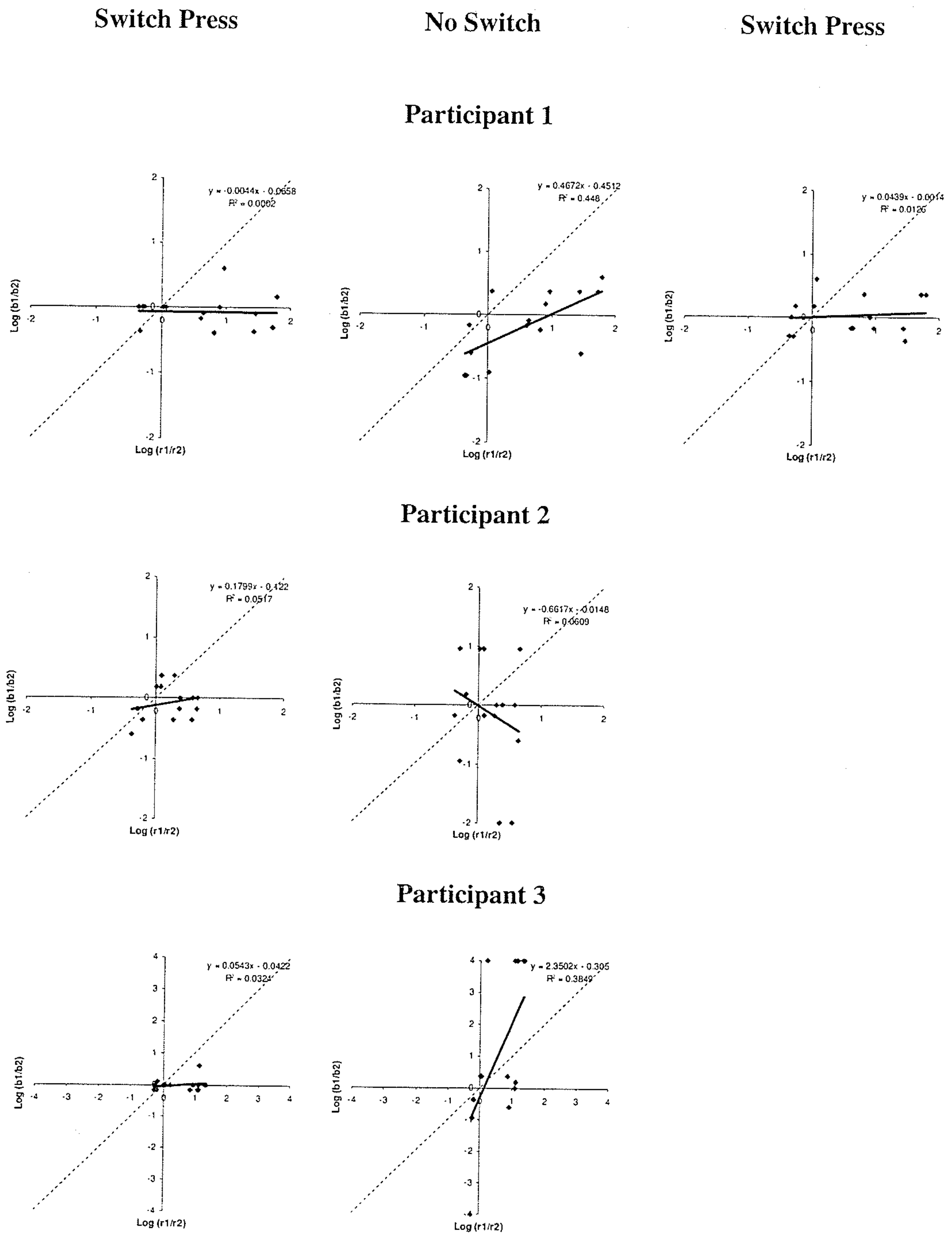

Figure 2. Power function of preference and reinforcer values during preference assessments with and without a micro-switch for each participant. Dotted line shows unity (perfect matching).

preference and reinforcer values was observed during the preference assessment without switch and no bias was detected.

The two graphs in the third row of Figure 2 show the results of the preference assessments for Participant 3 with and without the micro-switch, respectively. Indifferent responding was observed in the preference assessment with the switch (i.e., slope was near zero) and no bias was detected (i.e., y-intercept was near zero). During the preference assessment without the switch, a strong positive correlation was observed. Unlike Participant 1, however, Participant 3 displayed overmatching (i.e., slope was greater than 1). Participant 3 also showed a bias toward one of the response alternatives (i.e., negative y-intercept).

Stimulus Interactions

The mean percentages of trials that the moderate reinforcers (MRs) had been selected when they were paired with a weaker reinforcer (MR-WR), another moderate reinforcer (MR-MR), and a stronger reinforcer (MR-SR) are shown for each participant in Figure 3. Note that during MR-MR pairings, MR1 selection is plotted in the figure; during MR-WR and MR-SR pairings, the mean selection for MR1 and MR2 is plotted. In each graph, the dash line represents the mean expected percentage of MR selection based on perfect matching given the reinforcing values of the stimulus pairings. The lines with unfilled and filled ovals represent preference assessments with and without a micro-switch, respectively. Large interactions were observed across participants and across assessments with or without a switch during MR-WR pairings, with MRs being selected less frequently than expected by as much as 50%. Results were mixed during other pairings, with MR selection deviating from the expected frequency by less than 20% (except for the MR-MR pairing for Participant 1).

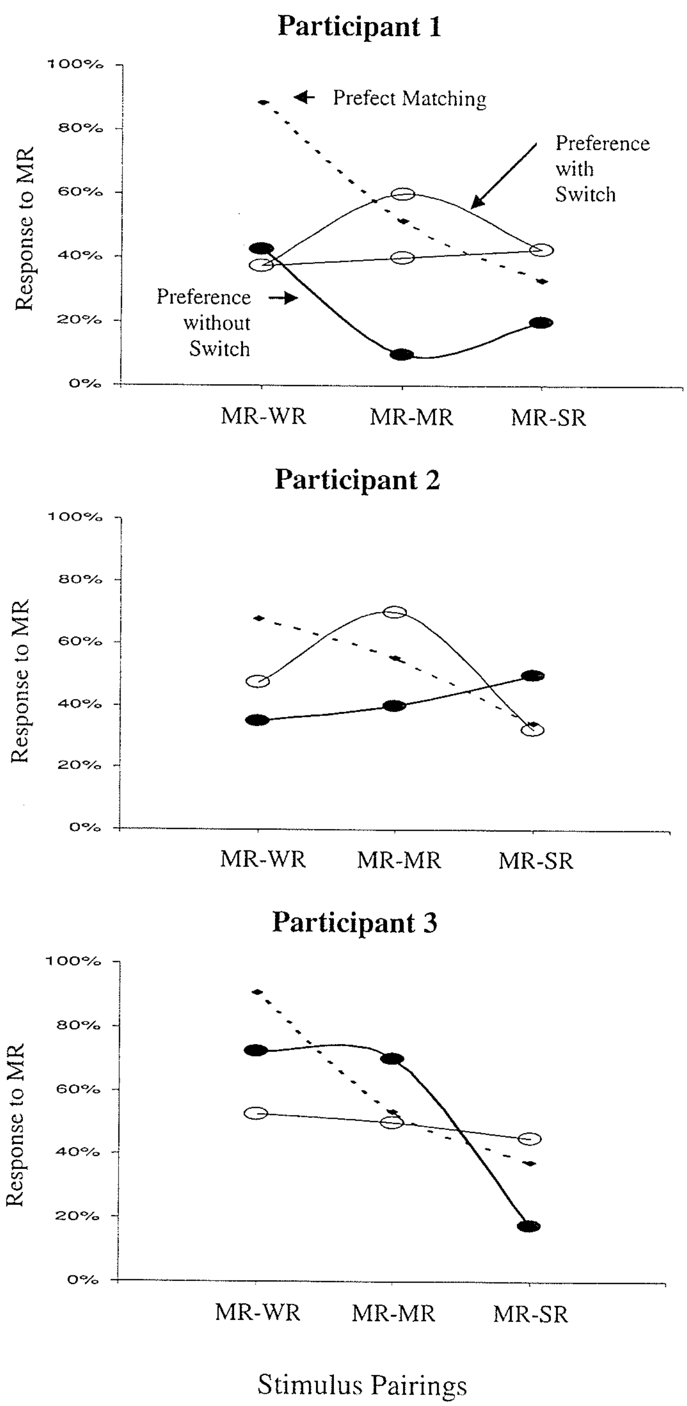

Figure 3. Mean percentage of trials the moderate reinforcers were chosen when paired with weaker reinforcers (MR-WR), another moderate reinforcer (MR-MR), and stronger reinforcers (MR-SR) during preference assessments with and without a micro-switch. Dotted line shows expected response values based on perfect matching.

Discussion

One of the limitations of previous research on preference assessment is that the reinforcing values of the stimuli are unknown. As a result, it is unclear how well preference values reflect the "true" reinforcing values of the stimuli. The present study addressed this limitation by independently quantifying the reinforcer values and selecting three specific levels of reinforcer value for preference assessments. Overall, preference assessments without the micro-switch, which is typically done in applied settings, yielded stronger correlations with the reinforcing values of the stimuli than preference assessments with the switch for two of the three participants.

However, the paired-stimulus preference assessment procedure identified only one of the two strongest reinforcers as the preferred stimulus for Participants 1 and 3 (i.e., chosen on 80% of the assessment trials; see Appendix A), and it failed to differentiate the MRs and WRs according to their reinforcing values. The negative correlation found for Participant 2 could have been a result of a change in preference, although this was not verified in the study.

By using stimuli with pre-established reinforcing values, this study permitted an analysis of the preference data according to the matching law. Although positive correlations between preference and reinforcer values, ranging from .2 to .83, were found for all but one preference assessment, some degree of matching was found only during assessments without the micro-switch for two of the three participants. Even though undermatching is commonly reported in studies with humans (Mace, Neef, Shade, & Mauro, 1994; Oscar-Berman, Heyman, Bonner, & Ryder, 1980), one participant showed undermatching and the other, overmatching, in this study. Overall, the results of this study showed that preference of stimuli with different reinforcing values did not consistently follow the matching law. The procedural differences between this study and past matching law studies described in the introduction may also have limited the degree of matching. Nonetheless, this study is the first to extend the matching law to preference assessments with individuals with developmental disabilities.

The only consistent interaction observed was during the MR-WR pairings in which MR was selected less frequently than expected. The direction of the observed interaction is unexpected since previous research suggests that stronger reinforcers would displace weaker reinforcers during preference assessments (Bojak & Carr, 1999; DeLeon et al., 1997; Taravella et al., 2000). No consistent interaction was observed during other pairings.

The present study suggests that preference assessments using a pointing or touching response showed stronger correlations between preference for items and the reinforcing values of those items. In fact, matching was observed only in this condition and not when the micro-switch was used as the selection response. Even though the participants in this study had prior experience using the switch (for operating equipment in the classroom to provide sensory stimulation), they probably had a much longer history of reinforcement for indicating their preferences by pointing, rather than by pressing a switch, in everyday situations.

This study has several limitations. First, although three levels of reinforcing values were specified for each participant, they were not the same across participants at each level. For example, Participant 1's SRs had reinforcing values (percent increase in response rate over baseline) of 427 and 367, respectively; Participant 2's SRs were 1550 and 1288, respectively; and Participant 3's SRs were 1114 and 1060, respectively. The same is true for the moderate and weak reinforcers (see values in Appendix A). Controlling the reinforcer values across participants may yield more consistent interactions, if any. However, this may be practically difficult to achieve in preference assessment studies using qualitatively different stimuli. An alternative is to use only one reinforcer and manipulate its reinforcing value by using different schedules of reinforcement.

Another potential limitation of this study is that the method used to determine the reinforcing and preference values of the stimuli may be inadequate. The mean rate of responding during each phase of the reinforcer tests was based on the last three sessions of each phase (two sessions in one instance, see Appendices B through D). Perhaps additional sessions would increase the accuracy of the reinforcer value estimates. Similarly, each unique stimulus pairing was presented for 10 times during the preference assessment. It is possible that additional trials may yield more accurate estimates of preference values.

Lastly, the results of this study are limited by the small number of participants. Replications with additional participants are needed to confirm the present findings.

Preference assessments are widely used for identifying potential reinforcers for persons with developmental disabilities. In a typical preference assessment, a stimulus is considered highly preferred if it has been selected on 80% or more of the trials (Pace et al., 1985). In this study, only two of the strong reinforcers met this criterion (SR1 for Participants 1 and 3; see Appendix A) despite the fact that other strong and moderate reinforcers increased baseline response rates ranging from 190% to 1550% during the reinforcer tests. If the present results are generalizable, it is clear that the paired-stimulus preference assessment procedure and the 80% criterion underestimate the reinforcing values of many stimuli (i.e., false negatives). From an applied standpoint, this is a concern because potentially powerful reinforcers would have been excluded from use for intervention. This is particularly relevant for individuals for whom available reinforcers may be limited due to dietary restrictions and other physical and sensory impairments. Further research is needed to refine and improve the predictive validity of this technology.

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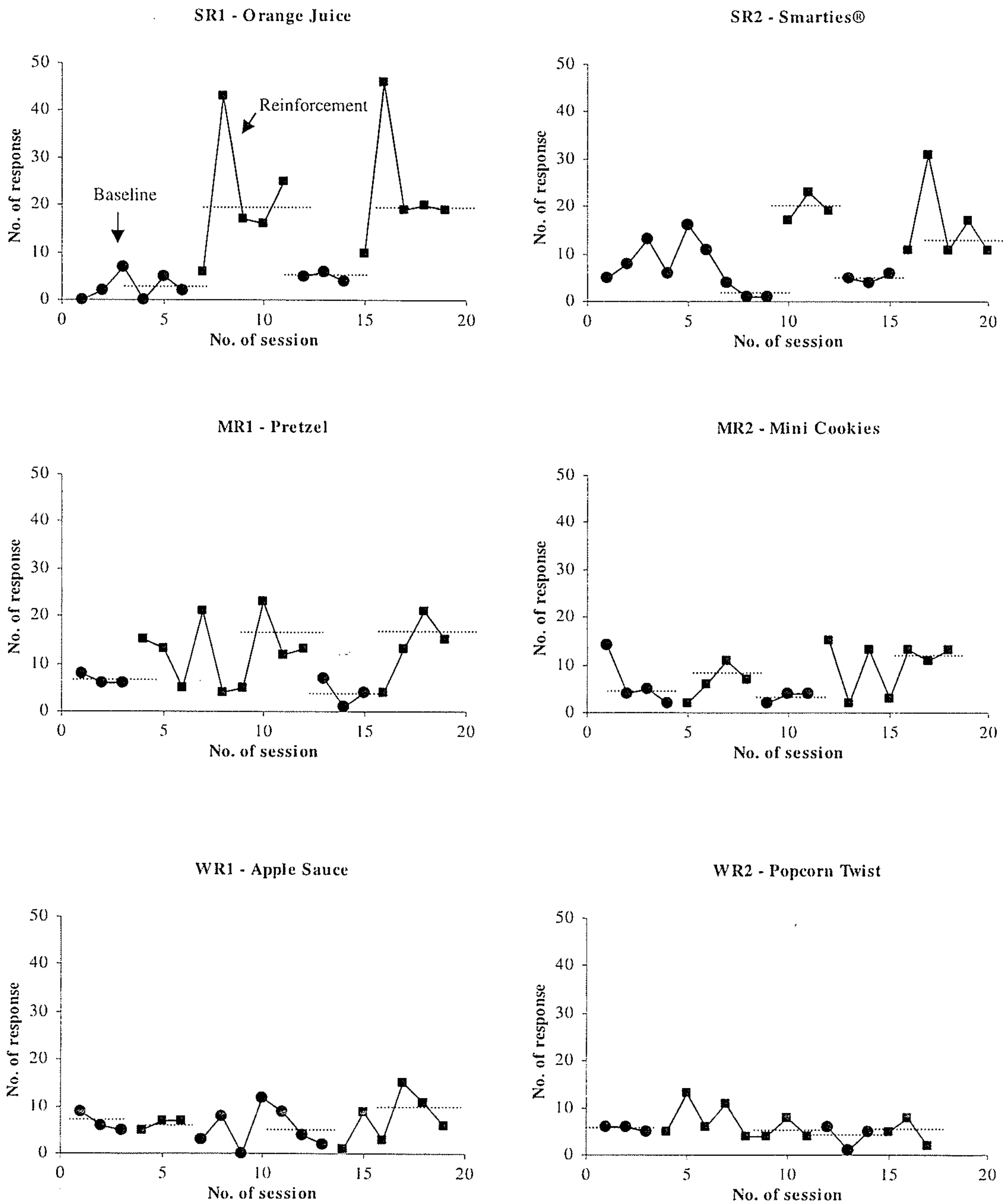
Appendix A
Reinforcer and Preference Values

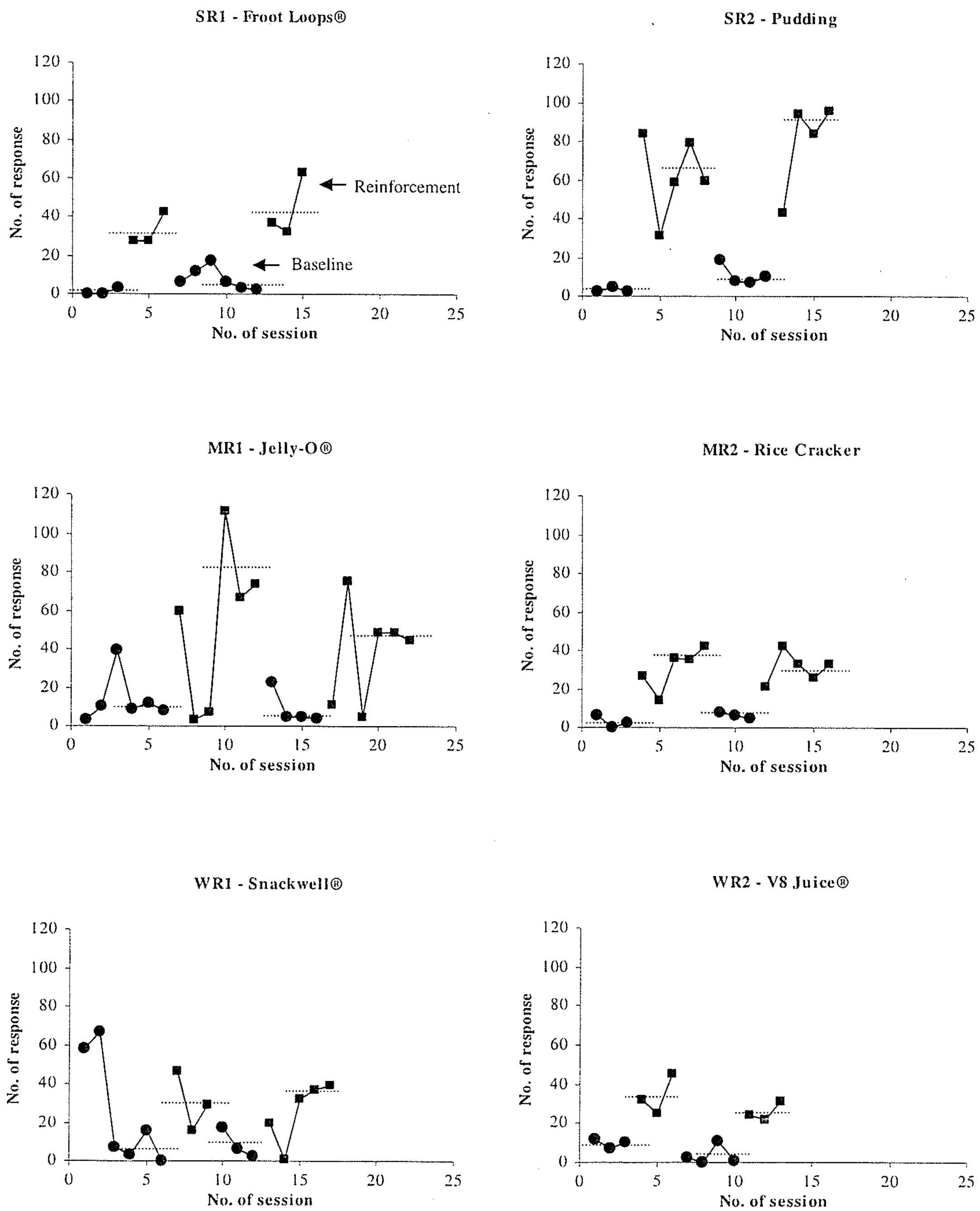
Stimuli[a]	Mean Responses per Min[b]		Derived Reinforcer Values[c]	Preference Values[d]		
	Baseline Phases	Reinforcement Phases		Switch	No Switch	Switch
Participant 1						
SR1-Orange Juice	3.7	19.3	427.3	62	80	60
SR2-Smarties®	3.5	16.3	366.7	42	60	48
MR1-Pretzel	5.3	16.2	203.3	40	20	48
MR2-Mini Cookies	3.5	10.2	190.5	40	48	36
WR1-Apple Sauce	5.8	8.5	45.7	38	44	60
WR2-Popcorn Twist	4.8	5.2	6.9	54	46	44
r with reinforcing value				.41	.60	.41
Participant 2						
SR1-Froot Loops®	2.3	38.5	1550.0	58	70	
SR2-Pudding	5.7	78.7	1288.2	50	22	
MR1-Jelly-O®	7.2	65.8	818.6	46	32	
MR2-Rice Cracker	4.5	34.2	659.3	38	56	
WR1-Snackwell®	7.3	33.2	352.3	64	86	
WR2-V8 Juice®	6.8	29.8	336.6	44	34	
r with reinforcing value				.31	–.20	
Participant 3						
SR1-Cheese	8.7	105.2	1113.9	52	80	
SR2-Gold Fish Cracker	8.0	92.8	1060.4	48	68	
MR1-Pretzel	4.2	33.2	696.0	54	50	
MR2-Popcorn Twist	5.5	38.7	603.0	44	42	
WR1-Froot Loops®	6.8	12.5	82.9	54	60	
WR2-Jelly-O®	6.0	9.0	50.0	46	0	
r with reinforcing value				.20	.83	

[a] SR = strong reinforcer, MR = moderate reinforcer, WR = weak reinforcer. [b] Last 3 sessions during each phase except during one phase for Participant 3, SR1, which had two sessions. [c] Defined as mean percent increase in response rate over baseline. [d] Defined as percent of trials selected during preference assessments.

Appendix B
Session by Session Data During Reinforcer Assessments for Participant 1

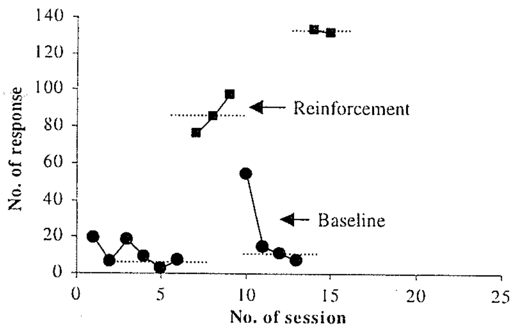


Appendix C
Session by Session Data During Reinforcer Assessments for Participant 2

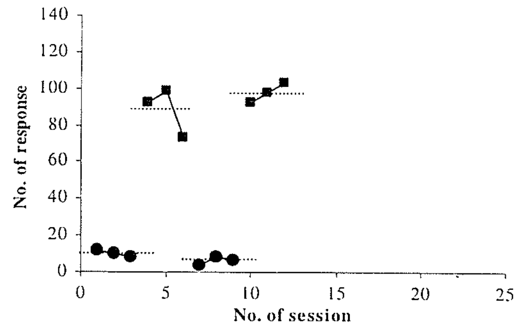


Appendix D
Session by Session Data During Reinforcer Assessments for Participant 3

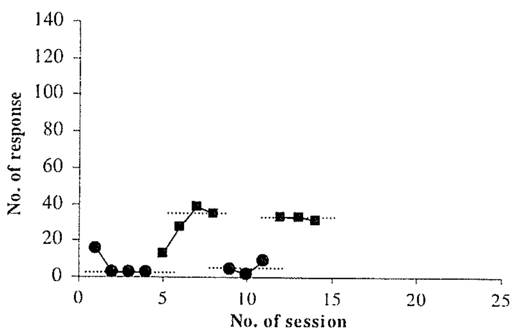
SR1 - Cheese



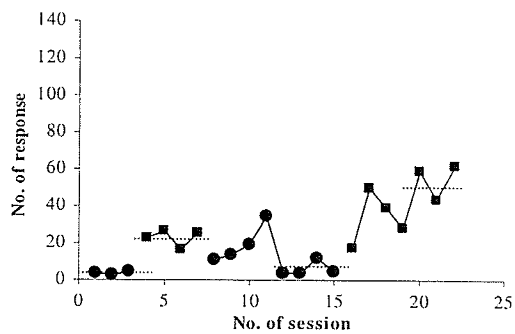
SR2 - Gold Fish Cracker



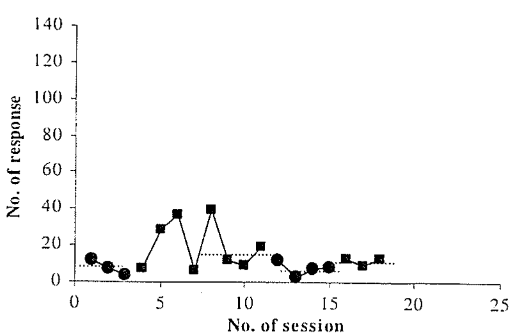
MR1 - Pretzel



MR2 - Popcorn Twist



WR1 - Froot Loops®



WR2 - Jelly-O®