AN EVALUATION OF DEMAND FUNCTIONS FOR ATTENTION AND FOOD

IN CHILDREN WITH AUTISM

by

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ABSTRACT

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Utah State University, 2015

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Social deficit is one of the core symptoms of autism. The current research provides evidence for social deficits in autism, but limited work exists on addressing these deficits with better diagnostic tools and treatment. Approaches borrowed from other fields could assist the understanding of social deficits in autism. This study integrates the current research on social deficits of autism with methods from behavioral economics and investigates the reinforcing properties of social attention. We examined the use of demand functions to describe differences between behavior reinforced by food, and behavior reinforced by attention in children with autism. Several previous studies have identified systematic scalar differences in reinforcer value across different classes. This study extends these findings by examining differences in essential value, or how the behavior reinforced by food and attention changes as the price of those commodities increases. Prior to the assessment of the essential value, we identified preferred food items using paired-preference assessment. To identify preferred form of attention, we applied a modified version of paired-preference assessment. Next, the identified stimuli were delivered on fixed-ratio schedules. Response requirements on the ratio schedules were manipulated across sessions in an increasing sequence. In all participants, the results showed systematic changes in the reinforcers earned (consumption) and response-rate as a function of ratio requirement. For three of the participants, the rate of change in consumption of food and attention appeared notably different.

(67 pages)

PUBLIC ABSTRACT

An Evaluation of Demand Functions for Attention and Food in Children with Autism

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The dominant approach to treating social dysfunction in individuals with autism views that dysfunction as a skill deficit. However, another plausible interpretation is that social dysfunction in some individuals arises from motivational deficits. The proposed study presents a method to assess motivational deficits for social attention in individuals with autism. By borrowing methods from behavioral economics, we assessed the essential value for social attention and compared it to the essential value for food.

Five individuals diagnosed with autism were included in the project. First, we assessed preference for food by using paired-preference assessment. To identify preference hierarchy for attention, we used a modified version of the paired-preference assessment. After establishing the preference hierarchies for food and attention, the top items from each category were delivered on a fixed-ratio schedule. During this reinforcement assessment the participants received one reinforcer every time they emitted the target response. The final stage of the study included the assessment of the essential value for each of the two commodities (food and attention). During this stage, we increased the number of responses participants were required to emit to earn a reinforcer across each daily session. All of the participants showed a decrease in reinforcers earned as the work requirement increased, and for three of the participants the essential value of food appeared noticeably higher than that of attention.

Using the methods from behavior economics allowed the comparison of two commodities that differed in nature, and assisted capturing the important qualities of these potential reinforcers. These results suggest that behavioral economic-based assessments of reinforcer value may have clinical utility.

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Bistra K. Bogoev

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CHAPTER I

INTRODUCTION

Autism spectrum disorder (ASD) is one of the five disorders under the category of "Pervasive Developmental Disorders" (PDD) according to the American Psychiatric Association (APA, 2013), and it occurs in approximately 1 of 68 births (Centers for Disease Control [CDC], 2014). It is characterized by both general and core symptoms. Social deficit is one of the core symptoms of autism. The current literature provides evidence for social deficits in autism, but limited research exists on targeting these deficits with better diagnostics and treatment. There is also limited understanding of what contributes to the social impairment. From a behavioral perspective, it might look as though some of the deficits occur because the degree to which individuals with autism find social interaction reinforcing is decreased. To assess the reinforcing value of social interaction, several methods can be used. A method borrowed from behavioral economics for assessing essential value seems well suited to achieve this goal. This method uses demand curves to illustrate how reinforcer consumption changes with manipulation of the price as arranged using different ratio schedules. Also, this method permits the evaluation of reinforcers of differing nature. Utilizing the aspects of this method will contribute to better assessment of attention as a reinforcer. It may be possible to detect to what extent social reinforcement is valuable to individuals with autism on its own, as well as when compared to other reinforcements (e.g., food).

This study integrated the current research on social deficits of autism with methods from behavioral economics and investigated the reinforcing properties of social attention while comparing them to the reinforcing properties of food.

CHAPTER II

LITERATURE REVIEW

Background and Significance

Features of Autism

ASD typically appears during the first 3 years of life. It occurs approximately in 1 of 68 births (CDC, 2014), and it is one of the five disorders that fall under the category of PDD, a category of neurological disorders characterized by severe and pervasive impairment in several areas of development (APA, 2013). The impact on society is substantial: The estimated annual cost of autism in children is $66 billion, with an additional $175 billion spent on adults. The overall lifelong cost of individuals with autism is estimated at $2.4 million per person (Ostrow, 2014). However, cost of lifelong care might be reduced with early diagnosis and intervention. Some of the treatments for autism involve alleviating the symptoms of co-morbid conditions, including sleep disturbances, attention deficit/hyperactivity disorder (ADHD), gastrointestinal problems, anxiety, depression, and epilepsy. In general, symptoms and deficits associated with autism could be divided into two categories: general symptoms and core symptoms.

General symptoms. Obsessive interests, stereotypy, echolalia, and delayed speech/language skills are symptoms of autism and are evident in other developmental disorders as well. Matson and Nebel-Schwalm (2007) described major depression, bipolar disorder, anxiety, phobias, and obsessive compulsive disorders (OCD) as comorbid psychopathology in autism. Some of these disorders exhibit the aforementioned deficits; therefore, these deficits could be considered as general symptoms.

Core symptoms. There is a group of symptoms that is specific to autism, and this symptom group serves as the primary diagnostic tool for autism. From early on, individuals with autism fail to respond to their name, make less frequent and abnormally timed eye contact, or fail to show empathy (APA, 2013). Later on, these individuals show a decline in appropriate social behavior (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998). Social behavior encompasses several skills that include orienting to social stimuli, eye contact, joint attention, and facial recognition. Various fields of psychology have conceptualized these group differences as theory of mind, creativity, pretend play, visual-spatial tasks, and eye gaze (Craig & Baron-Cohen, 1999; Korkmaz, 2011). Deficits of these skills could impede proper social development in individuals with autism.

Behavior analysts have also characterized differences between individuals with autism and individuals without. From a behavioral-analytic point of view, these deficits may be conceptualized as a stimulus control deficit (Dube, MacDonald, Mansfield, Holcomb, & Ahearn, 2004). For example, “overselectivity” or attention to irrelevant features of the environment is observed frequently in individuals with autism. Another way to conceptualize differences in individuals with autism is in terms of sensitivity to contingencies (Dube & McIlvane, 1999; Mullins & Rincover, 1985). Individuals with autism may not be sensitive to subtle differences in reinforcement frequency in choice situations. Similarly, it may be possible that problems in the acquisition and maintenance of social skills are at least in part due to deficits in the degree to which social interactions function as reinforcers.

Acquisition of social skills might be related to a failure to orient toward social stimuli. Dawson and colleagues (1998) suggested that failure to orient toward social stimuli could occur as early as 5 months, and can serve as a precursor to the development of joint attention. Joint attention is the ability of a person to initiate pointing, or to follow eye gaze towards an object or person. Dawson and colleagues (2004) even suggested that a good way to identify children with autism is to assess their ability to orient toward social stimuli. More support for failure to orient toward social stimuli comes from Annaz, Campbell, Coleman, Milne, and Swettenham (2012), who suggested that a failure to attend to socially relevant stimuli might come from lack of interest in people rather than to the ability to attend to a specific stimulus. Perhaps attending to social stimuli does not offer as much reinforcing value as it offers to typically developing people. Failure to maintain social skills can be attributed to the fact that individuals with autism might not find social interaction reinforcing.

So far, the aforementioned studies point out autism-specific deficits in the area of social communication. However, as much as these studies are designed to detect and assess deficits in autism, they fail to answer the questions of why individuals with autism exhibit social skill deficits. In order to assist the development of social skills, we need to understand the importance of social reinforcement in individuals with autism. Social reinforcement is a conditioned reinforcer that occurs in almost all natural settings. If social attention is identified as a potential reinforcer, it can serve as a powerful tool in skill acquisition and treatment of problem behavior in individuals in which other types of reinforcement maybe contraindicative. Understanding the role and the possible reinforcing properties of social attention in individuals with autism will further assist in teaching these individuals the necessary skills to act in a socially appropriate way by using social attention as a potential reinforcer. One way to find out if social attention can serve as a potential reinforcer is to assess the reinforcing value of social interaction. Such research is important given the potential relevance for individuals with autism, who may not prefer commonly occurring forms of social interaction.

Assessing Reinforcing Value

Several methods exist for assessing reinforcer value. One approach was to simply measure the rate of a single response under conditions in which a reinforcer was made available following completion of that response. However, this method can be misleading, because the response rate can be affected directly by the type of schedule of reinforcement (Ferster & Skinner, 1957; Morgan, 2010), even though the rates of the schedules are the same (e.g., FR10 vs. VR10). In addition, ceiling effects may obscure subtle differences in reinforcer value.

In concurrent-operant procedures, which involve arranging choices between two or more options, the relative reinforcer value is inferred from the percent of selections toward each of the alternatives. Herrnstein (1961) showed that response allocation on concurrent schedules was well described by the matching law. The law predicts that the proportion of choices of a given alternative matches the proportion of reinforcement, out of the total reinforcement earned, that are obtained by responding on that alternative. Furthermore, the framework accommodates scalar differences in reinforcer magnitude and quality. Thus, Herrnstein (1970) showed that relative response rate is more sensitive to changes in reinforcer rates than it is in a single-operant procedure. The key of this method is that instead of measuring the absolute value, as in single operant procedure, it measures the relative value of the reinforcer. However, this could be problematic when comparing two different types of commodities, because preference can shift if response requirement is changed (Bickel & Madden, 1999). This method of reinforcement assessment can be also problematic because some populations are not sensitive to the arranged contingencies (Mullins & Rincover, 1985); therefore, the percent of selections toward one option could be an unreliable indicator of the reinforcing value.

In the progressive-ratio procedure, originally described by Hodos (1961), response requirements increase within a session after each reinforcer delivery and the last response requirement completed by the subject can be indicative of the value of the reinforcer. Breakpoint is a useful measure, but it does not illustrate the response rate at each the organism responds for different ratio requirements. If two commodities are compared, the breakpoint provides information about the response requirement at which the organism quits responding; however it is unknown if the organism responds more readily for one commodity than another at other schedule values. Poling (2010) described the use of progressive-ratio schedules in applied setting along with some potential shortcomings when progressive schedules are implemented. Possible procedural considerations that might affect the outcome when using progressive-ratio schedules can depend on the type of target response, or on the initial schedule value, or step-size progression (Roane, 2008). So far there is not an established algorithm for determining the initial schedule value and step size.

Another way of assessing reinforcer value is by using methods from behavioral economics. In behavioral-economic approaches, the value of a commodity is inferred from the consumption of the commodity at a number of different prices (Hursh, 1991). When consumption is plotted as a function of the price, the function is called a demand curve. For example, Hursh investigated two commodities, food and saccharine and plotted consumption of these commodities as a function of price as determined by a fixed ratio. The results showed that when prices are low, consumption of goods is the same across commodities, but as the price increases the consumption of saccharin decreases much more rapidly than the consumption of food. In addition, Hursh illustrated the response output, plotted as a function of the price. As the price increases, more responses are required to obtain a certain amount of reinforcer.

Hursh and Silberburg (2008) used demand curves to show how reinforcer consumption changes with manipulation in the price that different ratio schedules require. They suggested a model for assessing the essential value of reinforcers by using the exponential-demand equation $\log Q = \log Q_0 + k(e^{-\alpha Q_0 C} - 1)$, where Q is the quantity consumed, Q_0 is the highest level of consumption at price 0, *k* is a constant that specifies the range of the dependent variable, α (alpha) reflects the essential value, and C is the varying cost of the reinforcer. Essential value determines the consumption level that is expected at particular prices, and what the response rate is expected to be in order to obtain that reinforcer.

This model is advantageous because it distinguishes between the scalar and essential values of a particular reinforcer. It permits comparing reinforcers that are of a different nature, not just by the rate of occurrence. Here, the term scalar value refers to the raw number of reinforcers consumed at a particular (usually low) price. For example, if I were to find a bowl of fresh cherries on my desk around lunchtime, I might eat 200 g worth. Alternatively, if I were to find a bowl of ice cream, I might eat 600 g worth. Thus, in scalar terms, ice cream appears to be worth approximately three times as much as cherries. However, the difference between ice cream and cherries is intuitively more complex than by what is captured by scalar value. At least one aspect of value that is not captured by scalar value is the degree to which an individual might defend the level of consumption of a commodity in the face of increasing prices. This idea represents what Hursh and Silberberg (2008) referred to as essential value. Differences in scalar value appear as differences in Q_0, and differences in essential value appear as differences in alpha.

The strength of using this approach from behavioral economics is that it reveals differences between commodities that might not be apparent at individual prices, whereas all the approaches mentioned previously were able to detect differences at a single price. It is clinically important to understand the essential value of different commodities that might potentially serve as reinforcers. It is possible that individuals with autism have a higher response rate at lower prices for one commodity, but as the price increases, the response rate for the alternative commodity increases. In other words, preference for one commodity over another might change following an increase in price. Clinically, this is important because reinforcers with lower essential value could be potentially used in teaching smaller tasks, whereas reinforcers with higher essential value can be used for managing severe problem behavior, or acquisition of lengthy and complex tasks. More importantly, this approach could be used in assessing the essential value for social interaction in individuals with autism, where the anecdotally adopted notion is that social interactions are of no value. It is possible that social interaction is not preferred when the response requirement is too high, but still preferred over other commodities when the response requirement is lower. Another possibility is that social interaction is “overshadowed” by other commodities, commonly used with special populations (e.g., food). It might be that social interactions can serve as potential reinforcers when assessed adequately.

Assessing Reinforcing Value of Social Interaction

Several studies have attempted to assess the reinforcing properties of social interaction in special populations. Smaby, MacDonald, Ahearn, and Dube (2007), assessed relative reinforcing efficacy of three different social stimuli (praise, head rubs and tickles) by using single-operant assessment. Subjects were taught to hand a plastic chip to an experimenter to earn each social consequence. For one of the participants, the defined response was placing a hand in the experimenter’s hand (“low five”). The results demonstrated and identified a social consequence for each of the three children. For two of these children, one of these social consequences was shown to be of no particular value. One disadvantage of the Smaby and colleagues’ (2007) study was that each social consequence was assessed using a single-operant schedule of reinforcement. As was mentioned previously, response rates under this arrangement may not be sensitive to subtle differences reinforcing value. It is unknown, if a higher response requirement would have sustained responding for social consequence. Another weakness of the study was the inconsistent session termination criteria within (e.g., extinction), and between (e.g., extinction and social consequence condition) conditions. It is unclear if the same results would have been obtained if all of the conditions were same in length. In addition, the session duration for social preference is questionably short (1 minute), to produce sufficient responding. It is possible that longer duration of exposure to social consequences would have established a different preference hierarchy.

Nuernberger (2012) investigated preference for social interaction using multiple stimulus preference assessment without replacement (DeLeon & Iwata, 1996), followed by a reinforcement assessment arranged under single-operant schedule to determine if the stimulus preference assessment accurately predicted whether the social interactions functioned as reinforcers. All of the three participants in the study were diagnosed with autism. The advantage over the Smaby and colleagues' (2007) study was that the length of baseline and the length of the reinforcement assessment were the same. In addition, the session lasted 5 minutes, allowing sufficient time for responding. Another interesting approach was that the selected response choices for each of the participants were not taught prior to the assessment, but they were already part of their repertoire acquired in therapy. The results showed that for one of the participants responding under the reinforcement assessment, when compared to baseline, increased for his highest preferred choice. In contrast, for the other two participants, responding during the reinforcement assessment did not increase for the highest preferred item. For one of the participants, the increase in responding occurred when the second choice from the hierarchy was arranged as a consequence, and for the third participant responding was not highly distinguishable between the arranged choices. This study was able to establish clear preference hierarchy for two of the participants using multiple stimulus without a replacement preference assessment (MSWO). The reinforcement assessment suggested that preference assessment might be predictive of the outcome of the reinforcement assessment, and that most of the social interactions can possibly serve as reinforcers. Another interesting finding was that some of the identified less preferred social interaction could serve as reinforcers as well. The limitation of this study was that all of the assessed items were thought to be preferred, therefore the results from the preference assessment hierarchy were not definitive.

In support that low- or medium-preferred stimuli could serve as reinforcer comes from Glover, Roane, Kadey, and Grow (2008). This study, even though it did not have a primary target to assess social attention, found that during a concurrent arrangement of reinforcing, responding for attention was close to zero for one participant, but when social attention was presented on a single FR schedule, the participant emitted the maximum number of responses in most of the sessions, suggesting possible reinforcing properties for social attention. As Roscoe, Iwata, and Kahng (1999) suggested, when dealing with reinforcers of different nature (e.g., attention vs. tangible), single operant arrangement might be more suitable, because concurrent arrangements are not sensitive to the absolute reinforcement effect associated with less preferred stimulus (e.g., social attention).

A creative way to assess social interaction was offered by Call, Shillingsburg, Bowen, Reavis, and Findley (2013). The study used a concurrent operant arrangement to evaluate if social interaction served as a positive reinforcer, negative reinforcer, or a neutral stimulus for individuals with autism. In three experimental conditions “stay,” “follow,” and “leave,” the percentage of time participants allocated to the social interaction and no-interaction sides served as a primary dependent variable. One of the participants demonstrated a preference for social interaction. For five of the participants’ social interaction was a neutral stimulus. This study’s approach has attempted to identify the functional properties of social interaction in individuals with autisms. However, as suggested by the authors, the dichotomous nature of the concurrent operant might have limited the findings, because it focused on the categorical characterization of the properties of social attention. They suggested that other measures of reinforcing efficacy (e.g., responding under progressive ratio schedules) might be more appropriate and allow for a more dimensional estimate of preference for social interaction.

Summary and Purpose

Results from the aforementioned studies conclude that social interaction may serve as a potential reinforcer. However, it is unclear to what extent social interaction is reinforcing in individuals with autism when compared to other, possibly more potent, reinforcers. In addition, it is unclear if differences in reinforcing value between social interaction and other reinforcers are similar in individuals with autism and in typically developing people. The proposed study uses demand functions (Hursh & Silberburg,

2008) for describing differences between behavior that is reinforced by attention and behavior that is reinforced by food. In addition to the studies describing systematic scalar differences in reinforcer value across different classes, this study examines the essential value for attention and food in individuals with autism. In other words, how responding behavior reinforced by food or attention changes when the price requirement for these commodities increases. The study provides an orderly data by using behavioral economic approaches for clinically relevant commodities. Demonstrating the utility of a behavioral economic paradigm for measuring reinforcer value in children with autism may be the necessary first step in answering the question of whether social attention is less reinforcing than food for people with autism, and if this difference is larger than in people without autism. It may also serve a means for obtaining baseline levels of the value of social interactions prior to early intensive behavioral intervention.

CHAPTER III

METHODS

Participants

Five children who were currently attending an early-intensive behavioral intervention program (ASSERT) on the Utah State University campus were recruited to participate in the study. All had previously been diagnosed with autism. Their ages varied from 3 to 5 years. Arlo, Danny, Michelle, and Simon could communicate using three or more words per sentence. One of the participants, Barstow, could communicate by pointing or using single words. All participants were ambulatory and engaged in some kind of vocal or motor stereotypy. There were no dietary restrictions for any of the participants except Michelle, who had banana and milk products intolerance. All of the participants were able to follow simple instructions. All of the participants had a history of receiving edible reinforcers and social attention in the form of praise after engaging in a desirable behavior as part of the programmed activities in the preschool program.

Phase 1: Preference Assessments

The purpose of Phase 1 was to identify high-preferred forms of food and social attention using separate preference assessments. Prior to the food assessment, we interviewed the parents/caregivers to identify and approve food items that might be favored by the participants. An analogous interview was conducted to identify possible kinds of social attention that might be favored by each of the participants.

During Phase 1, two different size rooms were used. Preference assessments for food were conducted in the children's cubicles, which were 2.5 m x 3.5 m and equipped with a small table and two child-sized chairs. No other items, besides the items used for the preference assessment, were placed on the table. Preference assessments for social attention were conducted in a 5 m x 7 m room that was equipped with one table. For each of the participants, the two preference assessments were conducted on separate days.

Food Preference Assessment

Seven to nine food items previously identified by the parents or caregivers were used during the Paired Stimulus Preference Assessment (Fisher et al., 1992). At the beginning of the assessment, the participant and the investigator were seated at a small table across from each other. Before the actual assessment began, the participants were invited to try the food items, one at a time. The time between each invitation to try was approximately 30 seconds. During the actual assessment, food items were presented in pairs and placed simultaneously on the table in front of the participant. The participant was invited to choose between the two items after the investigator said "Pick one!" The choice was considered complete after the participant had touched the food item. If participants did not approach the food items in 10 seconds, "No Response" was recorded, and the food items were removed from the table. The assessment continued until every combination of food items was presented twice. Items were ranked according to the percentage of times they were chosen by the participant out of the number of times they were available for selection.

Two independent observers, the therapist and a second observer, recorded which food item was chosen during each choice trial. Data from both observers were examined and compared on a trial-by-trial basis. The agreement between the two observers was 100% for all of the participants.

Attention Preference Assessment

Four forms of attention were selected based on the recommendation of the parents/caregivers of the participants, and a Paired Stimulus Preference Assessment was conducted following the procedures described by Clay, Samaha, Bloom, Bogoev, and Boyle (2013). Each form of attention was assigned and delivered by a different therapist in six blocks, five trials per block. After completing the six blocks, a tracking test was performed. Each form of attention included both a physical and a vocal component. For example, “tickles” involved a therapist tickling the participant for 2 seconds or less while saying “Tickle, tickle, tickle.” The first block of the assessment started with initial pre-exposure to the type of attention the participant was about to experience. One therapist was standing behind the participant in the middle of the room facing the wall, in the corner of which another therapist was standing ready to deliver the assigned form of attention. The therapist standing behind the participant gently guided the participant toward the therapist in the corner. When the participant was within 1 meter of the therapist in the corner, that therapist delivered the assigned form of attention. This pre-exposure to the form of attention was repeated with the other therapist and another form of attention. After the pre-exposure, the two therapists, delivering the two forms of attention, stood in the two corners at the same time. The participant was guided to stand in the middle in approximately 3 meters from both therapists. Next, the participant was invited to choose one form of attention by hearing the therapist behind him to say, “Pick one!” Then the participant independently approached one of the therapists to receive the form of attention. In the next trial, the two therapists switched places, but continued to deliver the assigned form of attention. This process was repeated five times. Prior to the next block of five trials, the pre-exposure occurred again, but this time with a new combination of therapists and forms of attention. This procedure was repeated for all six blocks.

After the completion of six blocks, the tracking test took place. First, we calculated the percentage of trials for which each form of attention was selected, and based on that selected the lowest and the highest preferred form of attention to use in the tracking test. To see if participants’ choices were under the control of the form of attention as opposed to idiosyncratic features of a particular therapist, the therapist that delivered the highest-preferred form of attention now delivered the lowest preferred form of attention. Conversely, the therapist who previously delivered the lowest-preferred form of attention now delivered the highest-preferred form of attention.

Two independent observers recorded the choices of the participants as well as the side (left or right) at which a particular form of attention was delivered. After completion of the assessment, they calculated the percentage at which the forms of attention were selected. In addition, side bias was monitored as well. The two observers had 100% agreement and side bias was not observed.

Phase 2: Reinforcement Assessment

After identifying the preferred edible and the preferred form of social attention in Phase 1, it was necessary to determine the reinforcing efficacy of these stimuli.

Participants and Settings

All of the participants from Phase 1 also participated in Phase 2. Phase 2 was conducted in the participants' cubicles, measuring 2.5 m x 3.5 m. The cubicles were equipped with a small table and two child-size chairs.

Apparatus

Two white round keys, 8 cm in diameter, mounted on a 20 cm x 40 cm wooden box, served as response keys during sessions. Responses on the keys closed a circuit on an XBee wireless transceiver that was paired with a corresponding transceiver attached to a nearby laptop. A program written in Processing served to recorded time-stamped responses and signaled to the therapist wearing a Bluetooth earpiece when the programmed schedule of reinforcement had been met. The apparatus was tested prior to each session to make sure the correct schedule of reinforcement was in place and to ensure both the apparatus and Bluetooth earpiece were paired correctly with the laptop. The two-key box was placed on the table in front of the participant prior to the start of each session.

Procedure

Phase 2 consisted of response training followed by a no-reinforcement baseline

(BL) and an FR1 phase. The former two conditions were then repeated for each stimulus type. The order in which each stimulus type was introduced was counter-balanced among the participants. For Danny, Arlo, and Simon, we introduced food first, followed by attention, while for Barstow and Michelle; attention was introduced first, followed by food.

Response training. On day one, the participants were seated behind a table and the two-key box was placed in front of them. It remained there for 5 minutes. Participants were left to interact with the box, pressing the keys as they wished. The accumulated data from this test were analyzed to determine if the child exhibited any side preference and to identify the combination of key pressing that occurred least (e.g., left, left, right). If the participant did not have a preference for the left or right key, an arbitrary key was assigned as their required response. In cases in which the child had side bias, the opposite key was used as their required response. If the participants emitted a high rate of key-pressing, the data were examined closely to identify simple but rare sequences (e.g., left, left, right) to serve as the descriptive operant in subsequent phases.

Baseline (BL). During baseline, the two-key box was placed in front of the participant, and it remained there for the length of the session (5 minutes). The session started with the investigator pressing the assigned key and saying, “When you do this, nothing happens.” During BL, responses on the keys did not result in programmed consequences and no reinforcer was delivered. This phase continued for at least three consecutive sessions of values below 0.4 responses per minute (RPM).

Fixed-ratio 1 (FR1). Similarly, during FR1, the two-key box was placed in front of the participant for the entire session. The session began with the investigator pressing the assigned key and saying: “When you do this, you will get this.” Depending on the particular phase, the participants received an edible or a form of social attention following completion of the FR-1 schedule requirement. Each session was 5 minutes and was conducted once per day during the same time of the day. This condition continued until it reached stability. Stability was determined by an observation of at least 5 sessions of 5.0 or above RPM.

Phase 3: Demand Assessment (Essential Value)

The purpose of Phase 3 was to compare the essential value of the two stimuli (attention and food) by using an ascending sequence of ratio schedules that were incremented across daily sessions.

Participants and Settings

All of the participants for whom we identified one preferred stimulus from each class (of food and attention; Phase 1) and who demonstrated a reinforcement effect when those stimuli were presented following the occurrence of a response during Phase 2 continued onto Phase 3. One of the participants (Danny) did not participate in the essential value assessment for social attention, because there was no responding during Phase 2 (reinforcement assessment). We used the same settings described for Phase 2. The two-key box was placed on the table in front of the participant and recorded the participants’ responses.

Procedure

The participants underwent two demand assessments with two ascending sequences, one for food and one for attention. Sessions were 5 minutes and conducted once per day. The order in which participants were assessed was counterbalanced. Some of the participants started the demand assessment for attention, while others started with the demand assessment for food. Each day we increased the fixed value (e.g., FR1, FR2, FR4, FR8, where FR doubles each day). The assessment was terminated when the participant either stopped responding or failed to emit enough responses to satisfy the following day's ratio requirement. Next, we restarted the assessment with the other stimulus.

Each session started with the investigator placing the two-key box in front of the participant. After the participant fulfilled the schedule requirement for the particular session (e.g., FR32), the investigator received audible feedback and delivered the edible reinforcer and removed the response apparatus. After, the consumption of the reinforcer, the apparatus was returned to its original position on the table. The demand assessment for attention was identical to the demand assessment for food, except that instead of food, the investigator delivered the most preferred form of attention.

CHAPTER IV

RESULTS

Phase 1: Preference Assessments

In Phase 1, we identified highly preferred forms of food and social attention, using separate preference assessments. All of the participants demonstrated a clear hierarchy of preference for food and attention ranging from 0% to 100% selection.

Results from each participant from the food preference assessment are depicted in Figure 1. For Barstow, *Ruffles*® were selected every single time they were presented (100%), while pretzels and *Teddy Grahams* were not selected on any occasion. For Michelle, the highest preferred edible was *Cheetos*® (80%), and the lowest preferred was *Hershey's® Cookies'n'Cream* (0%). *M&Ms*® were the top choice for Danny (100%), whereas cookies was not selected at all (0%). For Arlo, the highest preferred item was *Reese's® Mini Cups* (100%), while gummy bears were not selected (0%). For Simon, the highly preferred edible was jelly beans (100%), and the lowest preferred was potato chips.

Figure 2 shows results from the preference assessments for attention. All five participants showed a preference hierarchy of attention. "Tickles" was the highest preferred form of attention for Barstow (53.3%); whereas, "Rocket Man" was the highest for Michelle (80%). Danny selected "Lift" 100% of the time, and for Arlo "Noodle arms" was selected 73% of the time. For Simon, the highest preferred form of attention was "Rocket man" (80%).

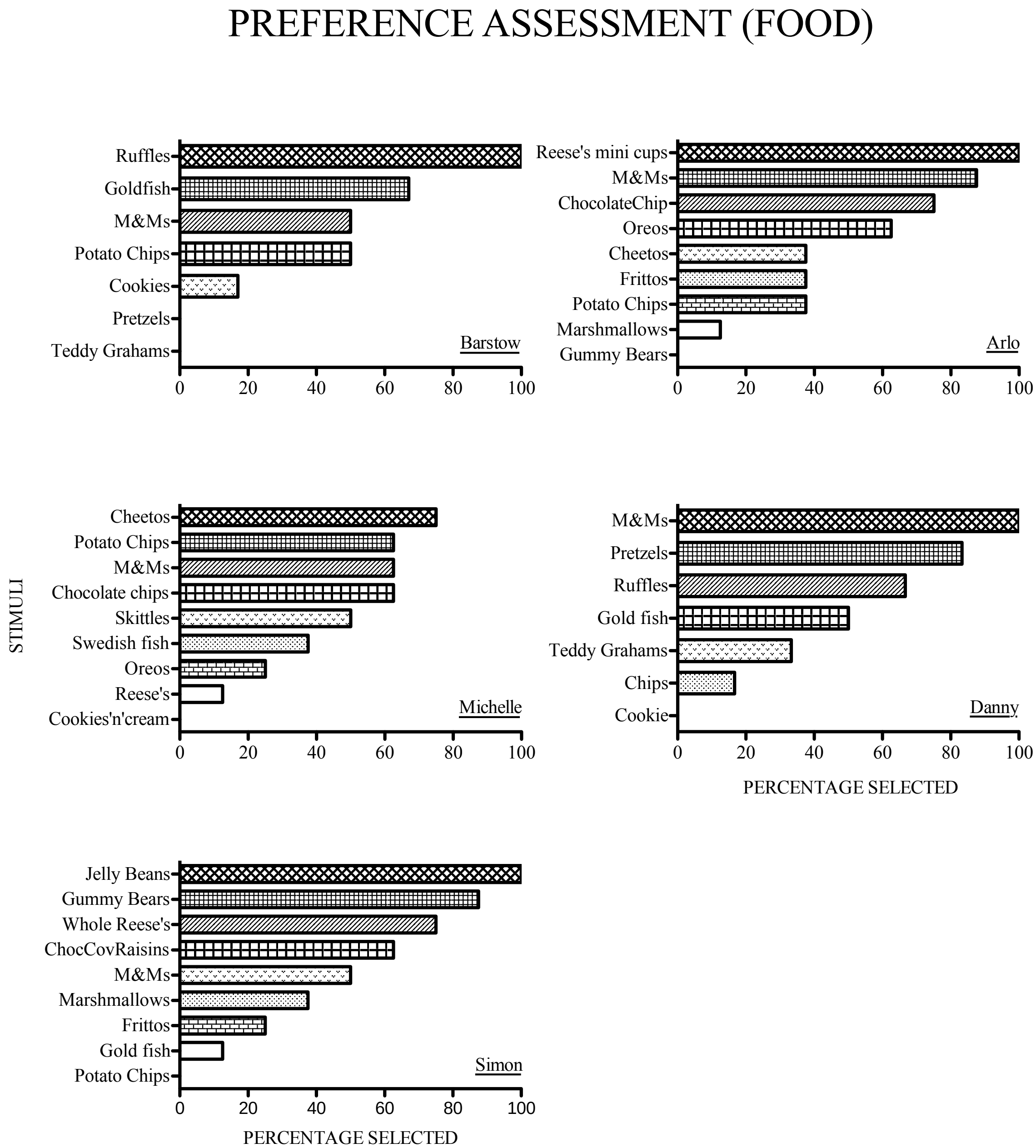


Figure 1. Results from Phase 1 (paired stimulus preference assessment for food). All participants, except for Michelle, had chosen their top choice 100% of the time. Michelle chose *Cheetos* as her top choice 80% of the time.

PREFERENCE ASSESSMENT (ATTENTION)

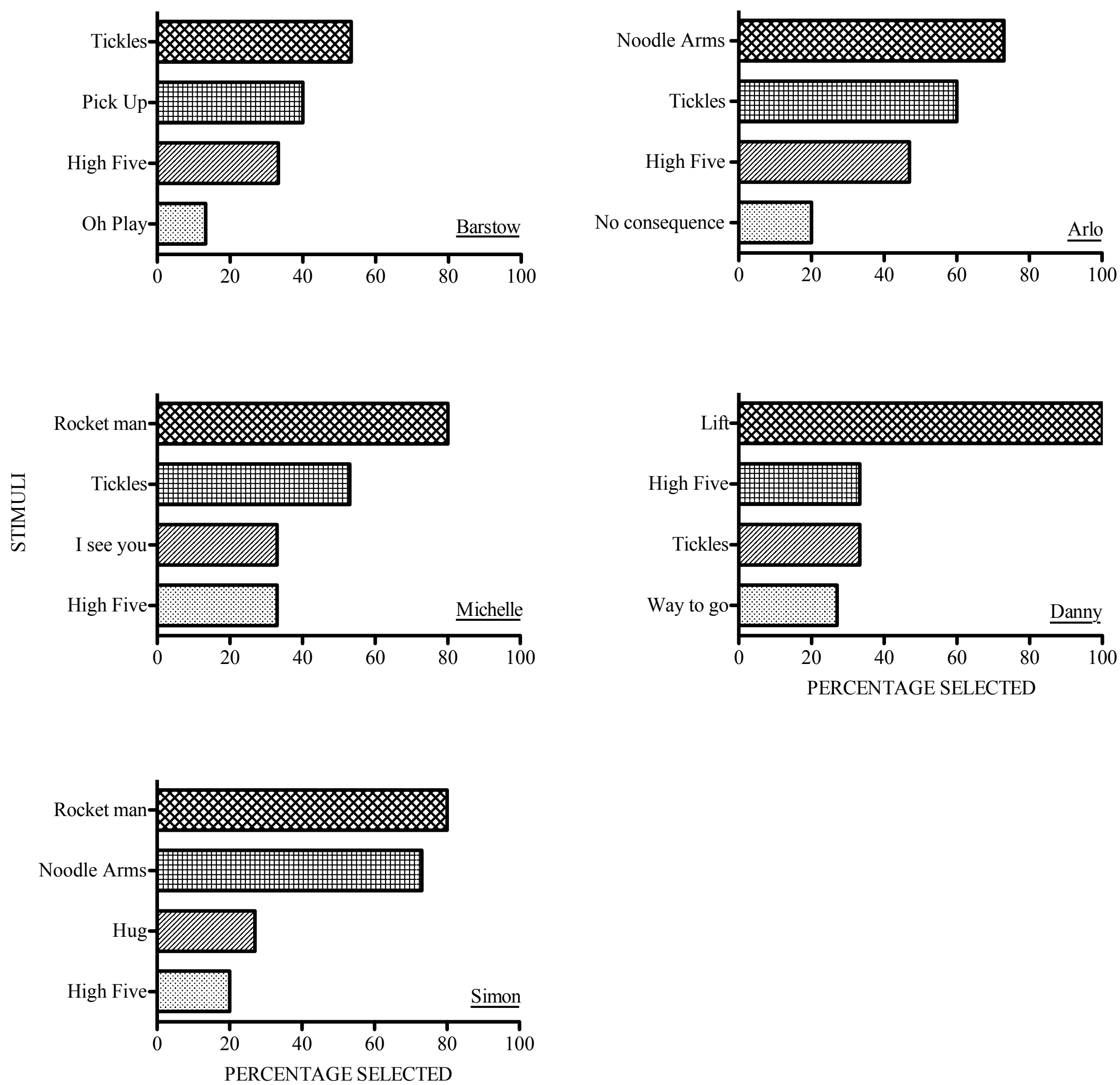


Figure 2. Results from Phase 1 (paired stimulus preference assessment for attention). Data indicates the percentage of selections each of the participants made for any given form of attention.

After establishing preference hierarchies for attention, we conducted tracking tests. Figure 3 shows that all participants tracked the form of attention, as oppose to the person delivering the form of attention. The first trial block (BL) shows participant selections during trials from the initial preference assessment, while consecutive trial blocks represent selections during the tracking test. The closed data path depicts the highly preferred form of attention, while the open path depicts the lowest preferred. For Barstow, “Tickles” was selected 53.3% of the time during the initial preference test, and the tracking test demonstrated that “Tickles” was still preferred even when delivered by the therapist previous associated with his lowest preferred form of attention. Similar results were shown for Michelle, Danny, and Arlo. For Simon, we conducted two extra trial blocks to ensure that Simon was tracking the form of attention.

Phase 2: Reinforcement Assessment

The purpose of the reinforcement assessment was to determine whether the selected highest forms of attention and food would function as reinforcers for the participants. Figure 4 demonstrates that for all of the participants, the most preferred edible item served as reinforcer. On the contrary, the highest preferred form of social attention did not serve as a reinforcer in all of the cases. For two of the participants, Arlo and Danny, the highest preferred form of attention did not serve as a reinforcer, which is evident in the downward trend of the data. For Danny, during BL when responding produced no programmed consequence, the average rate was 0.8 responses per minute (RPM), whereas when a preferred edible was provided following responses (FR1 Food)

TRACKING TEST

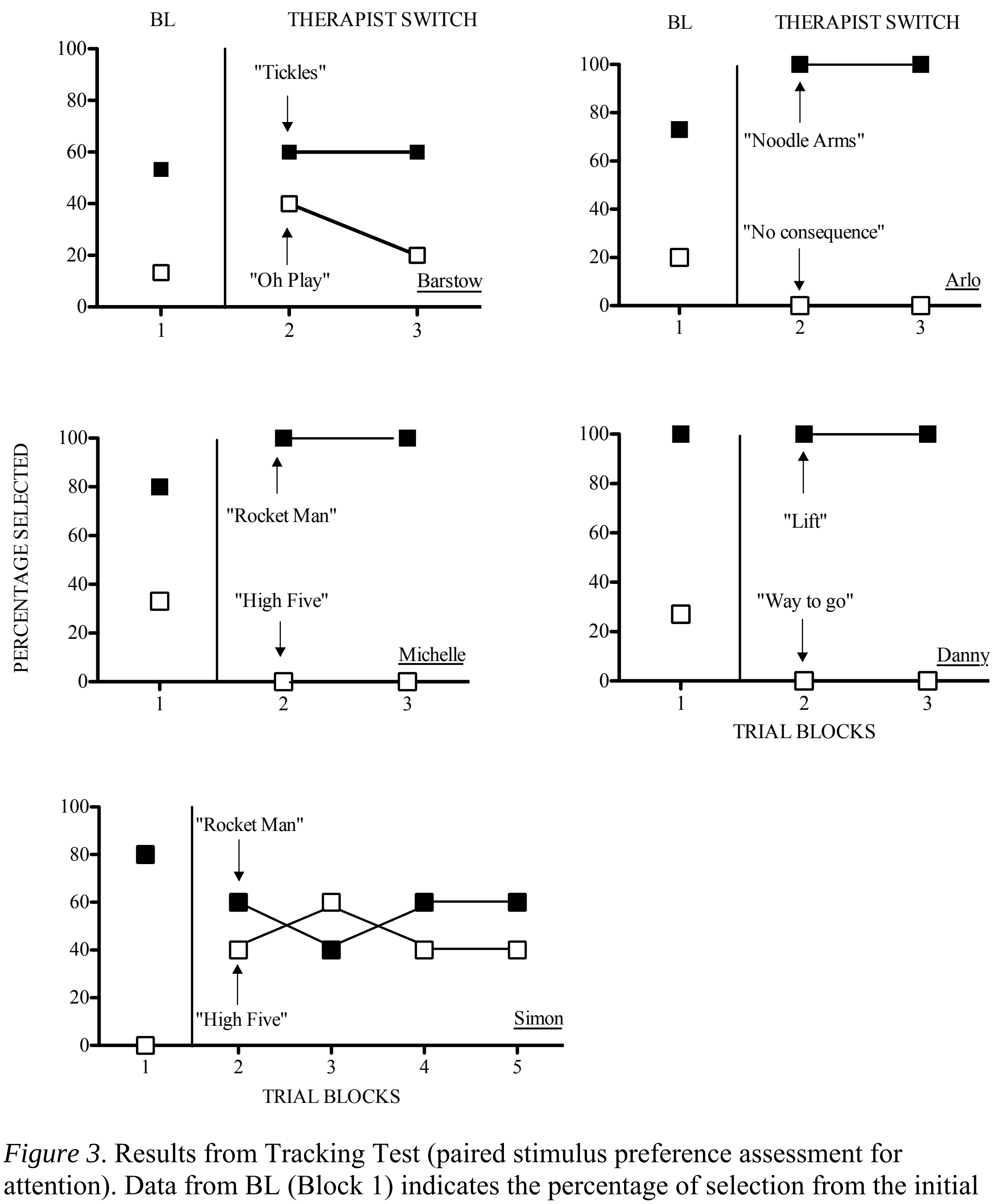


Figure 3. Results from Tracking Test (paired stimulus preference assessment for attention). Data from BL (Block 1) indicates the percentage of selection from the initial preference assessment. The THERAPIST SWITCH (Blocks 2–5) indicates selections made after the switch of the therapist. The therapist who previously delivered the most preferred form of attention, now delivered the least preferred form of attention.

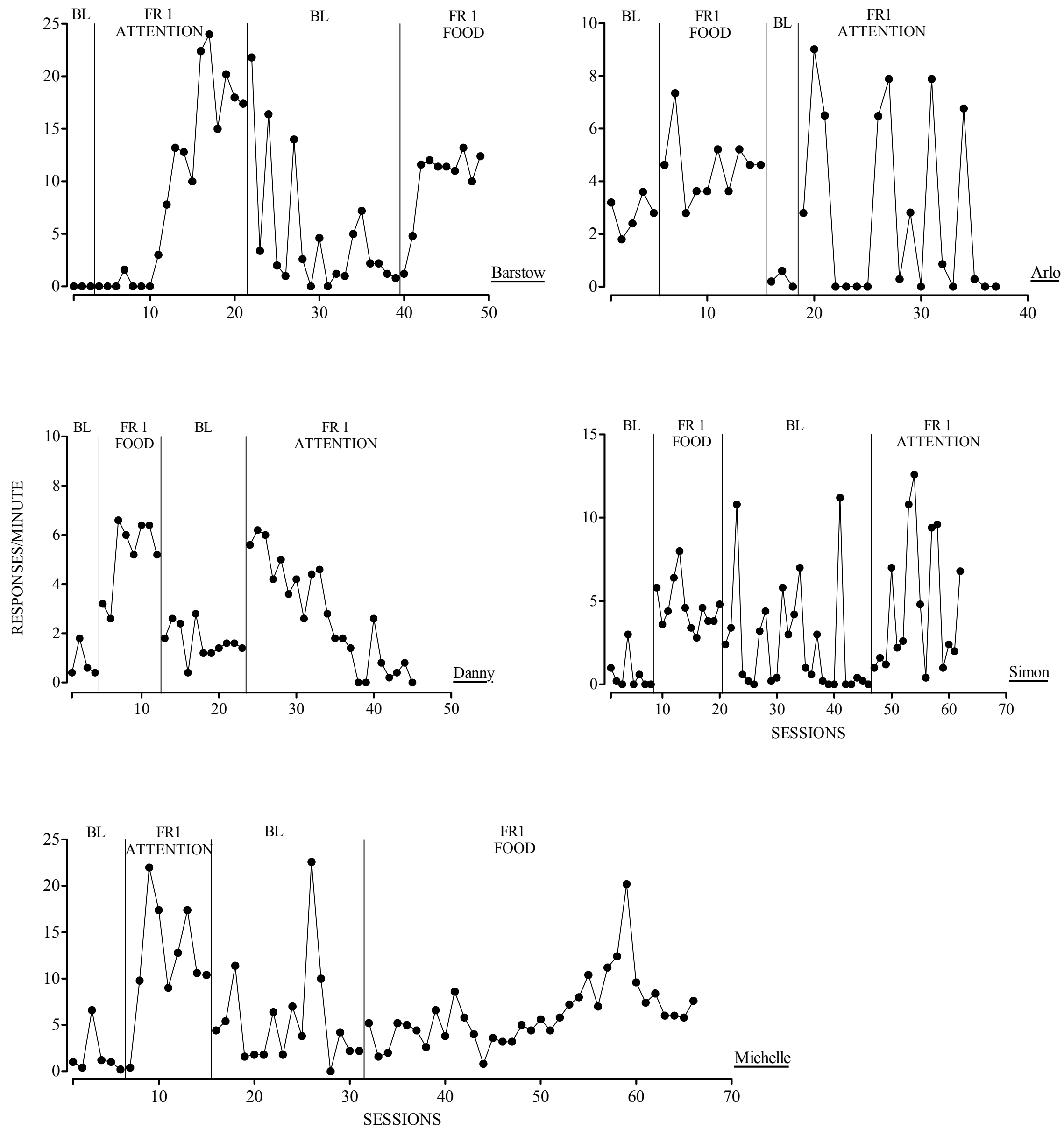


Figure 4. Results from Phase 2 (reinforcement assessment).

the average response rate increased to 5.2 RPM. The following phase was a return to BL. The average response rate decreased to 1.67 RPM, and when the preferred form of attention was provided following responses (FR1 Attention), the average response rate increased to 2.68 RPM. However, over time the response rate decreased to values close to zero. Similarly, for Arlo, the response rate during BL was 2.76 RPM, followed by an increase during FR 1 Food, averaging 4.5 RPM. The reestablishment of BL decreased the average response rate to 0.26 RPM, followed by variable trend with average response rate 2.71 RPM during FR1 Attention. Comparably to Danny's data, Arlo's responses decreased to a value close to zero. With the exception of these two participants, the rest of the participants showed a decreased response rate during BL sessions, and an increased response rate during both FR1 Food and Attention phases, providing evidence that both functioned as reinforcers.

Phase 3: Demand Assessment and Essential Value

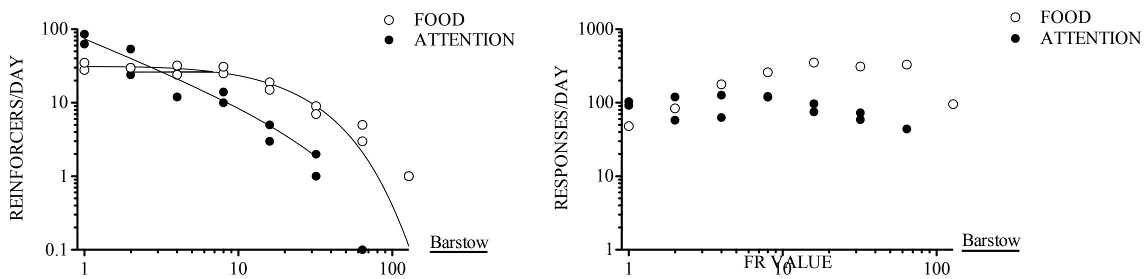
Figure 5 (a & b) shows the results from the demand assessment for the two examined commodities (food and attention) for each participant. We fit Hursh (1991) logarithmic equation

$$\ln(Q) = \ln(L) + b(\ln P) - a(P)$$

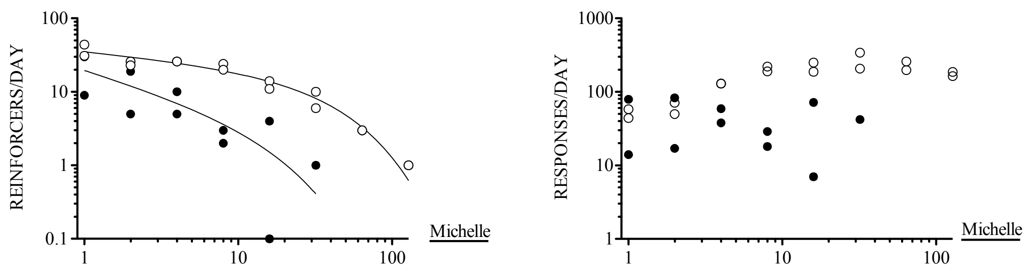
to the data from Series 1 and 2 for food and for attention for each individual FR value (unit price). This equation has three parameters (values of which are displayed in the boxes below each graph), where *L* is the initial level of demand at minimal price, *b* is the initial slope at minimal price, and *a* is the increase in slope. The results from Figure 5 (a & b) can be interpreted in terms of elasticity of demand. From a behavioral point of view,

(a)

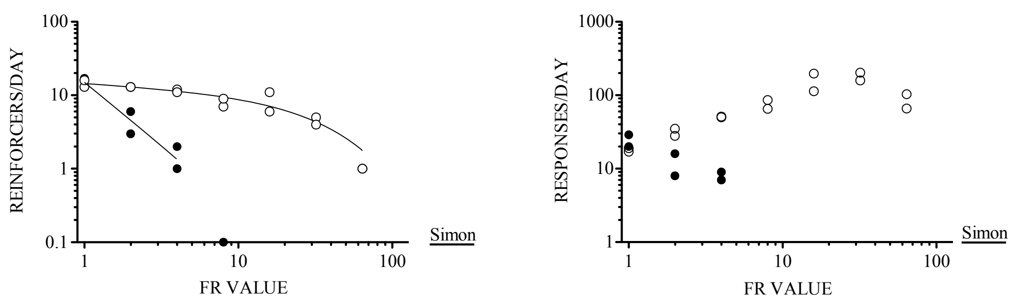
DEMAND FUNCTION RESPONSE OUTPUT



	ATTENTION	FOOD
R^2	0.90	0.95
L	75.95	32.37
a	0.01016	0.02024
b	- 0.8566	0.06111

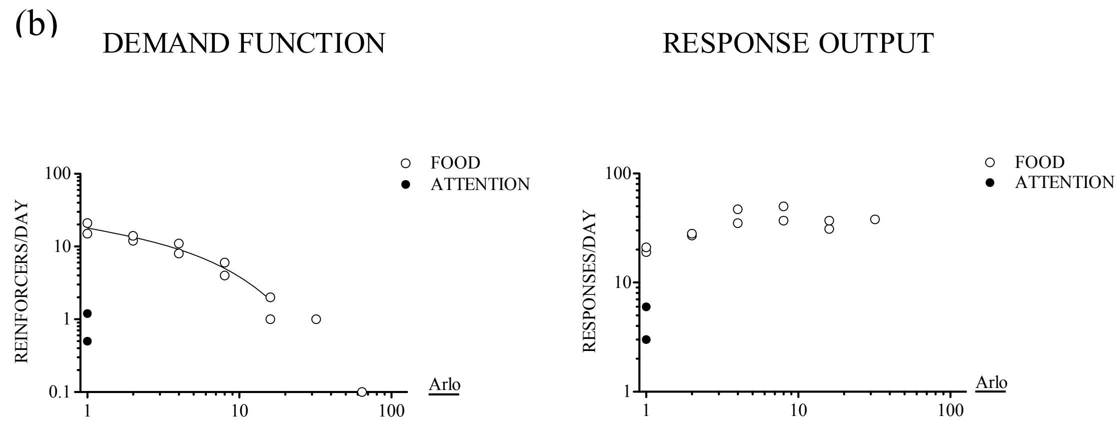


	ATTENTION	FOOD
R^2	0.58	0.92
L	20.65	35.99
a	0.02357	0.01031
b	- 0.6301	- 0.2096

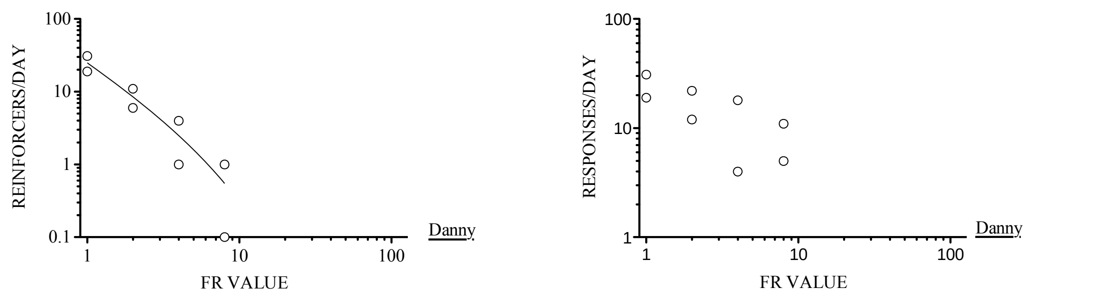


	ATTENTION	FOOD
R^2	0.95	0.90
L	15.43	14.78
a	0.01235	0.01108
b	- 1.677	- 0.1183

Figure 5. Results from the demand analysis for study participants. (a) Barstow, Michelle, and Simon; (b) Arlo and Danny. The left column shows demand functions (reinforcers obtained per unit price); right column shows response output associated with that price.



	ATTENTION	FOOD
R^2	N/A	0.94
L	N/A	19.82
a	N/A	0.04501
b	N/A	- 0.2633



	ATTENTION	FOOD
R^2	N/A	0.89
L	N/A	28.90
a	N/A	0.06298
b	N/A	-1.347

Figure 5. Continued.

elasticity refers to the changes in the number of reinforcers earned as a function of changes in the schedule of reinforcement. When comparing two commodities, the changes in the slope of the demand curve, as a function of increased unit price, can be indicative of the relative reinforcer efficacy for the commodity. A commodity that produces a steeper slope (more elastic) can be considered less valuable, as opposed to a commodity that produces a more gradual (less elastic) decrease in slope.

The left column on Figure 5 (a & b) represents the demand functions (reinforcers obtained as a function of unit price), and the right column represents the work functions (the response output associated with that unit price). The left column is indicative of the value of the reinforcer, and right column is indicative of the amount of work the participant is willing to put in order to obtain the reinforcer at that price.

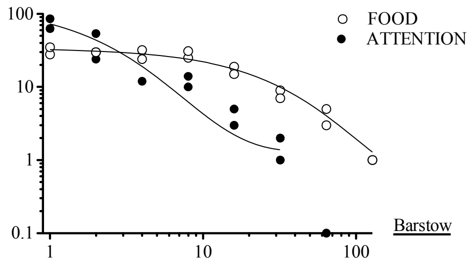
Consistent with the law of demand, all participants showed an initial increase in response output (corresponding to the inelastic portion of the demand curve), to accommodate the increase in unit price, but as the price increased further, the response output declined (corresponding to the elastic portion of the demand curve). As a result of the increase in price, reinforcers obtained decreased.

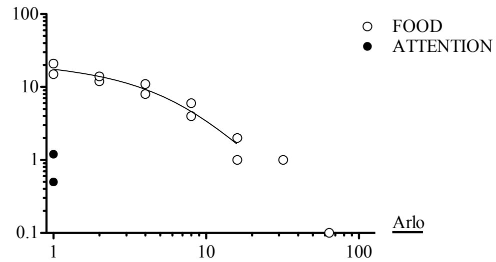
Comparison of the two commodities was possible for Barstow, Michelle, and Simon, for whom an increase in the unit price affected attention greatly, resulting in more elastic demand. In contrast, a commodity with less elastic demand, like food in this case, was less affected by change in price. For Danny and Arlo, we were not able to compare the two commodities. Arlo's responding during the demand assessment for attention ceased, therefore we were unable to assess rates at higher ratio values. Similarly, as a result of low response output during the reinforcement assessment for Danny, we were not able to conduct the demand assessment for attention.

In terms of predictive adequacy, applying the linear-elasticity equation (Hursh, 1991) was satisfactory, evident by the high values of R^2. For Barstow, the goodness of fit was .90 for attention, and .95 for food. The calculated R^2 for Michelle was low for attention ($R^2 = .55$), which can be explained by the inconsistency in responding during Series 1 and Series 2. On the contrary, R^2 was relatively high for food ($R^2 = .92$). For Simon, the R^2 for attention was .95, and for food was .90. The fit for Arlo and Danny for the food series was .94 and .89, respectively. The linear-elasticity equation (Hursh, 1991) is predictive, but does not have a single parameter that represents changes in elasticity of demand as a function of unit price. The Hursh and Silberberg (2008) equation

$$\log Q = \log Q_0 + k\,(e^{-\alpha Q_0 C} - 1)$$

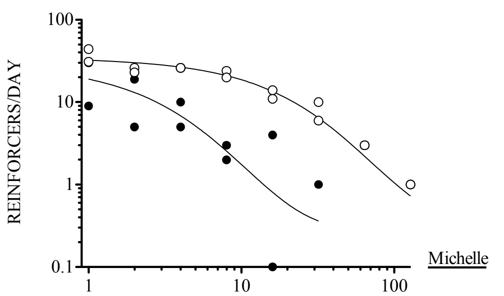
seems more apt to the task. This exponential demand model is more refined in terms of providing a measure of essential value (α), the parameter that controls the rate of decline in consumption in relation to the price change. By applying Hursh and Silberberg's model, we described the essential value for each of the commodities (Figure 6). All of the participants defended their consumption of food under increasing ratios as compared to attention. When the essential value equation was fit to the individual data, all participants showed greater essential value for food (open data path), evident in the smaller alpha values (Barstow = 0.00029, Michelle = 0.00041, Simon = 0.00071, Arlo = 0.00236, and Danny = 0.00344), in comparison to the alpha values for attention (closed data path). The values for attention for three of the participants were as follows: Barstow = 0.001036, Michelle = 0.003252, and Simon = 0.005468. As mentioned previously, we were not able to conduct demand assessment for attention for Danny due to the low response rate during the reinforcement assessment. For Arlo, we were not able to obtain an alpha value for attention, because there were too few data points. For Barstow, Michelle, and Simon, responding during the food demand assessment was maintained at higher rates under higher ratio values than responding during the attention demand assessment. More

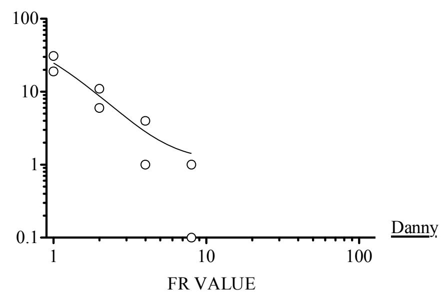




	ATTENTION	FOOD
R^2	0.89	0.94
Q_0	130	33.8
α	0.001036	0.0002859

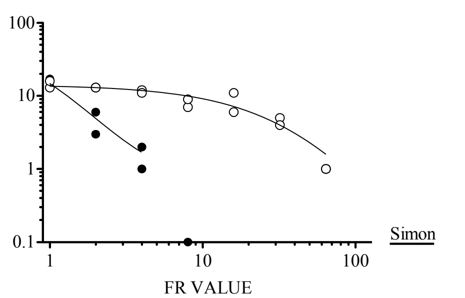
	ATTENTION	FOOD
R^2	Too few points	0.94
Q_0	Too few points	21.99
α	Too few points	0.002357





	ATTENTION	FOOD
R^2	0.58	0.90
Q_0	28.68	34.36
α	0.003252	0.0004121

	ATTENTION	FOOD
R^2	N/A	0.89
Q_0	N/A	122.9
α	N/A	0.003472



	ATTENTION	FOOD
R^2	0.94	0.88
Q_0	93.3	14.2
α	0.005468	0.0007093

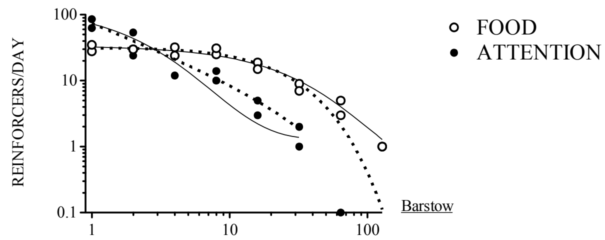
Figure 6. Results from the demand assessment, fitted with the Hursh and Silberberg (2008) equation. For Barstow, Michelle, and Simon two essential values curves were obtained (food and attention). For Arlo and Danny, the illustrated curve is for food.

specifically, Michelle and Simon each had similar consumption of food and attention at low prices (FR1). It was only when higher ratio requirements were assessed that differences emerged. For Barstow at FR1, consumption of attention was higher than consumption of food, but as the price increased, consumption of attention ceased at lower ratios than responses for food. Overall, the difference in the steepness of the curves shows a higher essential value for food than for attention for all of the participants that underwent both demand assessments.

Figure 7 (a & b), illustrates how both models (Hursh, 1991; Hursh & Silberburg, 2008) fit to the data. The two functions are superimposed on each other for comparison. The goodness of fit of the models is comparable; however, Hursh and Silberburg (2008) is superior to Hursh (1991) model because it provides a measure (alpha) describing the essential value of a commodity. In addition, the model accounts for scalar differences in a separate parameter.

To assess similarity in reinforcers earned per unit price during Series 1 and 2, we used a graphical comparison of nonparametric curves (Bowman & Young, 1996). One advantage of this method is that there is no need to specify a particular parametric form for the curves. The method creates a *reference band, which* graphically illustrates the "acceptance region" for the null hypothesis (H_0) of no difference between two groups at each point. The band is derived from the standard error of the difference between two curves at each point. In this study, the "group" is represented by one of the two commodities (food or attention). The smoothing parameter *h* controls the amount of local averaging. Larger values of *h* produce a smoother estimator with a smaller variance, but

(a)

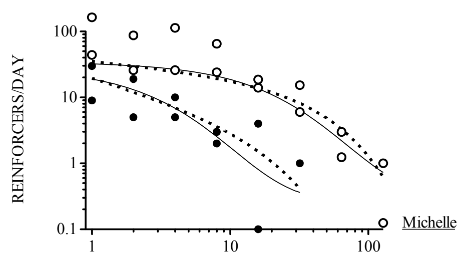


--- Hursh (1991)

	ATTENTION	FOOD
R^2	0.90	0.95
L	75.95	32.37
a	0.01016	0.02024
b	- 0.8566	0.06111

— Hursh & Silberberg (2008)

	ATTENTION	FOOD
R^2	0.89	0.94
Q_0	130	33.8
α	0.001036	0.0002859

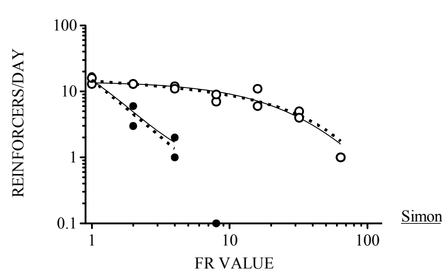


--- Hursh (1991)

	ATTENTION	FOOD
R^2	0.58	0.92
L	20.64	35.99
a	0.02357	0.01031
b	- 0.6301	- 0.2096

— Hursh & Silberberg (2008)

	ATTENTION	FOOD
R^2	0.58	0.90
Q_0	28.68	34.36
α	0.003252	0.0004121



--- Hursh (1991)

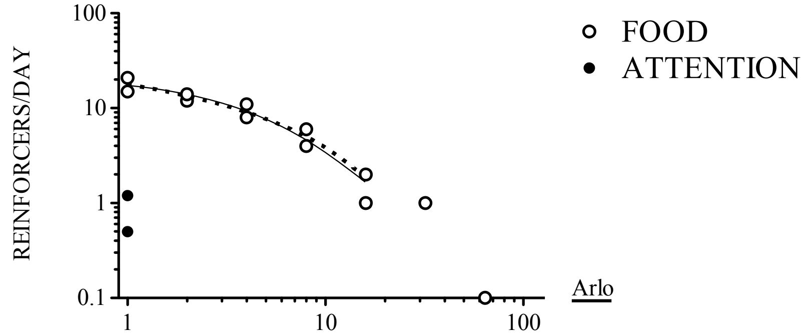
	ATTENTION	FOOD
R^2	0.95	0.90
L	15.43	14.78
a	0.01235	0.01108
b	- 1.677	- 0.1183

— Hursh & Silberberg (2008)

	ATTENTION	FOOD
R^2	0.94	0.88
Q_0	93.3	14.2
α	0.005468	0.0007093

Figure 7. Results from the demand assessment for food and attention for study participants. (a) Barstow, Michelle, and Simon; (b) Arlo and Danny. Fitted with Hursh (1991), and Hursh and Silberberg (2008) equations. The two functions are superimposed on each other for comparison. There is no demand function for attention, due to very few points for Arlo, and no data for Danny.

(b)

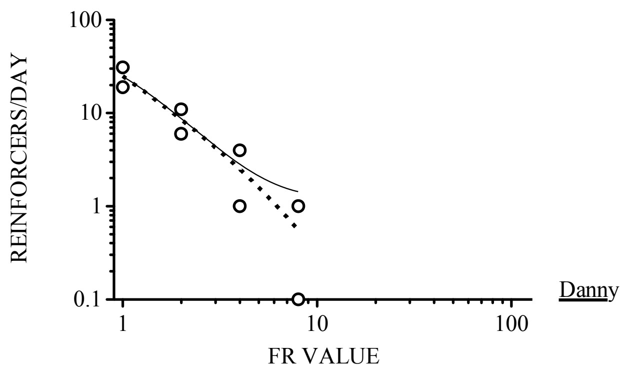


Hursh (1991)

	ATTENTION	FOOD
R^2	Too few points	0.93
L	Too few points	19.82
a	Too few points	0.04503
b	Too few points	- 0.2632

Hursh & Silberberg (2008)

	ATTENTION	FOOD
R^2	Too few points	0.93
Q_0	Too few points	21.99
α	Too few points	0.002356



Hursh (1991)

	ATTENTION	FOOD
R^2	N/A	0.89
L	N/A	28.90
a	N/A	0.06298
b	N/A	- 1.347

Hursh & Silberberg (2008)

	ATTENTION	FOOD
R^2	N/A	0.89
Q_0	N/A	122.9
α	N/A	0.003472

Figure 7. Continued.

larger bias. Smaller values of *h* result in an estimator with a smaller bias, but larger variance. This method generates an optimum width of the *reference band* based on the given experimental data. In some cases *h* value can be manipulated to control for the amount of smoothing. For the purpose of this comparison we interpret the results as they are, by allowing the program to estimate an optimal value of *h* using cross-validation. Data analyses were done using the sm package in R (Version 3.1.2, 2014-10-31).

The reference bands (the shaded grey area on the graph) are shown in Figure 8 for each participant. Table 1 reports the smoothing parameter *h* and the *p* value for the equality comparison for food and attention. For all participants, the demand curves for individual trials (Series 1 and 2) for food were not shown to be different (i.e., they were within the reference band). The reported *p* values for Barstow, Michelle, Simon, Arlo, and Danny are large ($p = 0.9861$, $p = 0.4971$, $p = 0.7461$, $p = 0.1176$, and $p = 0.613$ respectively), supporting the notion that there is no significant difference between Series 1 and Series 2 in terms of responding and earning a similar amount of reinforcers within the individual prices. For attention, only the demand curves obtained from Barstow's data did not reach statistical significance ($p = 0.1121$). For Michelle, the analysis suggests that two demand curves for attention were not consistent, as shown by data points outside the reference band, and a smaller *p* value ($p = 0.0909$). We were unable to obtain tests for Simon, Arlo and Danny due to insufficient data points. For Barstow, Michelle and Simon, we also compared two curves (one for food, and one for attention) that were derived from the averages between the two series at each individual FR value. The results of these comparisons are represented in the right column of Figure 8. Tests for Barstow

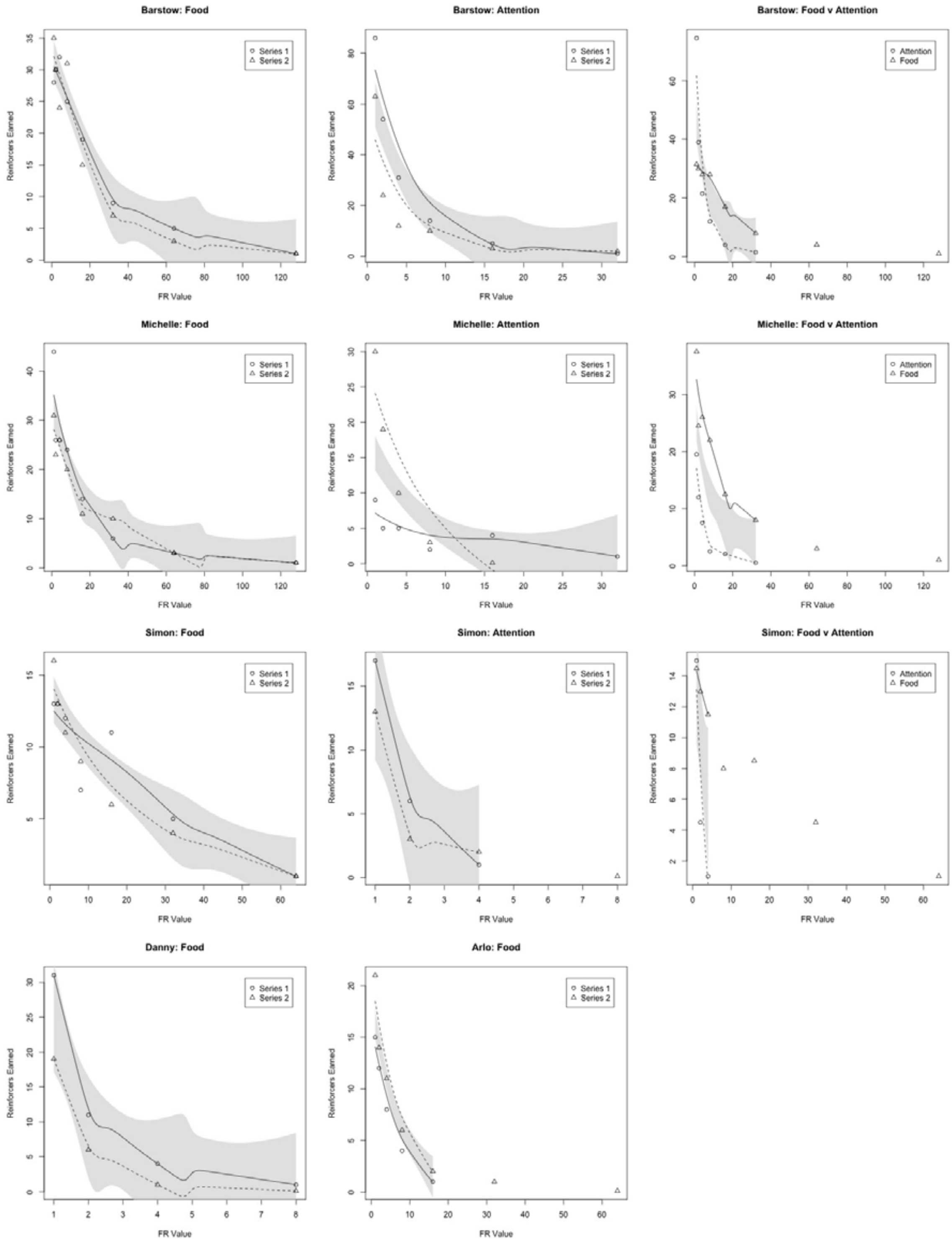


Figure 8. Observed data, curves, and reference bands for equality of nonparametric regression curves. Rows 1-3 represent comparisons of food, attention, and food vs. attention for Barstow, Michelle, and Simon. Row 4 represents comparison for food for Danny and Arlo.

Table 1

Smoothing Parameters (h) and p *Values for the Graphical Assessment of Equality of the Nonparametric Curves for Each of the Participants*

	Food		Attention		Food vs. attention	
Participant	*h*	*p* value	*h*	*p* value	*h*	*p* value
Barstow	11.4671	0.9861	4.41149	0.1121	3.551607	0.0799
Michelle	6.8299	0.4971	6.31232	0.0909	3.551661	0.0696
Simon	11.0093	0.7461	Unable to obtain		Unable to obtain	
Arlo	4.24889	0.1176	Unable to obtain		Unable to obtain	
Danny	0.665862	0.613	Unable to obtain		Unable to obtain	

($p = 0.079$) and Michelle ($p = 0.069$) were approaching significance, suggesting that responding and earning reinforcers at individual prices for attention and food differ. This was consistent with our findings from the essential value assessment, which suggest that food holds a higher essential value than attention. We were not able to obtain a test for Simon due to very few data points during the demand assessment for attention.

CHAPTER V

DISCUSSION

The present study examined demand functions for food and attention in five children diagnosed with autism. In Phase 1 we conducted paired stimulus preference assessments in order to identify preferred stimuli (attention and food), which we included in a subsequent reinforcer assessment (Phase 2). After establishing if the preferred stimuli could serve as reinforcers, we conducted the demand assessment (Phase 3) to identify the essential value for the preferred form of attention and the essential value for the preferred food item.

The preference assessment for food resulted in a hierarchical preference for each of the participants. Barstow, Arlo, Danny, and Simon selected one particular food item on 100% of the occasions the item was presented. Michelle selected one food item in 80% of the cases this item was offered.

The preference assessment for attention showed Danny chose one item exclusively, and for Barstow, Michelle, Simon, and Arlo, the percentage of times in which the preferred form of attention was selected varied between 53.3% and 80%. It is worth mentioning that for four of the participants (all but Danny) the difference in percentage between the most and second-most preferred form of attention was between 7% (Arlo) and 27% (Michelle). The follow-up tracking test yielded conclusive results, confirming that participants were tracking the form of attention, and not the therapist delivering the attention. For Simon, we conducted two extra trial blocks to ensure he was tracking the form of attention.

Next we assessed the reinforcing value for food and attention (Phase II) in a counterbalancing manner. For Barstow and Michelle, the first assessment was of attention, followed by food. Both participants demonstrated clear reinforcement effects for attention and food (Figure 4).

For Danny, Arlo, and Simon we started with the assessment for food, followed by the attention assessment. Results showed that the previously identified food item could serve as a reinforcer, as evidenced by the higher response rate during FR1 condition. In contrast, responding for attention for Simon and Arlo was variable, with a declining trend in responding for Arlo. For Danny, responding for attention declined steadily until cessation. In order for the demand assessment to take place, it was first necessary to show that responding would at least be maintained by attention. Because Danny' responding was systematically down trending, such evidence was lacking and he was excluded from the demand assessment. Arlo's responding during the reinforcement assessment was variable and not definitive, with greatly fluctuating values, so we decided to proceed with the demand assessment based on the overall average rate of responding. It is interesting to note that both Barstow and Michelle successfully completed the reinforcement assessments. In contrast, two of the participants Arlo and Danny, for whom the reinforcement assessment started with food, responding for attention ceased. Thus, one possible explanation for our results is that the order in which reinforcement assessment is conducted might have had a deciding impact on the outcome of the reinforcement assessment. Two of the participants who successfully finished both reinforcement assessments underwent the reinforcement assessment for attention first. We can hypothesize that when comparing two different commodities, it could be suggested that one of these commodities will be less preferable. Beginning the reinforcement assessment with the less preferable commodity might provide a better outcome in terms of completing the assessments for both commodities. The order in which the reinforcement assessment was conducted for Barstow and Michelle supports this hypothesis. Although not implausible, we should note that previous research examining reinforcement effects found very little evidence of order effects (e.g., Roscoe et al., 1999), albeit using stimuli from the same class (food). It could be that differences in reinforcing value of different food items used by Roscoe and colleagues were relatively small compared to the difference between the value of food and attention in this study. Thus, perhaps order effects are more apparent when the absolute reinforcing value differs by a greater degree.

One possible solution to avoid inconsistency in the outcome of the reinforcement assessment would be to conduct the assessments in the same order for all of the participants. More research is needed to determine what the order should be when dealing with two or more commodities of a different nature (e.g., food vs. attention). The question of how the order could influence the assessment of the less preferable item should be considered. In order to provide a better chance for completing the reinforcement assessment for both commodities, it could be beneficial to anecdotally assess which of the commodities is more likely to be less preferred, and begin the reinforcement assessment with that commodity.

Further investigating the low response rates for the preferred form of attention, offers another possible explanation. It might be that for some participants, the selected form of attention was not as definitively preferred compared to the selected food item (100%). Investigating the initial preference for attention shows that Barstow chose "Tickles" 53.3% of the time; nevertheless, he successfully completed the preference for attention assessment. The opposite is true for Danny, who showed preference for "Lift" 100% of the time, however, his responding for attention ceased during the reinforcement assessment. On the other hand, absence of a definitive preference could indicate either options that are of equally low preference or options that are of equally high preference. Failure to identify a clear reinforcement effect might be cited in support of the former.

During Phase 3 we conducted the demand evaluation. By fitting Hursh's (1991) logarithmic equation we evaluated the functional relation between the total reinforcers consumed per session and the unit price (demand function), as well as the response output within each unit price. By plotting the reinforcers earned and response output we were able to observe that all participants indeed behave in a way that is consistent with the law of demand. Initially, at lower prices, the participants showed an increase in the response output in order to accommodate the increase in the unit price. Hursh's (1991) model described the data relatively well, however due to its form it fails to capture the slope of the curve in a single parameter that would allow for easy comparison across commodities (essential value).

Following the application of the Hursh (1991) model, we assessed the essential value by fitting Hursh and Silberberg's (2008) model. The most representative and clear results came from Barstow's, Michelle's, and Simon's assessments. For all three participants the essential value for food was larger than the essential value for attention, evident by the smaller alpha values. For Arlo and Danny, we were not able to obtain demand curves for attention. An interesting finding emerged from Barstow's assessment. He was the only participant for whom attention had a higher essential value at lower prices. As the price increased to FR4, attention reinforcers obtained at this unit price dropped in comparison to the food reinforcers earned at the same unit price. For Michelle and Simon, the reinforcers earned for food were higher across all prices.

Hursh and Silberberg's (2008) model is superior to previous models because it provides a measure (alpha) describing the essential value of a commodity. By fitting both models, we were able to assess which model is more suitable for investigating reinforcing properties of attention and food. Both models fit the data adequately well, with Hursh (1991), providing slightly higher R^2 values. However, Hursh and Silberberg's (2008) model has fewer parameters, which contributes to the simplicity of the model, but yet it provides another measure. In addition, the later model accounts for scalar differences in a separate parameter. It is worth noting that both the fit of the model and the essential value are affected when interpreting data from two series separately, or as shared values. We looked at the consistency of reinforcers earned for Michelle, for whom reinforcers earned anecdotally appeared inconsistent. According to the reported R^2 values for both models, the fit is identical (.58). However, when two series for attention were fitted separately, the R^2 changed substantially. Figure 9 shows the representation of the fit for both models as two series separately, and as shared values.

For each participant, demand for each commodity was assessed twice. The analysis shows that at least for Michelle, the second assessment of demand for attention

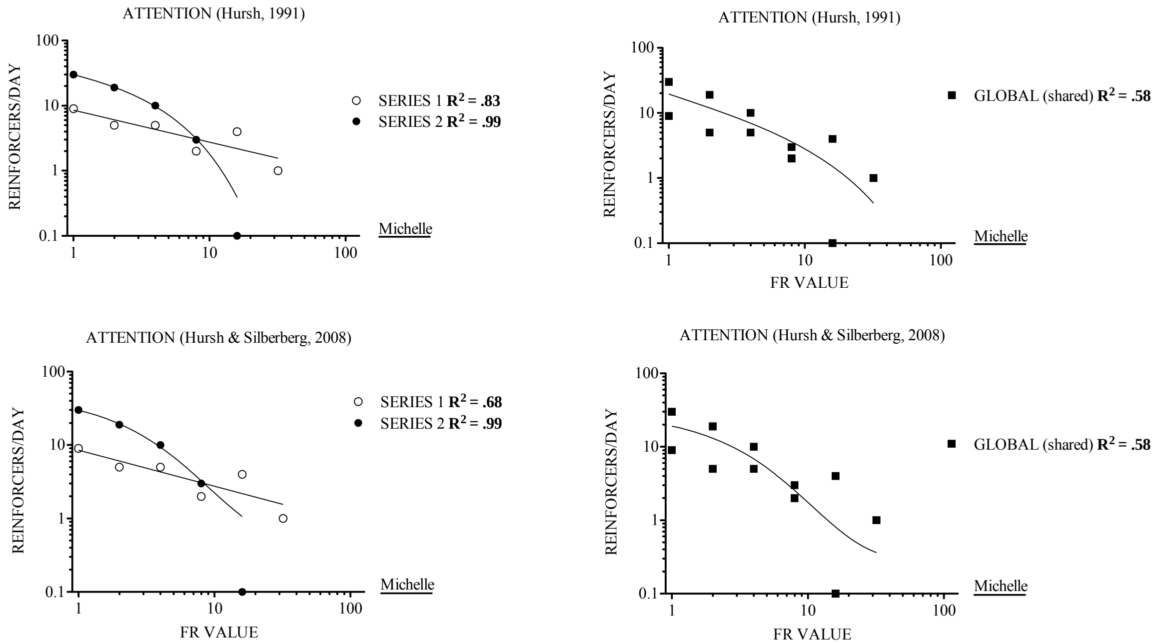


Figure 9. Comparison of fit of two series separately (left) and as shared values (right) from the demand assessment for attention for Michelle. Top row data is fitted with Hursh (1991) model and bottom row data is fitted with Hursh and Silberberg (2008) model.

produced a substantially better fit than the first. This suggests that there may be some benefit to conducting assessments for each commodity more than twice. These additional findings might be of assistance when designing future assessment and treatment strategies.

After completing the assessment for essential value, we looked at additional ways to analyze the findings of the study. However, the results obtained using the graphical comparison of nonparametric curves should be interpreted with caution. Initially, we did not design the study to produce data for the purposes of statistical analysis. However, we suspected that some of the inconsistent findings among participants might benefit from supplemental analysis. In addition, the conclusions drawn from these extended analyses might benefit a wider audience. First, we explored how similar the two demand curves for each of the commodities were. As suspected, for all of the participants, the two demand curves for food were similar; they were within the reference band, in addition to exhibiting large *p* values. Further, we assessed the two demand curves for attention, and found greater inconsistency between the demand curves for Michelle (smaller *p* value). Third, we examined how similar demand curves obtained from a preferred form of attention and demand curves obtained from a preferred form of food are. The results showed smaller *p* values in comparison to the *p* values obtained from the comparison of the two series of only one commodity. These findings, although not statistically significant, demonstrate consistency in findings using two conceptually different methods. Unfortunately, we were not able to conduct this type of analysis for all of the participants, due to few data points for Simon and Arlo, and the absence of data for a preferred form of attention for Danny.

Contribution to Future Research

The Hursh and Silberberg (2008) model appears to be superior over other models in defining essential value for a particular commodity. Previous attempts fail to assess value because none of the applied methods are independent of income and price. Hursh and Silberberg's essential value model provides a metric based on the differences in exponential demand that reflects the participant's priorities. This method is especially useful when assessing value of different commodities. The results from Phase 3 demonstrated an important possible application of the model. When assessing two or more commodities of different nature, using traditionally established methods mentioned previously might not capture an important quality of potential reinforcers. Not all reinforcers are created equal. Some reinforcers might serve as potent reinforcers when less work is required to obtain them, while other reinforcers can sustain larger work requirement. Clinically, this information might be useful when selecting reinforcers. Future researchers should examine whether for short-term and easy tasks, reinforcers of lower essential but greater scalar value could be used, while for more difficult tasks, or when dealing with problem behavior, the practitioners can rely on reinforcers of a higher essential value. Another potential implication is the ability to assess all types of reinforcers independent of their nature. Anecdotally, it is believed that individuals with autism do not benefit from using reinforcers that are based on a selected form of attention. However, the current study suggests otherwise. For at least one of the participants (Barstow), the form of attention produced greater response output at low work requirements than the preferred food item at the same work requirement. When the unit price increased, or the requirement for work was larger in order to obtain a reinforcer, the work output for the selected food item was larger. In other words, Barstow was more willing to work more for the preferred food item, rather than for the preferred form of attention. These results suggest that a more thorough examination of potential reinforcers is needed in order to draw a definitive conclusion concerning the reinforcing nature of a particular potential reinforcer.

Limitations and Future Directions

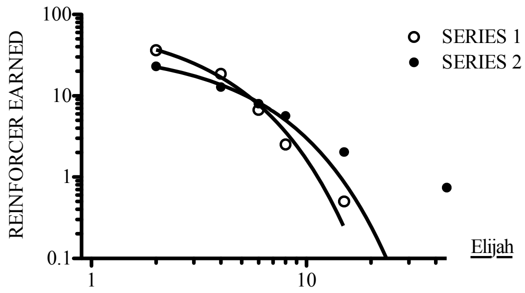
One limitation of the current study was the inability to obtain a demand curve for attention for two of the participants. There are several possible explanations. Conducting preference assessment followed by reinforcement assessment for attention might have contributed to satiation. This idea comes from examining Danny's preference and reinforcement assessments. Danny was the only participant that definitively selected a form of attention (100%). This selection would suggest that his chosen form of attention should possibly serve as a reinforcer. In addition, during the reinforcement assessment, following baseline, his responding for attention increased; however as sessions continued, responding for attention ceased. Conducting preference assessment followed by reinforcement assessment for twenty or more daily sessions might contribute to long-term satiation or habituation (although evidence for such an effect is lacking, see DeLeon et al., 2011). It is also important to look at the nature of the assessed commodity. Satiation for a preferred food item might take longer than satiation for a preferred form of attention. One possible solution would be to conduct demand assessment without a prior reinforcement assessment. Reed and colleagues (2009) investigated the predictive ability of traditional preference assessments (e.g., paired-stimulus, MSWO, and free operant) to the outcome of demand assessments. The researchers concluded that overall, preference assessments hold a high predictive value, and more importantly that even *moderately* preferred items might serve as efficacious reinforcers. The findings from Reed and colleagues could provide possible justification for the omission of the reinforcement assessment in the current study.

Another possibility to reduce the effect of satiation is to conduct the reinforcement and demand assessment with the top two or three choices of attention, or to provide two or three therapists delivering the selected form of attention. Additional benefit to taking this route is that it will more closely mimic the natural environment. People rarely receive the same form of attention from the same person in the matter of time in which this study was conducted.

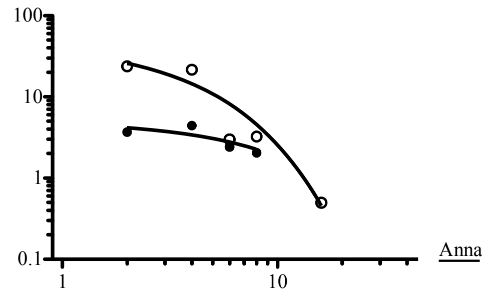
Several questions remained unanswered for this study. The overall findings suggest that in children with autism food holds a higher essential value than attention. Also, they suggest that in some participants attention is more valuable at low price, but as the price increases, food is more likely to sustain responding. It will be useful to find out if these findings generalize to typically developing children, or if they are specific to the population of children with autism. One known study by Delmendo, Borrero, Beauchamp, and Francisco (2009) used typically developing children to assess the reinforcing efficacy of food. Fitting Hursh and Silberberg's (2008) equation to their data (Figure 10) produced comparable alpha values to those reported here.

It is unclear how manipulating certain parameters when assessing attention, affects the results. One possibility is to experiment with different step sizes. It might be that a twofold ratio increase is too large for some of the participants when assessing attention, therefore using this step size fails to assess higher ratio requirements than were evaluated in this study.

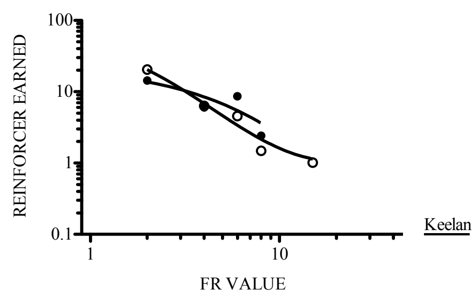
Another limitation of this study is the use of 5-minute sessions across different prices. Considering that the duration of the session is analogous to income, changes in consumption that accompany changes in price confound two separate effects. On one hand, changes in the session duration will necessarily result in decreases in consumption



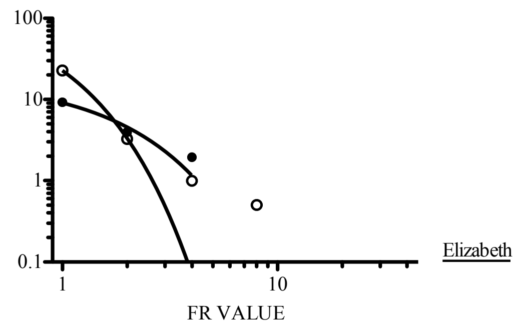
	SERIES 1	SERIES 2
R^2	0.99	0.99
Q_0	80.05	37.42
α	~1.041e^{-6}	~1.41e^{-6}



	SERIES 1	SERIES 2
R^2	0.84	0.61
Q_0	46.07	5.105
α	~2.542e^{-6}	~2.542e^{-6}



	SERIES 1	SERIES 2
R^2	0.99	0.76
Q_0	112.6	23.44
α	0.001969	0.001969



	SERIES 1	SERIES 2
R^2	0.99	0.96
Q_0	154.6	18
α	-7.267e^{-6}	7.267e^{-6}

Figure 10. Hursh and Silberberg (2008) model fitted to data from typically developing children. Data taken from Delmendo and colleagues (2009).

without simultaneous increases in the rate of responding. This is often labeled an income effect. In addition, as the price of a commodity increases consumers will often begin to search for substitutes. For example, when the price of gasoline increases, some consumers may begin to make use of public transportation. This is often labeled a substitution effect. In the case of the present data, we are unable to distinguish between these two effects. One possible approach for controlling for income effects is to increase session duration as price increases. Future investigators might use this latter approach. Still, assuming that each delivery of food and attention required similar amounts of session time (and arrangement was enforced in the program running the apparatus), then income effects should have been similar across the commodities. Therefore, even though income effects were not isolated, they should at least have been similar across both food and attention.

One other implication of Hursh and Silberburg (2008) essential value is to assess attention, but in light of different unit prices, for example, exploring the delivery of one vs. two reinforcers per required response in two consecutive series. As clarified by Hursh and Silberburg, this model accounts for scalar differences; therefore, alpha values should be the same for both of these assessments. To the best of our knowledge, exploration of this property of the model has not been done to further assess essential value for attention.

Another way to expand our understanding of attention as a reinforcer in children with autism is to look to other fields. Lloyd, Medina, Hawk, Fosco, and Richards (2014), proposed an integrative model called habituation of reinforcer effectiveness (HRE), which predicts a decrease in the reinforcer effectiveness due to repetition. The HRE model ties together both behavioral and neural-based explanations of the properties of reinforcers. The authors argued that current literature primarily focuses on edibles when studying the property of reinforcers. Nonclinical researchers use deprivation and other manipulations that could cloud the effects of habituation. The researchers hypothesize that some abnormal HRE due to genetic or environmental factor can underlie neurobiological conditions (e.g., ADHD). Understanding and applying the HRE hypothesis, or additional tools from other fields, could assist the interpretation of single cases for which other possible explanations have been ruled out. For typically developing individuals, HRE might not be an issue, but for individuals with developmental disabilities, differences in habituation might affect the duration at which certain reinforcers become less effective, regardless of the arrangement of reinforcer delivery. This finding might be of assistance when designing assessments, treatment, and educational strategies.

In conclusion, this study adds to the literature by demonstrating a method for assessing essential value of food and attention using Hursh and Silberburg's (2008) equation in individuals with autism. This method could serve as a basis for comparing the effects of interventions (e.g., more effective interventions may produce increases in the essential or scalar value of attention), as the basis for selecting a particular course of treatment (e.g., some individuals may benefit from procedures that help establish the value of attention as a reinforcer), and for examining the underlying mechanisms for some social deficits (e.g., it may be that attention functions as a weaker reinforcer for individuals with autism as compared to individuals with other developmental disabilities or typically developing individuals). In addition, the results from this study extend previous research on preference and reinforcer assessments to the evaluation of social attention in individuals with autism.

When working with special populations, thoughtful selection of reinforcers becomes a necessity in managing problem behavior and acquiring new skills. For example, potential reinforcers with a lower essential value could be used for smaller, short-term tasks, whereas reinforcers with higher essential value could be used in managing severe problem behavior, or in acquisition of harder tasks.

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