THE ASSESSMENT OF PREFERENCE FOR QUALITATIVELY DIFFERENT REINFORCERS IN PERSONS WITH DEVELOPMENTAL AND LEARNING DISABILITIES: A COMPARISON OF VALUE USING BEHAVIORAL ECONOMIC AND STANDARD PREFERENCE ASSESSMENT PROCEDURES

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DISSERTATION ABSTRACT

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Standard preference assessment results may have limited generality when schedule requirements are increased, which may compromise treatment efficacy. While standard procedures can provide reliable preference ranks and consistency of ranks, it remains unclear whether currently used preference assessments make accurate predictions about reinforcement effects under varying schedule requirements.

Behavioral economic analyses have been used in studies of persons with developmental disabilities; however, a general, systematic and effective method for

generating rapid demand curves has not been established. Experiment 1 developed a procedure for data collection that facilitated behavioral economic analyses. Participants responded on a progressively increasing FR schedule to obtain reinforcers during short, intermediate, and long sessions. The results of demand curve analyses suggested the session length, FR schedule progression, amount of reinforcement delivered, duration of the reinforcement interval, and session termination/ratio strain criteria.

Behavioral economic procedures from basic research provided novel methods for identification of reinforcers under increasing schedule requirements. The exponential-demand and the linear-elasticity models were successfully fit to the Experiment 2 data. The exponential model provided a single quantitative measure of the essential value of reinforcers independent of their dimensional properties and was able to adequately predict responding for qualitatively different reinforcers. Essential value may be a means of identifying functional reinforcers that may generalize to common treatment situations.

Reinforcer rankings among the standard preference and behavioral economic assessments were compared using rank-order correlations. Standard procedures could not adequately predict preference among qualitatively different reinforcers such as edibles and tangibles and were unable to identify the most potent reinforcers under increasing schedule requirements. Behavior economic measures of preference and value from the reinforcer assessment were able to define the relationships among different types of reinforcers and allowed for direct comparisons of preference for food and non-food items. The behavioral economic reinforcer assessment provided information about each participant's reinforcers that would suggest which items and at what magnitude should be used in treatment settings.

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INTRODUCTION

The response-contingent delivery of a stimulus can function as a reinforcing event under certain conditions. Both animals and humans have been shown to respond in order to gain access to a wide variety of stimuli, such as food, drugs and alcohol, money, tokens, attention, leisure items and sensory stimulation, to name just a few. Thus, the delivery of any one of these stimuli meets the definition of a reinforcer. Response-contingent stimulus delivery has been used as a basic method for studying the environmental determinants of behavior. However, fully defining a measure that can index the strength or value of a reinforcer has proven somewhat elusive within behavior analysis (Allison, 1983; Baum & Rachlin, 1969; Ferster & Skinner, 1957; Herrnstein, 1970; Hursh, 1980, 1984; Hursh, Raslear, Shurtleff, Bauman, & Simmons,1988; Hursh & Silberberg, 2008; Lea, 1978; Miller, 1976; Skinner, 1938, 1966; Stafford, LeSage, & Glowa, 1998). A goal of the science of behavior has been to develop a scale capable of ordering the values of reinforcers and predicting their affect on behavior. Many different operant accounts of strength of a reinforcer have been advanced, including response rate, relative response rate, ratio breakpoint on progressive ratio schedules, and economic demand.

Response Rate as Strength of a Reinforcer

Skinner (1931) asserted that a behavioral reflex was the correlation between a stimulus and a response. Skinner (1932a) then demonstrated this correlation by examining the relation of the hunger drive to the eating reflex in rats by measuring changes in the rate of food consumption since the onset of eating. The rate of consumption for hungry rats was a smooth, decreasing function of the time spent eating that reflected an orderly and continuous relationship between hunger and rate of food-pellet consumption. In another experiment, rats were required to press a lever prior to initiation of the eating reflex (Skinner, 1932b). The function representing the rate of pellet consumption to time spent eating was unchanged regardless of the addition to the reflex chain. The conclusion was that the rate of pellet consumption could be measured in terms of lever pressing as an index of strength. That is, response rate can serve as an index of reflex strength (Skinner, 1932b, 1938). Although Skinner and others conceptualized the rate at which behavior occurs (responses per unit of time) as a measure of strength, it became evident that this approach was flawed (Ferster & Skinner, 1957; Skinner, 1966). While rate of responding may be a useful index of strength, it may not be the most sensitive measure to determine how effectively a particular reinforcer maintains behavior. Skinner (1938) later found that the response rate is multiply determined and not simply a function of the effectiveness of the reinforcing event. Response rate was found to be shaped directly by reinforcement (Ferster & Skinner), so response rate cannot be an index of reflex strength when the value attributed to rate is not exclusively due to the reinforcer, but is also due to local contingencies of reinforcement. For this reason, concurrent choice arrangements were later used to demonstrate the strength of reinforcement.

Relative Response Rate as Strength of a Reinforcer

In an effort to alleviate some of the problems with measuring strength, Herrnstein (1970) compared reinforcers in choice arrangements. Herrnstein noted that the relative response rate measure of choice was more sensitive to changes in reinforcer rate than the rate obtained from the single-schedule approach of Skinner. Herrnstein demonstrated the orderliness between concurrent choice and reinforcement with the matching relation: The proportion of choices for one of two alternatives covaried with the proportion of reinforcement obtained from that alternative (Herrnstein, 1961). Additional studies of matching relations advanced relative response rate as an effective measure of strength. Herrnstein (1970) included an "equation for simple action" which broadened the choice measure to incorporate the effects of both single and concurrent schedules. With the broadening of measures of strength came a broadening of the construct of strength. Baum and Rachlin (1969) proposed that schedule performance be viewed as reflecting a choice between activities that differ not in strength, but in value. This reinterpretation of Skinner's and Herrnstein's conception of strength supported subsequent claims that it is possible to scale the relative value of different types of reinforcers when those reinforcers are presented in choice by using Herrnstein's matching equation (Miller, 1976). As such, the matching equation could serve as a means of scaling the strength or value of reinforcers. The key was to pursue the value of one reinforcer relative to another, rather than the absolute value of any one reinforcer. However, a matching-based scale of relative reinforcer value is not without limitation. Matching relations do not account for the economic conditions under which choice occurs.

Another approach to operant analysis favoring the concepts, language, and interpretations from consumer microeconomics, shows the problems with using matching as a scale of value. Elsmore, Fletcher, Conrad, and Sodetz (1980) utilized an economic approach by having baboons choose between food and heroin infusions under a variety of economic conditions. When income was high, meaning the baboons had many choices to "spend" each day, heroin was chosen more often than food. On the other hand, when income was low because they had just a few choices per day, preference reversed with the baboons choosing more food than heroin. Identical shifts in preference between two commodities have been shown with humans under conditions of increasing price during drug self-administration studies (Bickel & Madden, 1999; Bickel, Marsch, & Carroll, 2000; Madden, Bickel, & Jacobs, 2000). Similar preference shifts have been noted with other types of reinforcing stimuli, participants, and settings. Reinforcer preference in persons with developmental disabilities has also been shown to change similarly as a function of increasing schedule requirements or price (DeLeon, Iwata, Goh, & Worsell, 1997; Tustin, 1994). The results of these studies indicate that a scale of relative reinforcer value must account for income or its complement, price, especially when the reinforcers being compared are not identical.

Ratio Breakpoint as Strength of a Reinforcer

In the drug self-administration literature, relative reinforcing efficacy has traditionally been of interest in determining the strength of a reinforcing event. Relative reinforcing efficacy refers to the greater behavior-maintaining effect of one event as compared to another, whether drug self-administration, food delivery, or some other event (Bickel et al., 2000; Griffiths, Brady, & Bradford, 1979; Katz, 1990; Stafford, LeSage, & Glowa, 1998). The relative reinforcing efficacy concept provides a framework for integrating a range of behavioral measures obtained from different procedures and parameter values (Griffiths et al.). More general statements about which reinforcers more effectively maintain behavior are made possible by the convergence of data validating these conclusions and the correlation with quantitative and qualitative differences among reinforcers. That is, if there is a concordance of data obtained from several studies employing different methods and parameters that result in consistent evidence of the greater reinforcing efficacy of a particular reinforcer, then it allows for a statement that one reinforcer has greater relative reinforcing efficacy as compared to another. Depending on the measurement scaled used, more detailed comparison statements may also be made (Katz).

Comparison statements of relative reinforcing efficacy could be useful under a variety of circumstances and across settings and populations. Relative reinforcing efficacy has broad applications, from the evaluation of the effectiveness of behavioral and pharmacological interventions aimed at reducing drug use to increasing adaptive and/or decreasing maladaptive behaviors in persons with developmental disabilities (Bickel et al., 2000; DeLeon et al., 1997; Roane, Call, & Falcomata, 2005). Procedures have been developed for comparing different methods of evaluating reinforcer efficacy among qualitatively different reinforcers for persons with developmental disabilities. Moreover, relative reinforcing efficacy is not assumed to be a static property of a stimulus event but rather is assumed to be a function of the reinforcing event, the current environmental conditions, the presence of alternative reinforcers, and the organism’s behavioral history (Stafford et al., 1998). Behavioral measures used to determine the relative reinforcing efficacy of various substances, including drug and non-drug reinforcers, in both human and animal subjects include peak response rates obtained under single schedules of reinforcement, breakpoints obtained from progressive-ratio (PR) schedules, and preference of one reinforcer or reinforcer magnitude over another reinforcer or magnitude under conditions when both choices are concurrently available (Bickel et al., 2000; Foster, Temple, Robertson, Nair, & Poling, 1996; Hodos, 1961; Hodos & Kalman, 1963; Hollard & Davison, 1971; Katz, 1990; Mathews & Temple, 1979).

Hodos (1961) used PR schedules in which fixed ratio requirements were initially small and increased in steps across successive reinforcements. In this case, the measure of strength is the ratio breakpoint - the ratio size at which the animal stops responding. Breakpoint-ratio size increased with decreases in body weight and with increases in reinforcer size. Breakpoint varied in an orderly way with manipulations that affect the value of the reinforcer. PR schedules and the resulting breakpoints can provide a measure of the strength of a reinforcer. Stafford et al. (1998) reviewed the use of PR schedules in basic research. PR schedules have also been used in applied settings, such as behavioral economic research using persons with developmental disabilities (DeLeon et al., 1997; Roane, Call, & Falcomata, 2005; Roane, Lerman, and Vorndran, 2001; Tustin, 1994). However, breakpoint can be problematic because of the methods used to obtain it, and because it is a discontinuous measure. The ratio size of the breakpoint has been shown to vary with the step size of the PR used (Hodos & Kalman, 1963). Stafford and Branch (1998) did not find this to be the case with direct comparison of small and large step sizes; rather, step size did not greatly affect the ratio size of the breakpoint. The breakpoint is a discontinuous measure because it only specifies the behavior at one price. It provides no further information about behavior at other prices. While the breakpoint may have certain problems, it does provide a capable method of scaling reinforcer strength that accommodates the prevailing economic constraints. An assumption of breakpoint analysis is that reinforcer value can be measured in terms of how much effort will be expended to earn it.

Measures of relative reinforcing efficacy have sometimes provided discordant results of value that cannot be easily explained (Arnold & Roberts, 1997; Stafford et al., 1998). However, behavioral economic measures have been found to be congruent with reinforcing efficacy measures, and behavioral economics can provide a parsimonious framework for evaluating and understanding reinforcer strength (Bickel et al., 2000; Johnson & Bickel, 2006). Recently, behavioral economic procedures and analyses have been utilized to assess preference and demand for qualitatively different reinforcers using single and concurrent schedules of reinforcement, thereby providing a novel scale for measuring the value of reinforcers.

Economic Demand as Strength of a Reinforcer

Behavioral economics can provide a new approach to the analysis of behavior. Borrowing the principles and language of microeconomics, behavioral economics has changed the language, methods, and predictions of operant psychology. Behavior is no longer said to be strengthened by reinforcement. Instead, animal and human subjects are considered workers earning goods in exchange for their labor, and the price paid is defined in terms of the response-reinforcer function. Graphic representation of consumption as a function of work required to produce a good replaces response rate plotted as a function of reinforcer rate. Consumption typically refers to the number of reinforcers earned per unit of time as a function of price. Price is defined in terms of response requirement or the number of responses that must be completed under a fixed ratio (FR) schedule to obtain the reinforcer. As in microeconomics, consumption graphed as a function of price is known as a demand curve. Behavioral economics provides a measure of strength based on the economics of demand. A wide variety of reinforcers have been used to evaluate demand and substitutability across a number of different species. In the same way that the value of goods can be expressed, compared, and understood in economic terms, so too can the value of reinforcers (Allison, 1983; Hursh, 1980, 1984; Lea, 1978).

Demand Analysis

Demand analysis within behavioral economics requires procedural changes to traditional operant methods. Behavioral economic procedures typically establish a stable baseline of responding and consumption under FR schedules of reinforcement, and then systematically increase the size of the FR schedule until responding drops to some predetermined level, such as 10 -15% below baseline. FR schedules are favored because of the resulting simple definition of price as responses per reinforcer. The relations between responding (work) and consumption can be described mathematically through the use of demand curve analysis. That is, demand curve analyses describe the relationship between price (the FR requirement) and consumption of a given commodity (food, water, drugs, and leisure items, etcetera).

At least three important aspects of demand curves can reveal differences in reinforcers: the elasticity of demand, the intensity of demand, and the price at which responding is the greatest (Bickel et al., 2000; Hursh, Raslear, Shurtleff, Bauman, & Simmons, 1988; Hursh, 1980). Elasticity of demand refers to the nature and degree of the relationship between changes in quantity of a demand and changes in its price. Demand can vary from inelastic, in which consumption is relatively unaffected by price increments, to elastic, in which consumption is relatively sensitive to price with demand decreasing as price increases. Figure 1 demonstrates the common case in which elasticity typically changes from point to point along the hypothetical demand curve. Inelastic demand is represented by the upper portion of the demand curve that slowly decays with

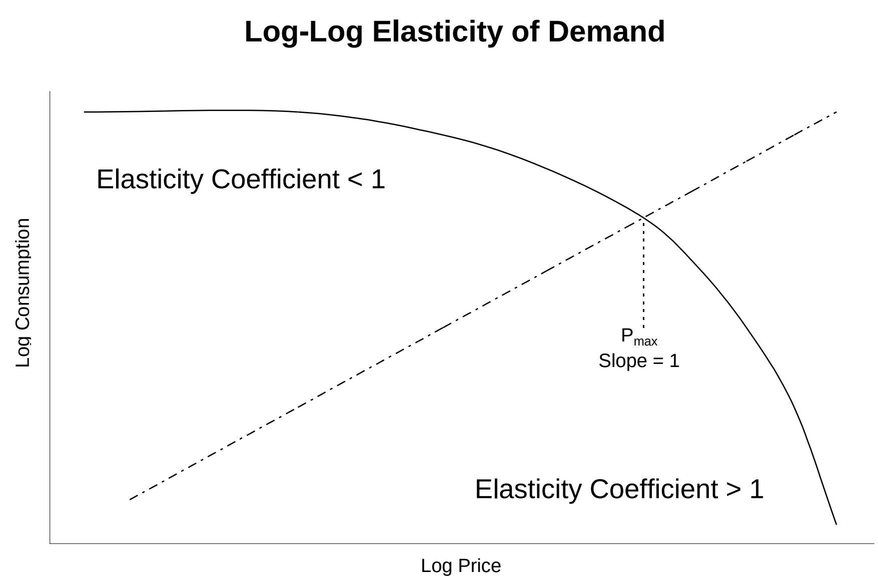

Figure 1. Log-log elasticity of demand with a hypothetical demand curve plotted in logarithmic units. The upper portion of the curve has an elasticity coefficient < 1 representing inelastic demand. The lower portion of the curve has an elasticity coefficient > 1 representing elastic demand. Price at which maximum responding occurs, P_{max}, is the price at which demand changes from inelastic to elastic. Figure adapted from Hursh (1980) with permission of the author.

increasing price meaning that a big change in price has a relatively small effect on consumption. Elastic demand is shown by the lower arm of the demand curve that steeply decelerates with increasing price indicating that small changes in price have a big effect on the quantity consumed. Most demand curves move downward so the slope is negative. The elasticity coefficient is that absolute value of the slope at any point along the demand curve scaled in logarithmic units. Graphically, inelastic demand is characterized by a demand curve with a coefficient or an absolute slope that is less than one, while elastic demand is represented by a slope greater than one (Hursh). The intensity of demand is the level of consumption of a good at a particular price, but intensity usually defines consumption at the lowest price for the good. The price sustaining maximal responding is identified by the price at which the slope of the demand curve changes from inelastic to elastic, slope equal to one, known as P_{max} (see Figure 1). Demand curve analysis can describe the cost of reinforcers, the substitutability of commodities, and consumption levels.

The model for behavioral-economic demand curves is Hursh, Raslear, Bauman, and Back's (1989) linear-elasticity equation. The equation restated in natural logarithm units is

$$\ln Q = \ln L + b\ln P - aP \qquad (1).$$

The parameters of Equation 1 relate the price (*P*) of a commodity to its consumption (*Q*). Intensity of demand, the level of consumption as the price approaches zero, is described by the variable *L*, *b* describes the initial slope of the demand curve after an imperceptibly small increase from zero-level price, and *a* is a coefficient that defines the acceleration of the curve. The value of *L* is determined empirically and typically defines the amount of consumption given unrestricted access to a commodity. The *b* value is expected to be near zero because consumption levels at near zero prices would remain the same. The maximal price a subject is willing to pay for a good is defined as,

$$P_{max} = (1 + b)/a \qquad (2).$$

Unit price (*P*) is a cost-benefit ratio reflecting the ratio of responses to magnitude of reinforcement obtained, or more simply responses/reinforcers (Collier, Johnson, Hill, & Kaufman, 1986; Hursh et al., 1988). A unit price equal to 1 can be met by an infinite number of different response requirements and reinforcer magnitudes. For example, one response for one food pellet and 100 responses for 100 food pellets both have a unit price of 1. Unit price can be manipulated by increasing the response requirement while holding the reinforcer magnitude constant, or by varying the magnitude of reinforcement. Research suggests that there is a functional equivalence between response cost and reinforcer magnitude. There is considerable empirical support for combining two independent variables, response requirement and reinforcer magnitude, into a single variable indicating unit price (Bickel, DeGrandpre, Higgins, & Hughes, 1990; Bickel, DeGrandpre, Hughes, & Higgins, 1991; Collier et al., 1986; DeGrandpre, Bickel, Hughes, Layng, & Badger, 1993; Hursh et al., 1988).

The slope of the demand curve, elasticity of demand, from the linear-elasticity equation (Equation 1) is

$$\text{Elasticity} = b - aP \qquad (3).$$

Because *a* and *b* are fixed values for each demand curve, elasticity of demand changes as a linear function of price (Hursh, 1991; Hursh et al., 1989). Setting elasticity equal to -1 and solving for *P* using Equation 3 yields the price point of unit elasticity where a 1%

increase in price results in a 1% decrease in consumption. The part of the curve to the left of the unit elasticity point represents inelastic demand, while the part to the right shows elastic demand.

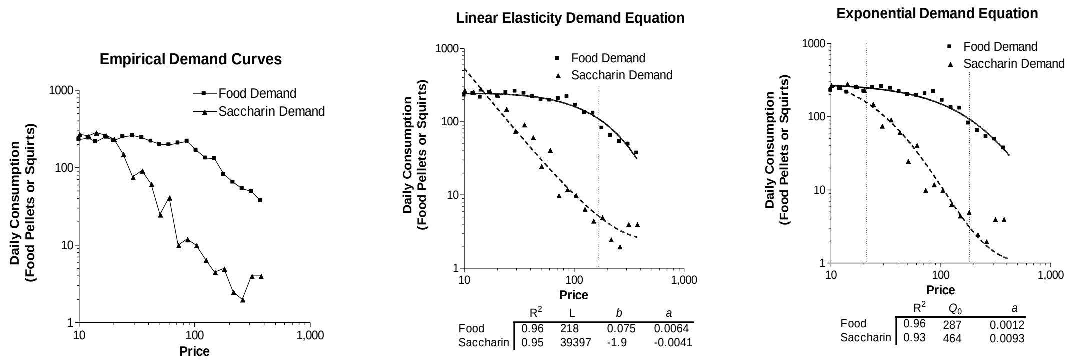

Figure 2. Three representations of demand from Hursh (1984). The left panel shows raw data, and the middle and right panels show the same data with curves fit using the linear-elasticity and exponential-demand equations. Vertical dashed lines indicate the calculated point of unit elasticity from each model. The R^2 and parameter values of each equation are shown in the table below each panel. Figure adapted from Hursh and Silberberg (2008) with permission of the author.

The linear-elasticity equation has been shown to closely predict actual responding; however, it cannot provide a single measure of reinforcer value because it models demand curves in terms of two parameters, *a* and *b*. Figure 2 shows a comparison of data with demand curves fit using different equations as well as the parameter values associated with the curves.

Exponential Demand Analysis

In an effort to identify a single measure of the value of a reinforcer, Hursh and Silberberg (2008) propose using an exponentially-based demand equation borrowed from microeconomics. The function graphed in logarithmic coordinates is

$$\log Q = \log Q_0 + k(e^{-\alpha P} - 1) \quad (4).$$

Consumption of the commodity when it is free, at a price of zero, is represented by the parameter Q_0. As in the linear-elasticity demand equation, *P* is the price of the commodity. The α parameter determines the rate of decline in relative consumption (log consumption) with increases in price. Hursh and Silberberg note that the estimated value of the α parameter is unaffected by the value of the base defining the natural logarithm. They propose that α provides a unitary measure of reinforcer value, what they term the essential value of the reinforcer. The *k* value specifies the range of the dependent variable in logarithmic units, and *k* is generally set to a common constant across comparisons. Demand elasticity is determined by both *k* and α; however, *k* is constant so changes in elasticity are determined by the rate constant α.

The predictive capability of the exponential-demand equation has been evaluated by fitting the equation to existing demand curves generated by data from previous behavioral economic research studies (see Figure 2). Hursh and Silberberg (2008) make four general observations about the exponential-demand equation. First, the exponential-demand equation appears to be just as predictive as the linear-elasticity equation although it has one less parameter. Figure 2 shows the parameter values derived from each equation. For example, the fit to the demand curves for food and saccharin from Hursh (1984) are R^2 = 0.96 and 0.95 using the linear-elasticity equation and R^2 = 0.96 and 0.93 using the exponential-demand equation. In all cases, both demand models account for greater than 90% of the variation in consumption of the two commodities under conditions of increasing price. Second, the parameter values predicted by the exponential equation are more accurate than those of the linear-elasticity model. Using the linear-elasticity equation and the same data set as above, the *L* value of saccharin, predicted consumption at zero price, is implausibly high (daily consumption of 39,397). Similarly, the predicted value of *b* for food, the initial slope of the demand curve at a low price is positive, indicating that consumption increases with price, rather than being negative or equal to zero as expected according to economic theory. Third, the exponential equation is able to predict the observed initial unit inelastic demand for saccharin; whereas, linear-elasticity predicts only elastic demand for saccharin. Fourth, the exponential-demand equation provides a single parameter estimate (α) to scale elasticity of demand as a measure of essential value given a constant range of consumption (*k*). Thus, exponential demand allows a means for defining and comparing the essential value of reinforcers.

A demand curve is dependent on the dimensions of the commodity that is purchased, so the size/amount/dose/concentration of the reinforcer will affect the elasticity of demand. That is, demand curves differ in form for different amounts of the same good under increasing FR schedules. Consequently, directly ranking the demand elasticity of each good will confound comparisons of value across commodities. Hursh and Winger (1995) described a normalization procedure that eliminates dimensional differences of a good. Consumption (Q) and price (P) raw data are transformed into scalar equivalents expressed in terms of percentages of maximal consumption. The exponential model predicts that maximal consumption will occur at zero price, Q_0 in the exponential equation (Equation 4). However, Q_0 is hypothetical because in practice at least one operant response is required to earn each unit of reinforcement. The value of Q_0 can be estimated in terms of the consumption at the lowest response requirement during baseline (Hursh & Silberberg, 2008). The transformation process can reduce two or more baseline values derived from commodities with differing scalar properties, such as magnitude, to a single value by defining each level of baseline consumption as 100% satiation during approximately unconstrained access to the reinforcer. Reinforcers earned under each programmed schedule of reinforcement can then be expressed as a percentage of baseline consumption. Hursh and Silberberg outline a simple example of normalization: one reinforcer to participant A that earns 100 reinforcers during baseline is equivalent to earning 1% of daily consumption for each completed response requirement ($100/Q_b = 100/100 = 1$). If the reinforcer is twice the size and only 50 reinforcers are earned by participant B during baseline, then every reinforcer is equal to 2% of daily consumption ($100/Q_b = 100/50 = 2$). Price (P) is similarly transformed by defining P as the number of responses required to earn 1% of daily consumption. So, participant A earning 1% of consumption on a FR 1 and participant B earning 2% of consumption on a FR 2 are paying the same unit price in responses for each reinforcer (FR 1/1% = 1/1 = 1 and FR 2/2% = 2/2 = 1).

Normalized demand curves represent normalized consumption as a function of normalized price. The axis transformations typically result in the convergence of the two demand curves obtained with different magnitudes of reinforcement into a single curve that eliminates dimensional differences (Hursh & Silberberg, 2008; Hursh & Winger, 1995; Ko, Terner, Hursh, Woods, & Winger, 2002; Winger, Hursh, Casey, & Woods, 2002; Winger, Woods, & Hursh, 1996). Failures of superimposition have occurred at extremely high and low magnitudes of drug reinforcers where essential value is lowered due to toxic levels and below threshold doses respectively (English, Rowlett, & Woolverton, 1995; Hughes, Sigmon, Pitts, & Dykstra, 2005; Sumpter, Temple, & Foster, 1999). As pointed out by Hursh and Silberberg, intermediately sized reinforcers are most likely to be purchased in natural economic contexts or given for therapeutic benefit.

The two original demand curves for each reinforcer must approximately superimpose upon one another after normalization in order to utilize the exponential-demand model to make essential value comparisons among reinforcers. If the normalized demand curves generated for the reinforcer superimpose on each other as a single demand curve, then the value of the α parameter of the exponential function will be closely approximated (Hursh & Silberberg, 2008). Note that normalized consumption must be logged prior to curve fitting because the exponential-demand equation (Equation 4) is in terms of log Q as a function of P. Normalization of demand facilitates essential value determination by eliminating the confounding influence of variations in the dimensional properties of the reinforcer. According to Hursh and Silberberg, dimensional variations such as amount, size, dose, or concentration of a reinforcer are variations in the constraint on obtaining the reinforcer rather than variations in the essential value of the reinforcer. The normalization process can control for dimensional differences of a reinforcer, does not obscure differences in essential value, and can detect differences in essential value due to the quality or context of reinforcement.

Hursh and Silberberg (2008) evaluated the exponential-demand model using normalized data obtained from numerous published studies of demand for a variety of reinforcers, including consumables and non-consumables, across species, in various economic contexts, and under different FR and PR schedules of reinforcement. Without exception, the exponential-demand equation (Equation 4) was capable of accommodating the majority of variance within the obtained data. Essential value comparisons can be made among any reinforcers that show dimensional indifference following the normalization process. The good with the highest essential value as defined by the α parameter in exponential equation has the lowest elasticity of demand (Hursh and Silberberg). There are several notable characteristics of the units and the relationships among the units of the exponential-demand equation proposed by Hursh and Silberberg. The units of price (*P*) are the inverse units of essential value (α), so because the units of *P* are cost/benefit then the units of α are benefit/cost. In other words, the α parameter determines the sensitivity of consumption to changes in price.

While the exponential-demand model utilizes the shape of the demand curve as the metric for essential value, there are other relevant measures of value. P_{max} was previously advanced as a measure of essential value (Hursh et al., 1989; Hursh & Winger, 1995), but the linear-elasticity model had two free parameters. Unit price was chosen to summarize the free parameters into a derived value to describe the shape of the demand curve. Recall that P_{max} is the point of maximal responding, where the slope of the demand curve equals -1. P_{max} is related to the effects of price on consumption; for example, demand curves that are less sensitive to price will have higher P_{max} values. As a result, P_{max} is related to essential value. P_{max} has new meaning in the exponential-demand model. Hursh and Silberberg (2008) suggest that P_{max} derived from a normalized demand curve has an inverse relationship to the α parameter in the exponential-demand model. Therefore the exponential-demand model provides a basis for also using P_{max} as a direct measure of essential value. P_{max} can provide information about the shape of exponential demand and its underlying response-output function.

Several additional procedural aspects are important in behavioral economic studies of demand and value. Certain economic conditions and operant methods can affect demand for reinforcers. The prevailing economic context can greatly influence elasticity of demand as well as response rate. Procedural variations for generating demand curves provide similar results; however, a rapid method for demand curves can save considerable time by exposing the subject to each reinforcement schedule for only one session. Effective and efficient demand analysis can be conducted with careful consideration of these topics.

The Economic Context

The overall availability of a commodity defines the economy. Hursh (1980) distinguished between open and closed economies. An open economy is one in which there is some independence between total daily consumption and interactions with the schedule of reinforcement. Open economies are usually arranged by providing additional access to reinforcement between sessions or by specifying a minimum number of presentations each session so that intake remains relatively constant. On the other hand, a closed economy is one in which total daily consumption is determined solely by the worker's interaction with the schedule of reinforcement (Hursh, 1980). Because the price the worker pays is viewed as a behavioral adjustment to meet consumptive need, demand analysis is more manageable when all goods are earned within a closed economy and no goods are freely provided (Hursh, 1980, 1984). A closed economy is preferable for experimental control purposes but is typically only attainable in basic research studies with animals. Open economies are much more common with human participants. Research suggests that the overall economy may play a significant role in the behavioral effects of reinforcement schedules (Collier, Hirsh, & Hamlin, 1972; Collier et al., 1986; Hursh, 1978, 1980, and 1984; Lea, 1978; Roane et al., 2005; Zeiler, 1999). The economic context should be treated as an independent variable (Lea). It should be noted that economic conditions can have a marked effect on elasticity of demand (Hursh et al., 1989) and how the schedules of reinforcement influence behavior (Roane et al., 2005; Zeiler). An open economy typically increases elasticity of demand, so essential value is also sensitive to economic constraints with a reinforcer losing value in an open economy (Hursh & Silberberg, 2008). A closed economy typically sustains higher rates of responding and results in more inelastic demand and higher essential value for the available commodity than an open economy.

Another important aspect of the economic context is the availability and price of other commodities (Lea, 1978). What has been referred to as elasticity of demand is more correctly own-price elasticity of demand. In contrast, cross-price elasticity of demand is the function relating the price of one commodity to the consumption of another (Hursh & Bauman, 1987). Own-price elasticity describes the relationship between the price of commodity A and its consumption. Cross-price relations lie on a continuum from substitutes to complements. Substitutes are commodities that share important functional properties and are characterized by a cross-price demand curve with a slope greater than zero (Green & Freed, 1993; Hursh, 1980; Hursh & Bauman). As the price of one commodity increases and its consumption subsequently decreases, the consumption of a substitute will increase. Substitute relations range from perfect to imperfect. An example of perfect substitutes would be identical commodities, such as the same food available from two different sources. Imperfect substitutes share similar properties but are not identical commodities, such as a standard food pellet and sucrose pellet. Independents are commodities that do not share important functional properties and are characterized by a cross-price demand curve with a slope of approximately zero. As the price of commodity A increases and subsequent consumption decreases, the consumption of an independent will remain unchanged; for example, coffee and movie tickets. Complements are commodities that share important functional properties; however, unlike substitutes they are characterized by a cross-price demand curve with a slope less than zero. The consumption of a complement decreases with increases in the price of an alternative commodity. Examples of complements include food and water, coffee and sugar, and movie tickets and popcorn. In general, elasticity of demand is greater when alternatives are available in the economy (Bauman, Raslear, Hursh, Shurtleff, & Simmons, 1996; Lea & Roper, 1977).

Procedural Considerations

The evaluation of steady-state behavior has been a standard practice in behavior analytic research (Johnston & Pennypacker, 1993; Sidman, 1960). Johnston and Pennypacker define a steady state as "a pattern of responding that exhibits relatively little variation in its measured dimensional quantities over a period of time" (p. 199). Typically, behavioral economic research evaluates a particular response requirement until some measure of stability is met - a process that can take up to six months to generate a demand curve with five data points (Raslear, Bauman, Hursh, Shurtleff, & Simmons, 1988). However, it has recently been demonstrated that evaluating a particular response requirement for only one day produces results comparable to responding obtained by running to stability and significantly reduces the time and costs required to conduct a behavioral economic assessment (Foster, Blackman, & Temple, 1997; Foster, Temple, Cameron, & Poling, 1997; Raslear et al., 1988).

Raslear and colleagues (1988) examined the influence of generating demand curves rapidly, within one week, by conducting only one session at each FR value using a between-subjects design. Their results indicated that a rapid method was capable of producing stable and replicable demand functions within a week. Subsequently, Foster, Blackman, and Temple (1997) compared rapid demand curves and demand curves from steady-state data using a within-subject design in an open economy. Comparisons were made of data obtained from individual hens working under seven different FR schedules of grain delivery, with each schedule in effect for a single session or for multiple sessions ranging from 37 to 53. Responding under a FR value for either one or five sessions in a closed economy was also assessed. The results of Foster, Blackman, et al. demonstrated that the multi-session data and single-session data were similar, and they concluded that "extended exposure to each FR value did not differ consistently from the functions obtained from the other conditions" (p. 72). The findings extend the generality of rapid demand curves. Foster, Temple, Cameron, et al. (1997) evaluated demand curves generated by hens working under FR or PR schedules of grain delivery. In the first PR phase, hens were exposed to a PR 5 schedule in which the first response produced food, and thereafter, the ratio requirement increased by five each time food was earned. Then a FR phase was implemented in which the hens were exposed to FR 5 baseline conditions for eight consecutive sessions. Subsequently, an increasing FR phase was conducted in which the FR value increased by five responses each session, with this phase lasting between 32 and 53 sessions for individual subjects. A return to baseline for eight sessions and then a return to the PR condition for 15 sessions followed. The data from 10 PR sessions, the final five sessions from each PR condition, and the data from the FR condition were used to generate demand curves. The authors noted that Equation 1, the linear-elasticity model, described the data well and that there were several noteworthy differences in the parameter estimates under the PR and FR schedules. First, initial consumption (*L*) was higher under the PR schedule than under the FR schedule. Second, the initial slope (*b*) was steeper under the PR schedule than under the FR schedule. Third, the rate of change (*a*) was greater under the PR schedule than under the FR schedule. Overall, the demand curves generated under the different conditions were similar. The magnitude of the observed differences was small and the demand curves generated under both conditions were similar to those obtained by Raslear et al. A similar procedure has been used to assess the reinforcing efficacy of cigarettes in humans (Bickel, Hughes, DeGrandpre, Higgins, & Rizzuto, 1992; Bickel & Madden, 1999; DeGrandpre, Bickel, Higgins, & Hughes, 1994; Madden et al., 2000; Shahan, Bickel, Madden, & Badger, 1999). The results of these studies suggest that meaningful and interpretable data can come from rapid demand curve analysis studies that evaluate a single value for only one session.

It has been proposed that exponential demand provides an index for scaling the essential value of reinforcers. Value derived from exponential demand can provide an alternative to assessing value in terms of preference. Relative-reinforcer efficacy as a measure of value in choice arrangement fails because preference is not independent of income and price. From a behavioral economic perspective, preference is the result of comparative levels of consumption; and the demand curves of the chosen goods describe the more general impact of different reinforcers on behavior across an array of economic constraints. Hursh and Silberberg (2008) maintain that essential value is superior to preference as an approach for defining reinforcer value, and demand analysis can be conducted quickly using rapid methods to generate demand curves. A behavioral economic approach can easily answer the question of how hard an animal or individual will work to obtain goods, which is an issue of practical concern to behavioral practitioners. Moreover, comparisons of essential value based on exponential demand derived from standard units of consumption and price provide a quantitative index that reflects an organism's priorities of need.

Preference Assessment in Persons with Developmental Disabilities

The Administration on Developmental Disabilities (ADD) of the Department of Health and Human Services estimates that 4.5 million people in the United States are developmentally disabled (Administration on Developmental Disabilities, 2006). According to the Developmental Disabilities Assistance and Bill of Rights Act of 2000 (DD ACT 2000, pp. 7-8), developmental disabilities are characterized by severe persistent mental and/or physical impairments that are manifested before age 22 and that result in substantial functional limitations. Limitations can occur in multiple areas of functioning, including self-care, receptive and expressive language, learning, physical mobility, self-direction, capacity for independent living, and economic self-sufficiency (DD ACT 2000, p. 8). Federal legislation passed during the past 30 years has significantly changed the rights of individuals with disabilities to live independently, to exert control and choice over their own lives, and to fully participate in and contribute to their communities through full integration and inclusion in the economic, political, social, cultural, and educational mainstream of United States society (DD ACT 2000, p. 2). Furthermore, research has demonstrated that individuals with developmental disabilities can learn through the application of behavior analytic principles such as shaping, reinforcement, discriminative control and generalization.

The Importance of Individual Preferences

Both legislation and research findings indicate the importance of incorporating individual preferences into the home, school, and work environments (Developmental Disabilities Assistance and Bill of Rights Act, 2000; Bannerman, Sheldon, Sherman, and Harchik, 1990). Preference identification also allows those working with individuals with developmental disabilities to identify and use potent reinforcers, thus enhancing learning and performance. However, these goals cannot be reached if an individual's preferences cannot be determined. Many persons with disabilities are unable to report their priority of needs and wants. The right to make choices (as an indication of personal preference) is guaranteed by federal legislation (Declaration of Rights of Mentally Retarded Persons, 1971; DD ACT 2000). Bannerman et al. (1990) review additional arguments supporting the right to choose. Research has demonstrated that choice may be associated with increases in appropriate behavior, improvements in task performance, and decreases in problem behavior (see Bannerman, et al. for a review). According to DeLeon, Fisher, Rodriquez-Catter, Maglieri, Herman, and Marhefka, (2001), providing choices may help to increase or sustain responding through three mechanisms. First, providing choices may accommodate shifts in preferences that occur over time, ensuring that an individual has access to highly-preferred stimuli. Second, providing choices increases reinforcer variation, which can reduce or prevent satiation in most cases. Third, providing choices may be reinforcing which can add to the reinforcement value of the selected item (DeLeon et al.). More importantly, stimuli must be identified as highly preferred to the individual so that choice is truly representative of value. The field of applied behavior analysis has developed several different systematic methods for identifying the preferences of those with disabilities.

Stimulus-Preference and Reinforcer Assessment Procedures

The phrase preference assessment often refers to the culmination of stimulus-preference and reinforcer assessments procedures. However, it is necessary to distinguish between stimulus-preference and reinforcer assessments because the two procedures provide different types of information about the stimuli. A stimulus-preference assessment provides a ranking of a large array of items according to preference, with preference typically measured and defined in terms of approach and/or consumption of a stimulus. For example Pace, Ivanic, Edward, Iwata, and Page (1985) used 16 different stimuli to identify items and activities that ranged from high to low preference for each participant. The stimulus-preference assessment provides information about individual preferences, usually for a relatively large number of items. The results do not indicate or demonstrate the reinforcer efficacy of the stimuli under evaluation (Fisher, Piazza, Bowman, & Amari, 1996). On the other hand, the reinforcer assessment provides information about reinforcer efficacy by evaluating the effects of contingent delivery of the stimulus on a target response (Fisher et al., 1996). Typically, the stimuli that are highly preferred are evaluated in the reinforcer assessment. However, some research studies have systematically evaluated the reinforcing efficacy of stimuli along the continuum of preference rankings (Graff, Gibson, & Galiatsatos, 2006; Paramore & Higbee, 2005; Piazza, Fisher, Hagopian, Bowman, & Tool, 1996; Taravella, Lerman, Contrucci, & Roane, 2000). These studies indicate that all items identified via a stimulus-preference assessment as highly preferred might not necessarily function as reinforcers for an individual, and that some low-preferred items might actually function as reinforcers. Preference and reinforcer efficacy has also been shown to vary across time, settings, behaviors, and response requirements. Stimulus-preference assessment and reinforcer assessment are usually conducted in conjunction in order to identify highly-valued stimuli that will function as effective reinforcers for persons with developmental disabilities. However, standard preference assessment procedures have often failed to meet this goal, and cannot provide a valid, unitary, quantitative index of reinforcer value.

Stimulus Preference Using Caregiver Derived Stimuli

Reinforcement-based procedures are used extensively in the treatment of people with developmental disabilities to establish and increase repertoires of appropriate behavior and reduce maladaptive behavior. Considering the critical role that reinforcement plays in current technologies employed in treating, training and educating individuals with developmental disabilities, the identification of stimuli that function as reinforcers for this population is crucial to the success of any behavioral intervention. However, identifying potent reinforcing stimuli for those with severe to profound mental retardation or multiple disabilities, such as mental retardation and cerebral palsy can be very difficult given their limited response repertoires (Rincover, Newson, Lovass, &

Koegel, 1977; Wacker, Berg, Wiggins, Muldoon, & Cavanaugh, 1985). For example, if an individual does not interact with a stimulus, it is unclear whether the stimulus is a non-preferred item or the client is merely unfamiliar with the stimulus. Alternatively, if an individual is exploring a new stimulus, the time allocated to exploring may be considered an indication of preference, resulting in the contingent delivery of a neutral or potentially aversive stimulus (Wacker et al.). Reinforcer surveys can be used with higher functioning persons, but self-report methods are not always applicable to persons with developmental or learning disabilities.

Given that conventional reinforcer identification procedures may not be as effective for those with severe developmental disabilities, practices such as informal observation and reports given by staff members and caregivers about seemingly preferred stimuli are not uncommon (Green, Reid, Canipe, & Gardner, 1991; Mason, McGee, Farmer-Dougan, & Risley, 1989). Such reports are speculative and may not accurately predict reinforcer value. However, there is support for using caregiver generated stimuli rather than using stimuli from a standardized set when conducting empirical preference assessment procedures (Green et al., 1991; Parsons & Reid, 1990). Parsons and Reid suggested that caregivers may be able to identify the most highly preferred items from a large array of foods and drinks, but may not be able to identify which item the individual will choose when stimuli were presented in pairs. Green et al. (1991) found that caregiver report may facilitate the reinforcer process, although caregivers may not reliably predict all cases of preference. These studies offer some support for the use of caregiver report in conjunction with an empirical preference assessment to identify preferred items for individuals with developmental disabilities.

Shortcomings associated with using a standard pool of potential reinforcers led to attempts to clarify the role of caregiver report in the reinforcer selection process. Because the use of a standardized set of stimuli had not consistently identified functional reinforcers; and the utility of caregiver report appeared to be enhanced by empirical-preference assessment, a structured caregiver interview was developed, called the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD) (Fisher et al., 1996). The RAISD is used to facilitate caregiver nomination of a list of potential reinforcers across a number of different sensory modalities that include visual, audible, olfactory, tactile, edible, movement, social attention, and toys. After the list is generated, caregivers are questioned further to obtain information that will allow investigators to delineate the conditions under which the stimuli are typically preferred. The stimuli that can be delivered easily using differential reinforcement procedures are then ranked by caregivers according to the hypothesized preferences of the individual. Fisher and colleagues found that stimuli identified by caregivers using the RAISD were more effective reinforcers on subsequent concurrent-choice assessments than stimuli ranked by caregivers from a standardized set. In the first phase, caregivers were asked to rank 16 stimuli identified with the RAISD and 16 standard stimuli according to perceived participant preference. A choice assessment (Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin, 1992) was then conducted with each set of 16 stimuli, and rank-order correlation coefficients were compared. The correlation between caregiver rankings of the standard stimuli and the results of the choice assessment was not significant (r = 0.19). The correlation for the caregiver rankings of the RAISD stimuli and the results of the choice assessment with the RAISD stimuli was significant (r = 0.32; $p < .005$).

Although the latter correlation was significant, the correlation was low, suggesting that the RAISD should not be used in place of the empirical assessment (Fisher et al.).

In a second phase, a reinforcer assessment was conducted using the most highly preferred stimuli from each choice assessment to evaluate their predictive utility in identifying reinforcers (Fisher et al., 1996). In the reinforcer assessment, concurrent schedules of reinforcement were used. They consisted of two chairs or squares outlined in tape on the floor: one associated with a highly-preferred caregiver stimulus and the other associated with a highly-preferred standard stimulus. Results were consistent with the findings reported by Green et al. (1991), in that caregivers did not accurately predict preferences of subjects from a standard set of stimuli; but were more accurate when stimuli were generated via the RAISD. Moreover, the choice assessment identified more potent reinforcers when caregiver-generated stimuli were used than when stimuli from a standardized set were used.

Empirical Evaluation of Stimulus Preference

The reinforcing effects of different stimuli vary widely across individuals. Because preferences seem to be idiosyncratic for each person, the reinforcer selection process could potentially be a laborious undertaking that might fail to identify functional reinforcers. A major technological advance in applied behavior analysis was the systematic delineation of stimulus preference for individuals with developmental disabilities. However, researchers have yet to develop a reliable, valid, and cost-effective set of standardized procedures for evaluating the reinforcing properties of various stimuli. Rather, various procedures have been empirically investigated and compared, producing a complex set of data. Pace et al. (1985) reported one of the first studies to address the problem of reinforcer selection by identifying preferred stimuli and subsequently evaluating the reinforcing effects of those stimuli.

Single-Stimulus Preference Assessments. The procedure developed by Pace and colleagues (1985) consisted of two steps (henceforth referred to as the Pace procedure), the first involving an empirical assessment of stimulus preference and a second involving an evaluation of the reinforcing effects of the identified stimuli. The stimulus-preference assessment consisted of repeated presentations of a variety of items, and the dependent measure was approach behavior to differentiate preference among the stimuli. Sixteen different stimulus items were evaluated during the assessment with each presented 10 times, and the stimulus properties of the items represented a number of different sensory modalities such as light for visual stimulation and coffee grounds for olfactory stimulation. Participants were six individuals with profound mental retardation who evidenced no obvious sensory impairment, although two of the participants were non-ambulatory. If the participants did not approach the stimulus, they were prompted to sample the item briefly, after which a second probe was presented. This procedure was included to ensure that lack of preference was not due to unfamiliarity with the item (Pace et al., 1985). The authors calculated the percentage of trials on which each participant approached the 16 stimuli. Preferred stimuli were defined as those approached on at least 80% of trials, while non-preferred stimuli were defined as those approached on a maximum of 50% of trials. The reinforcer-assessment phase involved verbal requests with accompanying modeled prompts for a variety of target responses that included reaching, making eye contact, raising a hand, and touching one's head. In two experimental conditions, either a preferred or non-preferred stimulus was provided contingent upon correct responding. In general, results indicated that an increase in target responses was associated with preferred stimuli compared to baseline conditions of non-preferred stimuli. However, not all the items identified as highly preferred functioned as reinforcers, and one non-preferred item functioned as a reinforcer for one participant.

Building on the Pace procedure, Green, Reid, White, Halford, Brittain, and Gardner (1998) evaluated the reinforcing efficacy of preferred items in vocational skill-training programs. The results of the reinforcer assessment suggested that the stimuli empirically assessed to be highly preferred by the participants were likely to function as reinforcers for certain skills, and no low-preferred stimuli served as reinforcers. In one case two items that were assessed to be highly preferred did not function as reinforcers for the target behavior, a finding consistent with the results reported by Pace and colleagues (1985). It was hypothesized that the target behavior, placing a utensil in a container, may have been too difficult for the participant thus explaining the lack of reinforcement effects (Green et al., 1998). After simplifying the task to switch pressing, one of the highly preferred items then served as a reinforcer for the target behavior.

Early studies found that all items identified as highly preferred did not subsequently function as reinforcers in all instances. These findings may represent a lack of correspondence between stimulus preference and reinforcement value using the single-stimulus presentation format developed by Pace et al. (1985), or it may be the case that reinforcement effects do not extend across all behaviors. That is, high-preference stimuli may serve as reinforcers for some behavior but not others.

Paired-Stimulus Preference Assessments. Because the preference assessment developed by Pace and colleagues (1985) has been shown to identify some stimuli as highly preferred that failed to function as reinforcers, a more valid assessment procedure was needed. The earliest forced-choice preference assessment procedures were used in conjunction with the Pace procedure (Mason et al., 1989; Parsons & Reid, 1990). Mason and colleagues used a daily, brief, concurrent-choice arrangement to evaluate minor shifts in preference among the small array of highly-preferred stimuli identified by the Pace procedure. The first item selected from each pair was used in a subsequent reinforcer-assessment session. Contingent delivery of the items selected by the participant during the choice assessment resulted in increased independent responding on a discrimination task (receptive body parts) and decreased maladaptive behavior during experimental sessions. Mason et al. (1989) suggested that conducting preference assessments prior to each session might enhance treatment effects. Another application of concurrent choice assessment was reported by Parsons and Reid. Food and drink items were presented in pairs over the course of 10 sessions that each consisted of one sample and five assessment trials. In the sample trial, the participant was instructed to sample a small portion of both items. During stimulus-preference assessment trials, the pair of items was placed in front of the participant and the experimenter prompted the individuals to "pick one." No reinforcer assessment was conducted to determine the reinforcing efficacy of the preferred items. However, this study offered additional support for the use of forced-choice assessment procedures.

Fisher et al. (1992) described a systematic paired-stimulus (PS) preference-assessment procedure that was found to be more effective for identifying reinforcers than the Pace procedure. In this choice assessment, the 16 stimuli under evaluation were taken from a standardized set of stimuli that represented a variety of sensory modalities. Fisher and colleagues varied presentation formats – stimuli were presented in both a single-stimulus and a forced-choice format, and approach responses to the stimuli were the dependent measure. The investigators hypothesized that the PS procedure would more selectively differentiate between high and low-preference stimuli than the single-stimulus preference assessment (Fisher et al.). Results indicated that all stimuli identified as highly preferred in the PS assessment were also highly preferred in the single-stimulus preference assessment. However, the single-stimulus procedure identified 27 additional items as highly preferred that were not identified via the choice procedure.

The second phase of the study consisted of a concurrent-operant-reinforcer assessment rather than a single-operant arrangement. That is, reinforcing efficacy for the items was evaluated using concurrent schedules of reinforcement. Concurrent schedules have been used in both basic and applied research to investigate choice behavior and preference (Catania, 1963, 1966). This arrangement generally consists of the participant having simultaneous access to at least two consequences: each associated with a different response or response requirement (Fisher et al., 1992). Continuous reinforcement (FR 1) schedules were used by Fisher and colleagues. During the reinforcer assessment, the room was divided into two squares with tape, and a chair was placed in each square. Each area was associated with a stimulus identified either as highly preferred in both preference assessment formats or by the single-stimulus preference assessment only. To gain access to the stimuli, the participant had to sit in the chair or stand in the square – behaviors that were in the child's repertoire. Results suggested that the forced-choice assessment was a better predictor of which stimuli would function as reinforcers under concurrent FR 1 FR 1 schedules than the single-stimulus preference assessment.

The PS procedure developed by Fisher and colleagues (1992) continues to be used for preference assessment in persons with developmental disabilities. However, the practice of using a standard set of stimuli for empirical assessments has been discontinued in favor of using stimuli identified by caregivers. The generality of the force-choice procedure has been demonstrated with alternative populations, including persons with mental retardation and visual impairments (Paclawskyj & Vollmer, 1995), children with attention deficit hyperactivity disorder and adolescents with emotional-behavioral disorders (Northup, George, Jones, Broussard, & Vollmer, 1996; Northup, Jones, Broussard, & George, 1995; Paramore & Higbee, 2005). The findings of these studies are consistent with those of Fisher et al. (1992) in reporting that a forced-choice format enhances the predictive validity of preference assessments in determining effectiveness of reinforcers.

Multiple-Stimulus Preference Assessments. Procedures consisting of concurrent presentations of more than one stimulus (Fisher et al., 1992) have been shown to predict reinforcer efficacy more accurately than single-stimulus procedures (Pace et al., 1985). Another procedure involving concurrently available stimuli was developed and evaluated by Windsor, Piche, and Locke (1994). With the multiple-stimulus (MS) procedure, a group of items was presented with replacement so that all items were available on every trial. The MS procedure was compared to the PS procedure in terms of the preference rankings, preference consistency, and administration time. In addition, staff rankings of participants' preferences were compared to the results of each stimulus preference assessment. The array of stimuli used in the preference assessments was identified by three staff members who were familiar with the participants. Only edible items were selected because they were currently used in programmatic activities. The PS procedure was similar to previous forced-choice assessment procedures (Fisher et al.) except that each item was paired with every other item twice, resulting in 10 presentations of each edible item in 150 trials. During the MS procedure, all six items were presented simultaneously in random order on every trial. In order to provide 10 presentations of every item as in the PS assessment, the MS procedure was administered 10 times.

The results indicated that similar preference rankings were identified in both the paired-and multiple-stimulus procedures, although the consistency of preference across administrations was higher for the paired-stimulus procedure. In addition, the PS assessment took approximately two to three times longer to conduct than did the MS procedure. Finally, staff ranking of preferences of the participants was not significantly correlated with either procedure, although the most highly preferred items as identified by both assessment procedures and staff ranking were generally in agreement. Although the MS procedure required significantly less time to conduct, the higher consistency associated with the PS procedure relative to the MS procedure (0.631 using Kendall's rank coefficient of concordance) may actually designate the PS procedure the more efficient assessment (DeLeon & Iwata, 1996). Given that several administrations of the MS assessment may be needed to identify somewhat stable individual preferences, a single administration of the PS assessment may be more desirable (DeLeon & Iwata). Moreover, because the most highly-preferred stimuli were available during every trial of MS procedure, some items were never selected, resulting in no differentiation among stimulus preferences. According to the 80% approach criteria for designating high-preference stimuli (Fisher et al., 1992; Pace, et al., 1985), items not selected might not be expected to function as reinforcers. The MS procedure may therefore be more likely than the PS procedure to portray stimuli as ineffective reinforcers based on a participant's seeming lack of preference, although the stimuli may in fact function as reinforcers when evaluated during a reinforcer assessment (DeLeon & Iwata).

Multiple-Stimulus Without Replacement Preference Assessments. In an attempt to combine the best features of the PS and MS procedures, another type of multiple-stimulus preference assessment was evaluated in which selections from any array of stimuli were made without replacement (MSWO) (DeLeon & Iwata, 1996). DeLeon and Iwata compared three methods of stimulus presentation, a MSWO format, a MS format (Windsor et al., 1994) and a PS format (Fisher et al., 1992). The PS format served as the standard for comparison. The dependent measures of interest were rank-order correlations with the PS assessment, consistency of preference across administration, administration time, and the number of potentially reinforcing stimuli identified. During a second experiment, the reinforcing effects of stimuli that were not selected during the multiple-stimulus procedure but selected during the MSWO and paired-stimulus procedures were evaluated.

Seven stimulus items were selected for each of the participants, with most items chosen arbitrarily by experimenters unfamiliar with participant preferences. A small number of items were chosen based on casual observation and caregiver report. Prior to the first session, participants were allowed to sample all edible items and interact with each leisure item for 30 seconds to insure familiarity with the stimuli. During the first trial of the MSWO procedure, all seven items were placed in a random order in a straight line on a table in front of the individual. The participant was instructed to pick an item, and the first item contacted resulted in access to the item. The leisure or edible item was not replaced for the next trial, and items were rotated by moving the item on the far left to the far right and spacing the items at equal distances from one another. The assessment continued until all stimuli were chosen or no choice response was made within 30 seconds of the beginning of the trial. The MSWO assessment was administered five times. The MS procedure was identical to the MSWO procedure except that stimulus items selected were replaced before the beginning of the next trial. The PS procedure was identical to the Fisher et al. (1992) choice assessment. During the second experiment, four items never chosen in the MS assessment but chosen on some percentage of trials during the MSWO and PS assessments were presented contingent on target responses to evaluate the reinforcing effects of the stimuli. Target responses for the participants were placing a checker piece into a Connect Four game, pressing an ink stamp onto a standard size legal pad, pressing a response panel that activated a microswitch, and placing wooden blocks into a plastic bucket.

During the first experiment, the three assessment formats generally produced comparable results in terms of the high-preference stimuli identified. It was also found that both the PS and MSWO procedures yielded more consistent rankings across administrations than did the MS procedure. Further, the MS and MSWO procedures each required less administration time than the PS procedure, with the MS procedure generally taking slightly less time to administer than the MSWO procedure. Finally, the PS and the MSWO procedures identified a greater number of potential reinforcers than did the MS procedure when 25 of the 49 items assessed were never selected by the participants. Of those 25 items that were not selected, 21 of those items (84%) were selected on some percentage of trials during the PS and MSWO procedures. During the second experiment, the contingent delivery of stimuli that were never selected during the MS assessment but were chosen on some proportion of trials in the PS and MSWO assessments resulted in increases in target responding for three of four participants. Therefore, it seems that the MS assessment procedure is susceptible to the production of false negatives, or the identification of seemingly non-preferred items, that actually function as reinforcers when schedule requirements are low.

In an effort to extend the research on MSWO assessments, Carr, Nicolson, and Higbee (2000) demonstrated that MSWO procedures developed by DeLeon and Iwata (1996) could be conducted more efficiently by administering the assessment three rather than five times. It should be noted, however, that the brief MSWO assessment was not directly compared to the standard five-session assessment. The subsequent reinforcer assessment evaluated the predictions of the stimulus-preference assessment in a naturalistic setting with curriculum-based target responses. In another comparison study of PS and MSWO assessments, DeLeon et al. (2001) evaluated relative reinforcer efficacy of stimuli identified by a single pretreatment PS assessment and daily pre-session MSWO assessments. When the results of the daily MSWO differed from the PS assessment, the relative reinforcer efficacy of both highly preferred stimuli was directly compared in a concurrent operant arrangement. For example, three identical tasks were placed on a table in front of the participant, and each was associated with a differential consequence by placing the items behind the task materials. The control task did not produce access to either of the stimuli. The results indicated that participants generally responded more on tasks associated with the stimuli identified through the daily MSWO procedure (DeLeon et al.). For two of the five participants, stimulus selection was consistent across days. The results suggest that individual's preferences as measured by standard assessment procedures can vary from day to day.

An important consideration of the various methods of stimulus and reinforcer-preference assessments is how well they can predict reinforcer efficacy. The effectiveness of reinforcement can be affected by a variety of procedural, dimensional, and idiosyncratic variables.

Assessing the Predictive Validity of Preference Assessments

In a study designed to investigate the correspondence between the degree of preference and reinforcer efficacy, the predictive validity of a choice assessment in determining the relative reinforcement value of high, middle, and low-preference stimuli was conducted by Piazza, Fisher, Hagopian, et al. (1996). The RAISD was used with caregivers to produce a list of potential reinforcers for each of four participants. First, a forced-choice assessment was conducted using the procedure described by Fisher et al. (1992). A reinforcer assessment was then conducted in which the reinforcing value of high, middle, and low-preference stimuli was evaluated. Prior to each reinforcer assessment session, a brief choice assessment (Mason et al., 1989) was conducted, with each of the three stimuli from each category being paired with every other stimulus in the category, resulting in three trials. The stimulus selected most frequently was used in the subsequent session. If no stimulus was selected more frequently than the others, one was randomly assigned for use in the upcoming session. High-preference stimuli were the three stimuli chosen most frequently in the choice assessment. The middle-preference stimuli were those three items chosen closest to the median number of times, and the low-preference items were the three items chosen least. During the reinforcer assessment, a concurrent-operants arrangement was used to compare high and middle-preference items, high and low-preference items, and middle and low-preference items using in-square or in-chair behavior as the target response. A third square and chair that was associated with no items was used as a control. Results showed that high-preference items functioned reliably as reinforcers for all participants, while middle-preference items functioned as reinforcers for two of four participants, and low-preference items did not serve as reinforcers for any participant. Thus, it appeared that the choice assessment developed by Fisher et al. (1992) has a great deal of predictive value regarding the relative reinforcement value of the stimuli when access to a stimulus was made contingent on simple free-operant behaviors such as sitting in a chair or standing in a square.

Other research has systematically evaluated the extent to which the reinforcement effects observed with simple free-operant behaviors extend to more complex, socially relevant behaviors. Reinforcers identified by a choice assessment were evaluated for use in reinforcement-based treatments for maladaptive behavior (Derby, Wacker, Andelman, Berg, Drew, Asmus, Prouty, & Laffey, 1995; Piazza, Fisher, Hanley, Hilker, & Derby, 1996). Derby and colleagues (1995) used a paired-stimulus procedure in which the participant was given access to the item selected until a targeted maladaptive behavior occurred or five minutes had elapsed. Two dependent measures were taken during the choice assessment – approach behavior and the latency between stimulus presentation and the occurrence of the first aberrant response. The utility of the approach and the latency measures were evaluated during treatment for maladaptive and self-injurious behavior. Treatments included response independent presentation of the items with and without parental attention, a differential reinforcement of other behavior (DRO) procedure, response independent social attention; and an ignore condition was also included. Results indicated that the most frequently approached stimulus was also associated with the shortest latency to the occurrence of maladaptive behavior. In general, the stimuli selected according the latency measure functioned as more effective reinforcers for appropriate behavior. These findings suggest that stimuli identified as high preference based on the frequency of approach behavior Fisher et al., (1992) may not be effective in reducing some maladaptive behaviors when delivered independent of responding or in a DRO procedure.

In a related study, Piazza, Fisher, Hanley, et al. (1996) evaluated the utility of single-stimulus preference and reinforcer assessments in predicting the beneficial and negative effects of stimuli used in a DRO procedure. Because the results of preference assessments have typically been used to predict reinforcer effects on simple free-operant responses, the investigators were interested in examining the extent to which these stimuli functioned as reinforcers for other behaviors. More specifically, the extent to which stimuli that were identified as highly preferred in a preference assessment and that functioned as reinforcers to simple free-operant behavior (in-chair behavior) could effectively treat self-injury without a clear function in two participants with profound mental retardation was evaluated (Piazza, Fisher, Hanley, et al.). In the first phase of the study, preference assessment was conducted using single-item presentations with each item presented a total of 10 times. During each presentation, participants were given continuous access to the item for 30 seconds. The duration of engagement with the item and the frequency of self-injurious behavior were measured. By measuring the duration of item contact, interpretive difficulties arising from both item competition and indiscriminate approach behavior may be avoided. Measures of SIB were taken to evaluate whether a measure of preference was predictive of reinforcer effects in the treatment of SIB, or whether measure of SIB frequency improved the identification of reinforcers for appropriate behavior. The stimuli were grouped into three categories: high preference and high SIB (HP/HS), high preference and low SIB (HP/LS), and low preference and low SIB (LP/LS). Following the preference assessment, a reinforcer assessment was conducted to evaluate the effects of the stimuli on a simple free-operant behavior (head turning). A concurrent-operants arrangement was used in which a single-stimulus from one of the categories was compared with a control condition associated with no item. Results were consistent with previous findings, and indicated that reinforcer effectiveness for a simple response correlated positively with preference (Piazza, Fisher, Hanley, et al).

In the last phase of the study, Piazza, Fisher, Hanley, et al. (1996) assessed the utility of the preference assessment to predict reinforcer value in a DRO procedure. For one subject a multielement design with four conditions was used to compare the effects of the stimuli to a control condition that provided no differential consequences for SIB. For the second subject, a reversal design was used to evaluate reinforcer potency for each type of stimulus. The investigators found that HP/HS stimuli consistently resulted in an increase in SIB for both participants, LP/LS stimuli resulted in no change in rates of SIB from the baseline control condition for both participants, and the HP/LS stimulus resulted in no change in rates for the one participant for which these stimuli were identified. The results indicated that the preference assessment accurately predicted the reinforcer effects of the stimuli during a reinforcer assessment, but not during the DRO procedure used to treat SIB.

It has been suggested that these findings are indicative of the difficulty with establishing cutoff criterion for the prediction of effective reinforcers (DeLeon & Iwata, 1996). The 80% selection criterion defining high-preferred stimuli used in paired-stimulus assessments (Fisher et al., 1992) was based on the criterion set by Pace et al. (1985) for use with a single-stimulus presentation format using a standardized set of stimuli. Stimuli well below 80% selection may function at least modestly as reinforcers, but this criterion would result in the rejection of these stimuli as potential reinforcers. Moreover, percentage criterion is difficult to set with the MSWO procedure because not every item is available on each trial. For example, given a consistent pattern of selection in which one item is always chosen first, another always chosen second, and so forth, the second highest ranked item is chosen on only 50% of trials. Rank ordering stimuli based on the order of selection is more appropriate in the case of the MSWO format.

The results of these studies are important because they suggest that the reinforcement effects of stimuli selected using empirical preference assessment may not generalize across behavior, settings, or other contingent arrangements. A similar concern regarding the durability of reinforcement effects under increasing schedule requirements was raised by Tustin (1994). That is, the preference assessments commonly used, such as the paired-stimulus (Fisher et al., 1992) and MSWO procedures (DeLeon & Iwata, 1996), evaluate client preference for reinforcers delivered under low schedule requirements. Individual preference was evaluated for concurrently available reinforcers using simultaneously increasing concurrent-ratio schedules (Tustin). The reinforcing stimuli included a computer-generated visual stimulus and combined visual and auditory stimuli. Results indicated that preference under low-schedule requirements (concurrent FR 1 FR 1) reversed when schedule requirements increased (concurrent FR 5 FR 5). Given that reinforcer-assessment procedures typically evaluate preference under low-schedule requirements, the findings suggest that such assessments may have less or lower predictive validity regarding reinforcement effects when response requirements are increased (Tustin).

Taken alone, Tustin's (1994) findings are inconclusive due to the small sample size (one subject), atypical reinforcers used, and the small number of sessions (three) conducted at each schedule requirement. In an attempt to replicate the preference effect reported by Tustin, client preference was evaluated by DeLeon, Iwata, Goh, et al. (1997) under simultaneously increasing schedule requirements using extended phases at each schedule requirement and using reinforcers that are commonly used with the population (food and leisure items). Results indicated that client preference for some reinforcers emerged as concurrent-schedule requirements increased. Under low-schedule requirements (concurrent FR 1 FR 1), participants displayed no clear preferences for available reinforcers. However, as response requirements were increased a clear preference for one reinforcer emerged. This effect was observed only for similar reinforcers but not dissimilar reinforcers. In addition, the preference for similar reinforcers exhibited under high-schedule requirements disappeared when schedule requirements returned to concurrent FR 1 FR 1. Even less-preferred reinforcers maintained some responding during higher ratio values, and DeLeon and colleagues (1997) proposed that both reinforcers might be likely to maintain similar response rates if presented as the only reinforcement option. The results of DeLeon, Iwata, Goh, et al. suggest that some preferences might be a function of schedule requirements and that some preferences are reversible. Taken together the results of these studies suggest that additional research is needed to evaluate reinforcer preference effects under varying schedule requirements or training conditions.

For person with developmental disabilities, food items, as a class of reinforcers, have been shown to be more potent than leisure items. Preference for leisure items may be more idiosyncratic than preference for food items (DeLeon & Iwata, 1996), making direct comparisons across reinforcer classes difficult. If therapists are concerned with identifying leisure items, food items may need to be omitted from the stimulus array. DeLeon, Iwata and Roscoe (1997) investigated the extent to which members of this population demonstrated general preference for food items over leisure items during MSWO assessments (DeLeon & Iwata, 1996). Separate seven-stimulus assessments were conducted with food-only stimulus arrays and leisure-item-only arrays, and then a combined array of the top selections was presented. Twelve of 14 participants showed a general preference for food items to the extent that non-food selections was displaced downward during the combined assessment relative to selection on the non-food only assessment. For two of the participants, a reinforcer assessment was conducted using a non-food item provided contingent on appropriate behavior. Increased response rates were observed with non-food reinforcers (DeLeon, Iwata, et al.).

The findings of DeLeon, Iwata and Roscoe (1997) that food was a highly preferred stimulus are consistent with many studies that have demonstrated the reinforcing efficacy of food for reducing maladaptive behavior and establishing and maintaining appropriate behavior. However, as a class of reinforcers, food may be problematic. Food reinforcers are used less in naturalistic settings (Rincover et al., 1977). Satiation tends to occur more quickly with food reinforcers than other forms of reinforcement. Moreover, ethical and legal issues related to food deprivation and health may contribute to food functioning inconsistently as a reinforcer (Rincover & Newsom, 1985). The reinforcement effectiveness of leisure items can be enhanced by creating establishing operations (McAdam, Klatt, Koffarnus, Dicesare, Solberg,Welch, & Murphy, 2005; Vollmer & Iwata, 1991), and far fewer ethical issues arise with the use of non-food items. Food reinforcement delivery may not occasion much caregiver-participant interaction (Rincover & Newsom), and relatively little participant behavior is necessary to derive reinforcement from food. Interaction with leisure stimuli is more likely to require extended durations and/or sequences of behavior related to item manipulation. Moreover, interaction with leisure items can effectively compete with maladaptive behavior (Rincover & Newsom).

Fluctuations or decreases in performance following successful intervention may occur because of changes in preference over time or other factors. The results of DeLeon et al. (2001) suggest that an individual’s preferences as measured by standard assessment procedures can vary from day to day. Measurement of preference at different points in time allows researchers to evaluate changes in preference over time; however, the results of studies of preference changes over time are difficult to compare because different assessment procedures were used with different measures of preference. Mason et al. (1989) reported approach percentages from preference assessments separated by approximately one month. Carr et al. (2000) used item rankings to report stable preference with eight repeated administrations of the brief MSWO over the course of one month. Zhou, Iwata, Goff, and Shore (2001) examined the stability of preference by conducting assessments approximately 16 months apart, and stability was represented by item rankings and Spearman rank-order correlations. Reanalyzing and comparing data from these studies indicated that stability of preference varies across individuals but only eight of 28 participants had stable preference (Hanley, Iwata, & Roscoe, 2006). According to Hanley et al. the variables that account for idiosyncratic preference stability reported in previous studies are unclear. They were able to produce systematic preference changes for leisure activities over three to six months that could be attributed to naturally occurring changes in establishing operations or learning histories.

Reinforcer and response dimensions can affect responding by persons with developmental disabilities. Research has assessed the influence of various dimensions of reinforcement: magnitude of reinforcement, quality of reinforcement, delay to reinforcement, rate of reinforcement, and response effort (Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994). Neef, et al. (1992) used concurrent variable-interval schedules of reinforcement to evaluate special education students' allocation between responses with reinforcers that differed in quality. The students all preferred the higher quality reinforcer. In another study, Neef et al. (1993)

used similar choice procedures and varied delay to reinforcer access. The students showed increased responding on the alternative that provided immediate reinforcement. These dimensional changes produced preference for higher quality or more immediate reinforcers that changed the effects of reinforcement rate alone. However, response allocation was unaffected by differences in response effort represented by match problem difficulty (Neef et al., 1992). In a comprehensive study Neef, Shade, and Miller systematically combined reinforcer rate, quality, delay, and response effort to determine how they affect the choices of individuals with learning and behavioral disabilities. The participants were given two sets of math problems that were the same on two dimensions but differed on two other dimensions. Competing dimensions were counterbalanced so that the effects of each dimension on time allocation could be evaluated. Each participant's responding was differentially affected by the reinforcer dimensions, and the results were explained in behavioral economic terms. Quality of reinforcement was influential for all participants. Some qualitatively different reinforcers were independent commodities during the rate-versus-quality condition (higher rate of reinforcement for equivalent response) because two of the participants continued to respond exclusively on one alternative even when the other was decreased in price. The quality-versus-effort condition produced similar results with near-exclusive responding on the more effortful response. For two of the participants increased delay to higher-quality reinforcement lead to decreased responding on that alternative during the immediacy-versus-quality condition. The results provide some information about the conditions under which qualitatively different reinforcers may or may not be substitutable or become substitutable (Neef et al., 1994).

Important implications for treatment can be gleaned from the findings of these authors. The results suggested which reinforcer or response dimensions should be altered and to what extent. For example, even a large differential rate of reinforcement could fail to produce desirable behavior change if the reinforcer maintaining problem behavior is different and non-substitutable for the reinforcer for the desirable alternative. Reinforcer immediacy could be varied within treatment to produce desirable behavior. The treatment might involve arranging immediate reinforcement for desirable behavior or more highly-preferred reinforcers for desirable behavior provided immediately as reinforcement for problem behavior. The concurrent-choice arrangement used in these studies of reinforcer dimensions had a notable limitation – exclusive responding on one alternative precluded contact with differential contingencies on dimensions that might otherwise control behavior allocation (Neef et al., 1994). In this case, the results of unequal schedules of reinforcement were difficult to interpret because the schedules can only be discriminated by sampling both response alternatives. The researchers suggested that requiring participants to sample each response alternative prior to the experimental condition might be helpful (Neef et al.). They proposed the utility of asking participants what rules they applied when choosing between the alternative to determine the extent that the reinforcement contingencies were discriminated. While soliciting participant self-report might be instructive with the special education student evaluated by Neef et al., this approach would be difficult or impossible with lower-functioning individuals for which discerning potent reinforcement is most difficult. These studies suggest that in applied situations, consideration of variations in reinforcer and response dimensions may aid in understanding, predicting, and managing behavior; and the influence of these variables can be interpreted by behavioral economic concepts (Green & Freed, 1993; Neef, Mace, Shea, et al.; 1992; Neef et al., 1994).

Rationale and Objectives of the Present Study

A large body of literature has established a variety of techniques for identifying highly valued and effective reinforcers for individuals with developmental disabilities (DeLeon & Iwata, 1996; Fisher et al., 1992; Windsor et al., 1994). Standard procedures consist of presenting stimuli in pairs or in a multiple array followed by an assessment to determine if the highly-preferred stimuli will increase and maintain responding. In most reinforcer assessments, a preferred stimulus is presented for every occurrence of a simple behavior that is already in the participant's repertoire, such a reaching, sitting in an area, or pressing a microswitch. Using simple operants and a continuous schedule of reinforcement may promote rapid identification of reinforcer efficacy while minimizing the potentially confounding effects of other variables such as response difficulty or ratio strain (Fisher & Mazur, 1997; Piazza, Fisher, Hagopian, et al., 1996). Schedule requirement has been shown to affect reinforcer efficacy (DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994). The relationship between reinforcer effectiveness and schedule requirement has important implications for the use of reinforcers with persons with developmental disabilities because schedule fading is typically incorporated in reinforcement-based treatment programs. Reinforcers must be identified that will maintain treatment effects across increasing schedule requirements. Unfortunately, standard reinforcer assessments may have limited generality when schedule thinning or differential reinforcement procedures are used (Fisher & Mazur). Thus, treatment efficacy may be compromised. The paired-stimulus procedure provides reliable preference ranks and consistency of ranks (DeLeon & Iwata, 1996; Fisher et al., 1992). However, it is unclear whether currently used preference assessments make accurate predictions about reinforcement effects under varying schedule requirements. Tustin and DeLeon et al. (1997) suggested that reinforcer efficacy under increasing schedule requirements should be assessed frequently as part of ongoing treatment development. However, the methods employed in these studies required repeated exposure to various schedule requirements over an extended period of time. Progressive-ratio schedules of reinforcement and behavioral economic analyses have been utilized for reinforcer identification (DeLeon et al.; Tustin; Roane et al.). The behavioral economic representations of data were work-rate functions (number of responses across increasing schedule requirements or work/price) and reinforcer-demand functions (number of reinforcers earned across increasing schedule requirements or consumption/price). Other behavioral economic procedures may provide novel methods for identification of reinforcers under increasing schedule requirements. Specifically, the exponential-demand model (Hursh & Silberberg, 2008) can provide a single quantitative measure of the essential value of reinforcers independent of the dimensional properties of reinforcement. If the model can adequately predict responding for qualitatively different reinforcers by persons with developmental disabilities, essential value may be a means of identifying functional reinforcers that may generalize to common treatment situations.

The purpose of this investigation was four-fold. First, Experiment 1 evaluated different session durations to generate rapid demand curves for reinforcers used with children and adolescents with developmental disabilities. Demand curves and ratio breakpoints were compared across short, intermediate, and long session lengths. The FR progression, session termination/ratio strain criteria, and the duration of the reinforcement interval were also evaluated. The results of Experiment 1 suggested an efficient and systematic method for obtaining demand curves that was used in the second part of the study. Standard preference assessment procedures were used in conjunction with a behavioral economic reinforcer assessment in Experiment 2. Second, the RAISD interview (Fisher et al., 1996) was used to identify five stimuli that were used in subsequent preference assessments. Preference ranks obtained from multiple paired-stimulus assessments (Fisher et al., 1992), conducted with food and non-food items separately and in combination using two magnitudes of reinforcement were compared with each other and to the results of the RAISD. Third, a behavioral economic reinforcer assessment of the three highest ranking items was conducted using single-operant procedures to obtain demand curves representing consumption of each reinforcer under increasing price/increasing response requirements (Hursh & Silberberg, 2008). The exponential demand model proposed by Hursh and Silberberg was evaluated by comparing the fit of predicted responding to responding obtained under increasing FR requirements. Fourth, the essential value as measured by the α parameter and P_{max} from the exponential demand model (Hursh & Silberberg) was calculated for each reinforcer. Essential value rankings were compared to the preference assessment rankings. Dependent measures are rank-order correlations among the paired-stimulus and behavioral-economic assessments. The exponential-demand model was evaluated in terms of utility in identifying highly-valued functional reinforcers in persons with developmental disabilities.

The present study sought to integrate basic and applied methods for identifying reinforcer value. A primary goal was to form stronger connections between applied work in developmental disabilities and behavioral economic work in the basic laboratory and applications with other populations. It has been recommended that integration of basic and applied research may promote the development of applied technologies and reveal new basic relations through application (Mace & Wacker, 1994; Roane et al., 2001).

EXPERIMENT 1: SESSION DURATION COMPARISON

METHOD

Participants and Setting

Four individuals took part in Experiment 1. Participants were twenty-one years of age or younger and diagnosed with developmental or other learning disabilities. Their diagnoses and functional levels were obtained from records maintained by The Learning Tree Tallassee Campus at which they receive services. All participants attended a daily six-hour educational program for children with intellectual disabilities and problem behavior such as aggression, disruption or self-injury. In addition to receiving educational services, participants lived in residential group homes within the local community. Participants were selected based on their performance on a vocational skill assessment (Lerman, Vorndran, Addison, and Kuhn, 2004).

Three individuals completed all three conditions of Experiment 1. The fourth participant finished only the intermediate condition because the excessive number of sessions he would have completed required too much time away from educational programming. Jason was a 12-year-old boy diagnosed with moderate mental retardation and autism, Jill was a 13-year-old girl diagnosed with severe mental retardation, Ross was a 21-year-old young man diagnosed with moderate mental retardation and autism, and Kyle was a 21-year-old young man diagnosed with severe mental retardation, autism, seizure disorders, and cerebral palsy limiting fine motor control. Exact Intelligence

Quotient scores were unavailable for the participants. Jason, Ross and Kyle communicated using spontaneous and prompted vocal speech and demonstrated good receptive language skills such as following two-step instructions. Jill was non-verbal and was able to follow one-step instructions. Throughout the duration of Experiment 1, Jason, Ross and Kyle took medication to control problem behavior. Kyle also took antiepileptic medication to control seizures. The medications taken by each participant during Experiment 1 are listed in Table 1.

Table 1
Medication Taken by Participants

Participant	Medication
Jason	Risperidone 1 mg twice daily, Risperidone 0.5 mg once daily
Ross	Oxcarbazepine 300 mg once daily, Sertraline 50 mg once daily
Kyle	Risperidone 1 mg twice daily, Divalproex Sodium 500 mg once daily, Divalproex Sodium 100 mg twice daily

Annual testing of the students at The Learning Tree was conducted by case managers from the Alabama Department of Human Resources using the Inventory for Client and Agency Planning (ICAP) (Bruininks, Hill, Weatherman, and Woodcock, 1986). The ICAP is a comprehensive 123-item standardized instrument to assess the adaptive functioning, maladaptive problem behavior, functional characteristics and service needs of individuals with developmental disabilities. The ICAP general score ranges from 0 to -74 with a standard deviation of -10. For example, no maladaptive problems would be a zero and serious maladaptive behavior problems would be reported with increasingly larger negative numbers. The ICAP service score ranges from 0 to 100 and level score ranges from 1 to 9. The ICAP service score is an overall measure of the individual's need for care, support, supervision and training that is based on the combined adaptive and maladaptive behavior scores. Persons receiving an ICAP service score less than 20 are assigned a level 1 score meaning that they require total personal care and intensive supervision while level 9 represents total independence. Levels 4 through 6 identify supervised intermediate care and levels 7 through 9 indicate that limited care is required. Participants' current ICAP results and age equivalents are shown in Table 2. The general and service level scores indicate that all participants have very serious maladaptive behavior, and they require total personal care and intensive supervision.

Table 2
Inventory for Client and Agency Planning (ICAP) Results for Participants

Participant	General Score Range 0 to -74	Service Score Range 0 to 100	Service Level Score Range 1 to 9	Overall Age Equivalent
Jason	-47	7	1	1 year, 8 months
Jill	-66	1	1	1 year, 6 months
Ross	-45	26	2	4 years, 3 months
Kyle	-52	8	1	2 years, 3 months

Sessions were conducted in a small, 3 meter by 4 meter, classroom of The Learning Tree Tallassee containing a table, chairs, video camera, laptop computer, task materials and stimuli necessary for assessment. Other objects such as storage bins, a fan, and a trash can were also present; however, participants were blocked from interacting with these items when necessary. One to two sessions were conducted each day with the first in the morning and the second in the afternoon. None of the sessions were conducted within an hour of the student's lunch time. Participants were exposed to three different session durations: short 15 minute sessions, intermediate 30 minute sessions, and long 45 minute sessions.

Informed Consent and Minor Assent for Participation

Written consent was obtained for each individual prior to his or her participation in the study. A parent provided informed consent for both Jill and Kyle. A state-appointed social worker consented for Jason's participation. Ross provided informed consent. He did not have a legal guardian or involved family member to consult. In addition to parent or guardian consent, Jill, Kyle and Jason were read and asked to sign an assent form to take part in the study. A staff member was present while consent/assent documentation was obtained to assist the experimenter in determining whether the individual demonstrated an understanding of the form. A representative from The Learning Tree also provided written informed consent for each individual to participate. All consent documents used in the study are included in Appendix A.

The experimenter obtained consent from the participant before each session. The individual was asked if he or she wanted to work with the blocks. If the individual agreed, he or she went to the session room. A refusal resulted in the individual remaining in the present location and continuing the current activity. A staff member was present at all times to assist with determining the participant's ongoing consent.

Data Collection and Interobserver Agreement

Observers trained in behavioral observation collected pen-and-paper data during the skill assessment procedure. Interobserver agreement data were collected for 69% of skill assessment trials by having a second observer simultaneously and independently record a participant's target responses. Agreement was calculated on a trial-by trial basis for skill assessment. Agreement was defined as both observers recording the occurrence or non-occurrence of the response. Interobserver agreement was collapsed across participants and across the skill probe and extinction conditions of the skill assessment. There was 97% agreement on skill assessment trials with a range of 88% to 100%.

During the behavioral economic assessment, observers collected data on laptop computers. Frequency measures were aggression, self injurious behavior, disruption, and the target functional response. Duration measures in seconds were taken on response completion, latency between responses, the reinforcement interval, and reinforcer consumption if applicable (see Appendix B for the operational definitions used during computerized data collection. A portion of the behavioral economic assessment was videotaped (86% of sessions), and a second observer collected data on 63% of videotaped sessions. Interobserver agreement was calculated by dividing each session into 10-second intervals and comparing the data of the two observers. Agreements were defined as the same responses scored within a 10-second interval, and disagreements were defined as a different responses scored within the interval. Interobserver agreement was calculated by dividing the number of 10-second intervals with agreement by the number of 10-second intervals with agreements plus the number of 10-second intervals with disagreement, multiplied by 100%. Interobserver agreement was collapsed across the frequency and duration measures with an average of 92% for Jason (range 84% - 98%), 93% for Jill (range 83% - 98%), 95% for Ross (range 86% - 100%), and 94% for Kyle range (84%-100%). Only interobserver agreement greater than or equal to 80% was included in the averages.

The Economic Context

Ethical issues could arise if all food and leisure items were only available during experimental conditions, so the overall economic context was an open economy. Participants continued to receive their typical reinforcers in the classroom. However, access to the specific reinforcers under evaluation was limited during the school day; but total restriction of all substitutes was impractical, if not impossible. For example, if chocolate chip cookies are used as reinforcers, free access to all cookies can be avoided; but a number of other sweet foods may be substitutable when the availability of chocolate chip cookies is constrained. That is, reinforcement can be obtained through interaction with the experimental environment, but other effective sources of reinforcement may also be available outside the experimental context. The use of tangible and edible reinforcers for persons with developmental disabilities and the availability of substitutable sources of reinforcement make it difficult to approximate a closed economy in an applied setting (Roane et al., 2005).

Pre-Assessment Skill Probe and Extinction Procedure

Skill probes were completed prior to the behavioral economic assessment. This determined whether each individual could perform a simple block sorting task when reinforcement was delivered following every correct response, and would cease responding when reinforcement was removed. The target response consisted of dropping a one-inch block through a slot in the top of a box. The task was a simple operant response that was already in the repertoire of the participants. This allowed practice of a pre-vocational skill that might have important potential implications for the individual as a prerequisite or component skill of a more complex response. The task also provided a discrete target response that the participant could complete correctly and independently following a one-step instruction. It has been shown that using simple operants and a continuous schedule of reinforcement may minimize the potentially confounding effects of other variables such as response difficulty or ratio strain (Fisher & Mazur, 1997; Piazza, Fisher, Hagopian, et al., 1996).

The skill assessment probes were conducted using methods similar to the rapid skill assessment procedure suggested by Lerman, Vorndran, Addison, and Kuhn (2004). Three consecutive sessions were conducted. Each session consisted of 10 trials presented approximately on a fixed-time 10-second schedule (FT 10-s). Prior to each session, the experimenter demonstrated the correct block-dropping response for the participant and then delivered a verbal prompt while physically guiding the individual to complete the response the same way. With the experimenter and participant seated on opposite sides of a table, one block and the slotted box were placed in front of the participant. Before the first trial of the session, the participant was verbally instructed to "Put the block in the box." After the first trial no additional prompts were given during the remainder of the session. Trials were scored as either correct, incorrect, or no response. Correct responding was defined as beginning the requested action (such as touching the block) within five seconds of the verbal instruction and independently completing the response within 10 seconds of the instruction (Lerman, et al.). If the participant had not attempted a response within five seconds or failed to complete the task within 10 seconds, the materials were removed and the trial was terminated. If the participant responded correctly to the task demand within the time limits, the materials were removed and the participant received descriptive praise and a reinforcer on a fixed ratio (FR 1) reinforcement schedule. The reinforcers used were listed on participants' Individual Educational Plans (IEPs) as highly-preferred stimuli identified via preference assessments previously conducted by behavior analysts at The Learning Tree. Reinforcers consisted of a small piece of food or 30-second access to a toy. Following correct block drops, Jason received half of a round fruit snack, Jill had access to a string of plastic beads for 30 seconds, Ross received a small piece of chocolate fudge snack cake, and Kyle received one piece of candy-covered chocolate.

Responses were evaluated based on the average percentage of correct responding across sessions calculated as the number of correct responses during the session (those initiated within five seconds of the verbal instruction and completed within 10 seconds) divided by the number of trials (10). Percentage of correct responding was then averaged across the three sessions. If the participant demonstrated an average of 80% or greater correct responding when reinforcing consequences were provided, then responding was evaluated in additional extinction trials.

The extinction procedure was similar to that of the skill probes described above with one exception - the participant did not receive descriptive praise on his or her performance or any other form of reinforcement following correct responding. Task demands were delivered consecutively, approximately on a fixed-time 10-second schedule (FT 10-s) with task materials briefly removed between trials. Sessions continued until responding ceased on five consecutive trials or 100 extinction trials (10 sessions) were completed. Correct responding was calculated for block drops on the extinction trials, and block dropping needed to rapidly extinguish for participants to reach zero response rates. To take part in the study, each participant had to have zero completion following extinction trials and an 80% or greater percentage of correct responding during sessions with reinforcing consequences.

Session Duration Comparison Procedure

Following successful completion of skill probes and extinction trials, participants began a behavioral economic assessment. The purpose of this assessment was to develop an efficient and systematic method for generating rapid demand curves with children, adolescent and young adults with disabilities. Data from three different session durations were compared. Participants completed a simple operant task to earn reinforcers. They had previous experience with the block-dropping task from the screening procedures; however, during the behavioral economic assessment the fixed ratio (FR) requirement increased systematically across sessions until the individual stopped responding for the reinforcer.

Three demand curves were generated for each participant's reinforcer during three different session durations. Demand curves for each reinforcer were estimated using progressively increasing FR schedules of reinforcement across sessions (DeLeon, Iwata, Goh, et al., 1997; Foster, Blackman, et al., 1997; Foster, Temple,, et al., 1997; Raslear et al., 1988; Tustin, 1994). Under increasing FR schedules, participants had to meet increasing response requirements to earn a reinforcer. The way in which schedules are programmed to generate demand curves has varied considerably across applied and basic behavioral economic research applications. Both FR and PR schedules have been used, and share many common characteristics. Stafford et al. (1998) reviewed the use of PR schedules in the drug self-administration literature and outlined the procedural issue associated with these schedules. An important consideration in the present study was the progression used so that consumption of a reinforcer across a range of prices could be efficiently assessed. Additive or proportional progressions have typically been used in behavioral economic research using persons with developmental disabilities (DeLeon, Iwata, Goh, et al.; Roane et al., 2005; Roane et al., 2001; Tustin). Basic research involving FR and PR schedules have also included exponential and logarithmic proportional progressions (reviewed by Stafford et al.). There is no clear consensus on how the schedule steps should be increased when the participants are persons with developmental disabilities. However, basic research indicates that ratio step size does not significantly change the breaking points obtained on PR schedules (Stafford & Branch, 1998). Tustin used an increasing FR schedule across sessions with three exposures to each ratio requirement (FR 1, FR 2, FR 5, FR 10, FR 20) presented in an ascending order, descending order, and again in ascending order; however other studies have shown that repeated, extended exposure to a single ratio may be unnecessary (Raslear et al., 1988; Foster, Blackman, et al., 1997). Other arbitrary schedules have been used for individual participants (Roane et al., 2001). The goal is to choose the most efficient procedure to evaluate consumption under increasing schedule constraint in order to reach the breakpoint of the reinforcer and to generate demand curves for the reinforcer.

Progressively Increasing Fixed-Ratio Schedules

Participants were exposed to a series of FR schedule requirements that increased by a fixed proportion across experimental sessions. Completion of the ratio requirement resulted in the removal of task materials and access to the reinforcer. The FR was gradually increased by multiplying each step value by 1.5 to obtain the subsequent response requirement until the maximum FR was reached, when responding ceased for 10 consecutive minutes. The FR schedule progression was FR 1, FR 2, FR 3, FR 5, FR 8, FR 12, FR 18, FR 27, FR 41, FR 62, and continued by multiplicative steps of 1.5 until the breaking point was reached. The breaking point was defined as the largest ratio requirement that the participant completes (Hodos, 1961), and the breaking point criterion was 10 minutes without a response. This schedule progression is similar to but more gradual than those used by DeLeon, Iwata, Goh, et al., (1997) and Tustin, (1994). Participants were exposed to each ratio requirement during a single session. This procedure has been found to yield similar demand curves as repeated, lengthy exposure to ratio requirements (Raslear et al., 1988, Foster, Blackman, & Temple, 1997).

The maximum duration of the experimental session varied. Sessions conditions were short (15 minute), intermediate (30 minute) and long (45 minute) durations. The order of session conditions was randomly selected for each participant. The schedule progression began at FR 1 and advanced by multiplicative steps of 1.5 for each session condition. The experimental session was terminated when one of the following conditions were met: the participant stopped responding for 10 consecutive minutes, either 15, 30 or 45 minutes elapsed since the task materials were placed in front of the participant, or the participants maladaptive behavior was uncontrollable. While data was collected on inappropriate behavior, no programmed consequences were provided for problem behavior during assessments. Minor problem behavior was ignored or physically blocked so the individuals did not hurt themselves. In the event of continuous aggression, self injury or high magnitude disruption, crisis procedures designated by The Learning Tree were implemented and the experimental session was immediately terminated. Participants were able to earn the same stimuli used during skill probes - half of a round fruit snack for Jason, 30-second access to a string of plastic beads for Jill, a small piece of chocolate fudge snack cake for Ross, and one piece of candy-covered chocolate for Kyle. The magnitude of reinforcement remained constant as the response requirement increased. Dropping blocks into a slotted container was used as the operant response requirement on the FR.

Sessions were separated by at least a 60 minute timeout period in which the participant was returned to his or her regular school activities. In most instances, sessions were conducted approximately two hours apart. The purpose of the timeout was to minimize the time that the participant was removed from standard classroom instruction and to minimize the probability that the repetitive task might become aversive to the individual. In the event that the task became overly aversive, problem behavior was likely to increase and responding could stop because of the punishing effects of the task rather than because the schedule requirement was too large to maintain responding for the reinforcer. Sessions were conducted in the morning and the afternoon during the school day. Sessions were counterbalanced across time of day with the exception of Jason's sessions. The majority of Jason's sessions took place in the morning because of his academic schedule.

Instructions to Participants

A school staff member familiar with the individual brought the participant to the session room. The staff member and participant were seated on opposite sides of a table. The participant was given one minute of access to the stimulus prior to beginning each session. This allowed the participant to sample the item under evaluation. Latency since the participant last consumed or interacted with the item was standardized which was important since participants had access to items throughout the school day that might function as substitutes for that stimulus (Bickel & Madden, 1999; DeGrandpre et al., 1994; Shahan et al. 1999). The participant was instructed that he or she could work to obtain the item; could work as much or as little as they wanted; but were not required to complete any work. The staff member read the following instructions at the beginning of the session: "You can have _____ if you put the blocks in the box. You can work as much as you want or not work at all." The required number of blocks for the FR requirement and the box were placed in front of the individual. Completion of the response requirement resulted in the removal of the task materials and access to the preferred item for 30 seconds. No verbal praise or other social reinforcement was provided. The reinforcement interval remained at 30 seconds regardless of how long the participant actually interacted with the reinforcer. Following the reinforcement interval, the blocks and box were placed in front of the participant again but no further instructions were given. The procedure continued until one of the session termination criteria was met and then the participant returned to educational and vocational activities.

The data collector was seated with a laptop computer at the far end of the table out of reach of the participant. The data collector did not interact with the participant but provided verbal prompts to the staff member to begin the session, end a reinforcement interval or end the session.

RESULTS AND DISCUSSION

Pre-Assessment Skill Probe and Extinction Sessions

All four participants met the criteria for inclusion in the study. Jason, Jill, and Ross correctly dropped the block in the box on all 30 skill probe trials. Kyle failed to drop the block within the time limit on one trial during session two. The range of average correct responding on skill probe sessions was 97% to 100%. The results of the skill probe sessions are shown in Table 3. Participants took between 10 and 30 minutes to complete the skill probe assessment.

Table 3
Performance on Pre-Assessment Skill Probe Sessions

	Percentage Correct Responding				Duration
Participant	Session 1	Session 2	Session 3	Average	in Minutes
Jason	100%	100%	100%	100%	18
Jill	100%	100%	100%	100%	27
Ross	100%	100%	100%	100%	10
Kyle	100%	90%	100%	97%	16

Extinction trials were conducted with the four participants because all exceeded an average of 80% correct responding on the skill probes. Table 4 shows the results of extinction trials. The number of extinction trials required varied across participants. Kyle required many more extinction trials than the other participants. Average correct responding ranged from 0% to 73%. Jill and Kyle continued to correctly drop the block into the container on a relatively high number of trials. The duration of extinction sessions was similar to skill probe sessions. Participants completed extinction sessions in less than 30 minutes. No maladaptive behavior was recorded for any participant during the pre-assessment skill probes or extinction trials.

Table 4
Performance on Pre-Assessment Extinction Trials

Participant	Number of Extinction Trials	Average Percentage Correct Responding	Duration in Minutes
Jason	15	45%	11
Jill	48	67%	18
Ross	5	0%	5
Kyle	85	73%	28

Session Duration Comparison

The primary purpose of the session duration comparison was to develop a method for generating rapid demand curves in persons with developmental disabilities. Of interest were differences in demand, ratio breakpoints, unit elasticity and amount of participation time across different session lengths. Each panel of Figures 3 and 4 depict three demand curves for participants' reinforcers. Kyle completed one condition so his graphs show data from only the intermediate sessions. In general, the demand curves varied with session duration as well as across participants. Long sessions produced rapidly decelerating curves for Jill, Ross and Jason. Maximum consumption occurred on the FR 1 during long sessions for all participants. This was simply due to the extra time available to repeatedly complete the response requirement. There was somewhat less consumption at FR 1 during intermediate sessions and the least amount of consumption took place in short sessions at FR1. However, there was little consumption at higher FR requirements during long sessions. The short and intermediate conditions generated more moderate demand curves. Participants typically continued to respond to increased FR requirements in short and intermediate conditions. Ross' intermediate data were an exception because he ceased responding at FR 2. This was unusual given the response persistence he demonstrated during other conditions. The intermediate sessions were the first conducted with Ross. Perhaps his inexperience with the procedure contributed to the limited responding at FR 2. Ross was clearly able to provide consent for his participation before each session. With little exposure to this choice situation, he had not contacted the contingency for revoking daily consent. In that case, discontinuing responding may have indicated momentary revocation of consent or an aversive situation rather than maximal

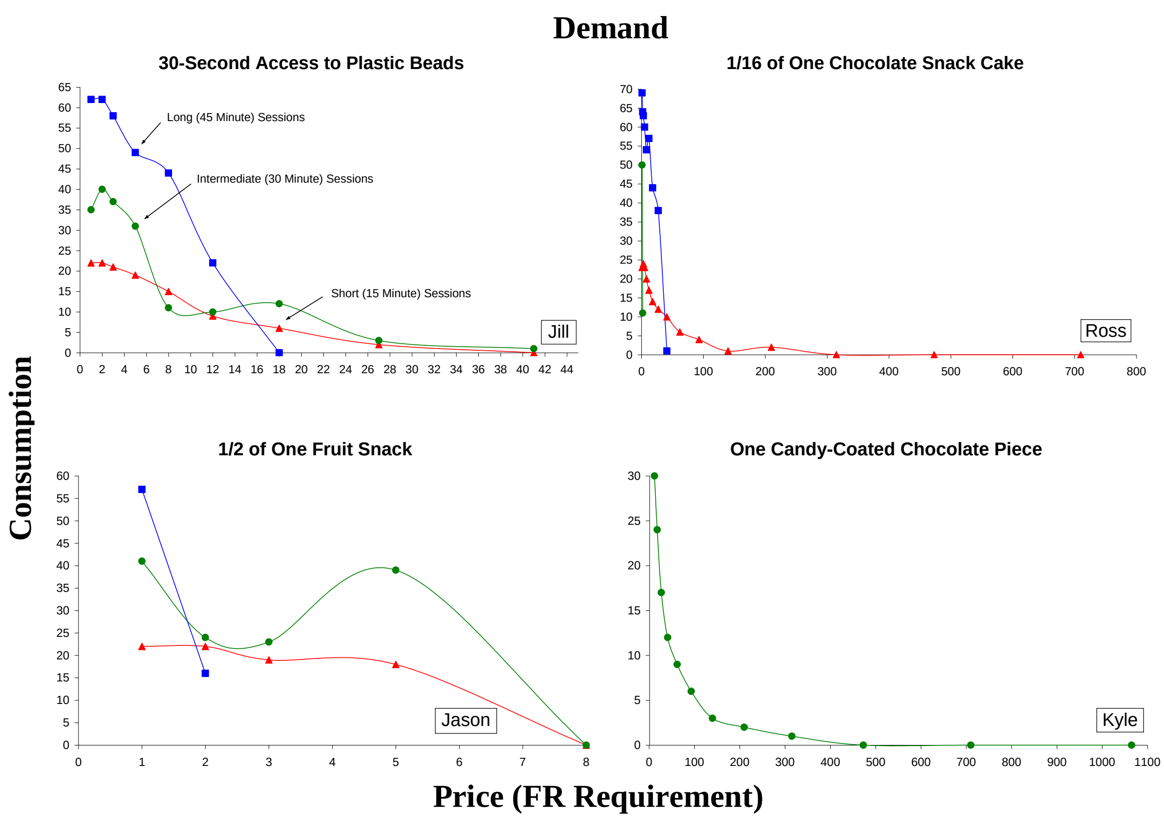

Figure 3. Empirical demand curves for the raw data from each session-duration condition. *Note.* The x- and y-axes differ in each panel.

responding for the reinforcer on the FR requirement. Jason's data show considerable variability in the intermediate condition. Only a few sessions were conducted with Jason in each condition which likely contributed to the variability evident in Figure 3.

Plotting the data on log-log coordinates provided an additional method for evaluating the demand curves that is common in behavioral economic research. Figure 4 shows the same demand curve data represented in Figure 3. However, the data are

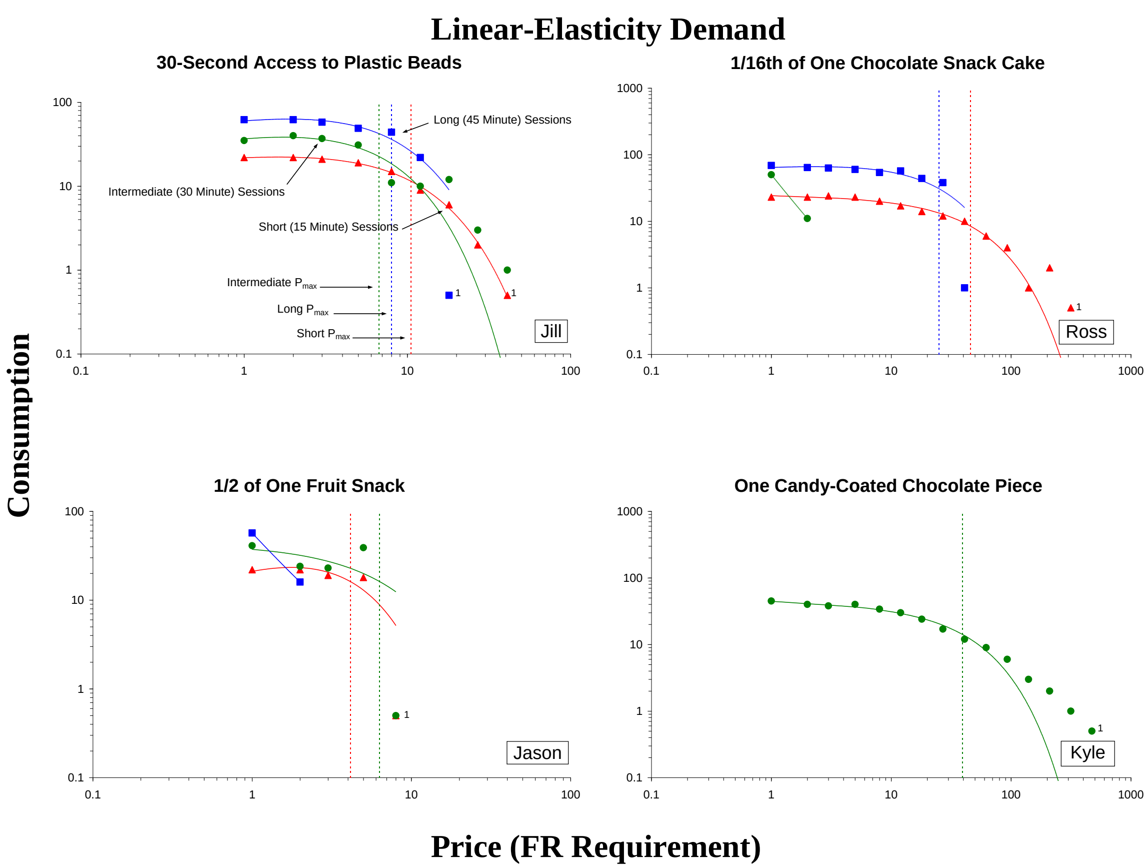

Figure 4. Raw data from each session-duration condition plotted on log-log coordinates with curves fit using the linear-elasticity model. Vertical dashed lines indicate the point of unit elasticity for conditions with more than two data points. [1]Zero consumption during the session is represented as a value of 0.5 on the graph. *Note.* The x- and y-axes differ in each column.

graphed on a log scale in order to make the range of data more manageable. Both Ross and Kyle continued to respond on high FR requirements, so the axis transformations are useful for their demand curve data. Demand curves were estimated using the linear-elasticity demand equation, $\ln Q = \ln L + b \ln P - aP$ (Hursh et al., 1989). The parameters of the linear-elasticity equation are price (P), consumption (Q), level of consumption as the price approaches zero (L), initial slope of the demand curve after an imperceptibly small increase from zero-level price (b), and a coefficient that defines the acceleration of the curve (a). Table 5 shows the coefficient of determination values (R^2) and the parameters derived from the linear-elasticity model for each demand curve. R^2 represents

Table 5
Variance Accounted for (R^2) and Linear-Elasticity Model Parameters Across Session Duration Conditions

Participant/Condition	R^2	L	b	a
Jason				
15 Minute Short Sessions	0.84	32.21	0.75	0.42
30 Minute Intermediate Sessions	0.43	43.73	0.01	0.16
45 Minute Long Sessions	N/A	48.44	-2.07	-0.16
Jill				
15 Minute Short Sessions	1.00	24.46	0.18	0.11
30 Minute Intermediate Sessions	0.92	44.93	0.35	0.20
45 Minute Long Sessions	0.95	70.69	0.31	0.16
Ross				
15 Minute Short Sessions	0.99	24.75	-0.03	0.02
30 Minute Intermediate Sessions	N/A	44.89	-2.34	-0.11
45 Minute Long Sessions	0.88	67.17	0.10	0.04
Kyle				
30 Minute Intermediate Sessions	0.99	45.62	-0.06	0.02

Note. No R^2 coefficients were reported when two or fewer sessions were conducted during a condition.

the proportion of variance accounted for by the statistical model. The short sessions yielded the best fitting demand curves for all participants. The variance accounted for ranged from 43% (Jason, intermediate sessions) to 100% (Jill, short sessions). The model had difficulty fitting Jason's data from intermediate sessions which were highly variable and consisted of only five data points. However, the linear-elasticity model did a good job of fitting the data for seven of the eight data series, and R^2 values were above 0.90 for five of the data series. The model underestimated unconstrained consumption (L) for Jason during long sessions and for Ross during intermediate and long sessions.

Elasticity of demand refers to the relationship between changes in demand and changes in price of a commodity. The slope of the demand curves shown in Figure 4 indicates the degree to which consumption was sensitive to price increments along the progressively increasing FR schedule. All participants' demand curves move downward with a negative slope. Elastic demand was shown by a demand curve that steeply decelerated with increasing price indicating that small changes in price have a big effect on the quantity consumed. Inelastic demand was represented by a demand curve that slowly decayed with increasing price meaning that a big change in price has a relatively small effect on consumption. Elasticity of demand calculated from the linear-elasticity equation is $b - \mathrm{a}P$. The price point of unit elasticity was determined by setting elasticity equal to -1 and solving for P. Unit elasticity coefficients for session duration conditions consisting of more than two data points are listed in Table 6 and are graphed as vertical dashed lines in Figure 4. This value is also the point of maximal responding and can also be defined as P_{max} (Hursh & Winger, 1995). Unit elasticity was not calculated for the

Table 6
Unit Elasticity Coefficients (P_{max}) Across Session Duration Conditions

Participant	15 Minute Short Sessions	30 Minute Intermediate Sessions	45 Minute Long Sessions
Jason	4.13	6.31	N/A
Jill	10.50	6.70	7.99
Ross	46.03	N/A	24.98
Kyle	N/A	39.33	N/A

intermediate sessions with Ross or the long sessions with Jason because only two sessions were conducted in each of these conditions. Larger values of unit elasticity indicate more inelastic demand for the commodity. For Jason demand for half of a fruit snack is highly elastic in all session conditions; whereas, elasticity of demand varied for Jill and Ross. Jill showed more inelastic demand for the beads in shorter, 15-minute sessions. Ross' demand for chocolate cake was very inelastic in the short condition but was more elastic in longer conditions. Demand for candy-coated chocolate pieces was inelastic for Kyle. Generally, elasticity of demand for the same reinforcer varied across session durations. Long sessions lasting 45 minutes produced more elastic demand indicating that consumption was very sensitive to changing price, while shorter sessions lead to both elastic and inelastic demand curves.

Breakpoints refer to the highest ratio requirement that the individual completed. For the session duration comparison, three breakpoints were obtained for each participant except for Kyle. Breakpoints were compared across three session lengths (see Table 7). The long condition yielded the lowest breakpoint values for Jason and Jill. The effect of satiation on responding during the 45-minute sessions was unclear. Because of the longer

Table 7

Ratio Breakpoints Across Session Duration Conditions

Participant	15 Minute Short Sessions	30 Minute Intermediate Sessions	45 Minute Long Sessions
Jason	FR 5	FR 5	FR 2
Jill	FR 27	FR 41	FR 12
Ross	FR 210	FR 2	FR 41
Kyle	N/A	FR 315	N/A

Note. Breakpoints values indicate the highest ratio completed by the participant. The value does not represent the highest ratio to which the participant was exposed.

session length, a participant had more opportunities to complete the ratio requirement. Because it took participants more and more time to complete increasing FR requirements, fewer reinforcers were earned. Satiation would have been more likely to occur when a participant earned maximum reinforcement at lower response requirements. This was not the case. Jason earned 57 reinforcers on FR 1 but only 18 reinforcers on FR 2 during long sessions. Jill had a similar pattern during long sessions. She earned 62 reinforcer on FR 1 and 22 reinforcers when she reached a breakpoint on FR 12. The session length itself may have contributed to lower breakpoints. Repeatedly dropping the blocks into the container for 45 minutes may have become somewhat aversive to Jason and Jill. Ross' highest breakpoint occurred during the short condition. He completed four more FR progressions in the short condition than the long condition. Ross responded at low rates beyond FR 210 but did not earn reinforcement during these sessions. Kyle had the highest breakpoint at FR 315. He continued to respond at high rates on additional progressions but was unable to complete the response requirement even once in the 30 minutes available.

Breakpoint criterion consisted of ten consecutive minutes without a response of placing a block into the container. However, Kyle and Ross did meet this criterion during the intermediate and short conditions respectively. An evaluation of interresponse times shown in the lower right panel of Figure 5 reveals that the maximum time between consecutive responses by Kyle was less than two and a half minutes (145.7 seconds) at FR 1065. Kyle's other interresponse times were less than two minutes. During the short condition, Ross' maximum interresponse time was less than four minutes (208.8 seconds in the upper, right hand panel of Figure 5) at FR 93 and there was less than two minutes between all other responses. Jill's interresponse time systematically increased with

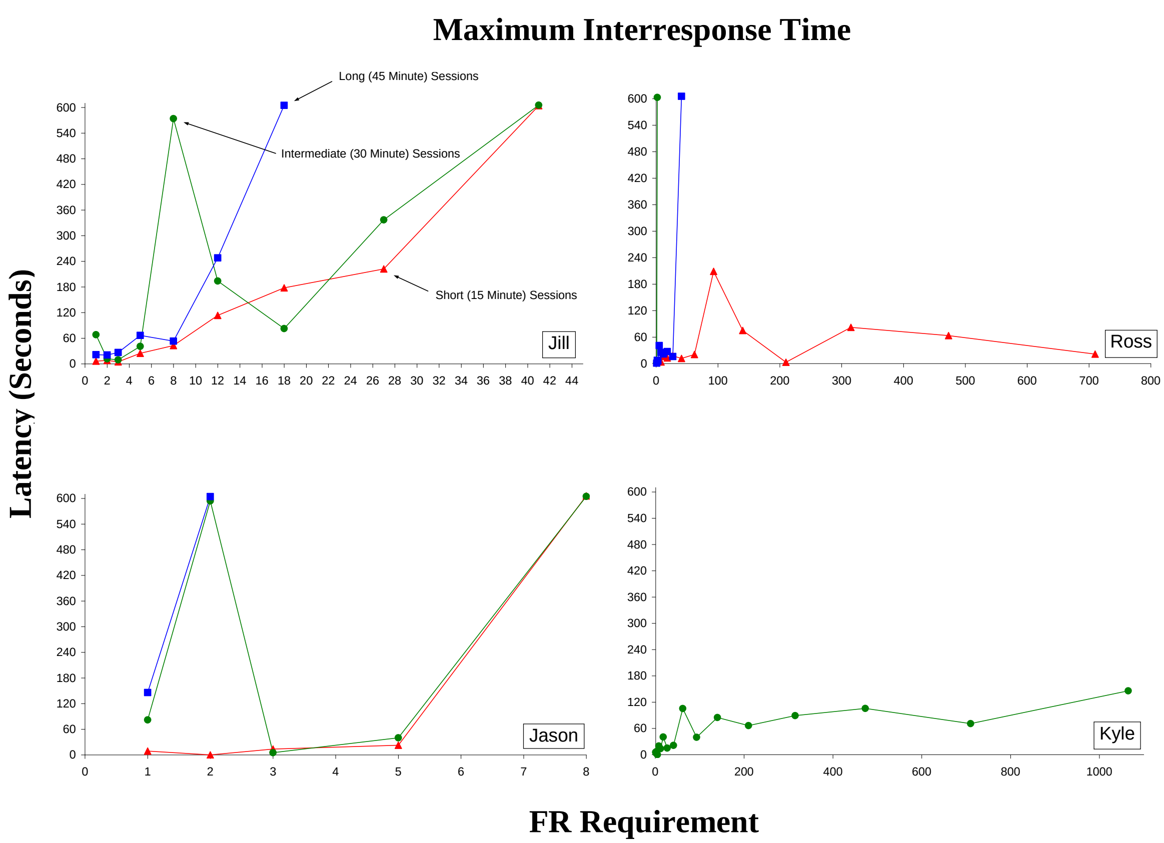

Figure 5. Maximum time between consecutive responses for each session. *Note.* The x- and y-axes differ in each panel.

increasing FR requirements during short and long sessions. Interresponse time was more variable during intermediate sessions with Jill but a similar increasing pattern occurred. Jason demonstrated systematically increasing interresponse time during short sessions and variable interresponse time in the other conditions.

Rather than changing the ten-minute breakpoint criterion for Kyle or Ross an additional requirement was included that sessions would end when the participant had completed three consecutive sessions without reinforcement. This change was implemented after Kyle had completed the first session without earning a reinforcer at FR 473 and he continued responding without reinforcement on FR 710 and FR 1065. Ross had not experienced a short session without a reinforcer when the breakpoint criterion was revised. Ross continued to respond in the short condition on FR 315, FR 473 and FR 710 without reinforcement.

Experiment 1 data for Kyle and Ross prompted further evaluation of the breakpoint criterion used. Interresponse times were analyzed to determine whether ratio breakpoint would have differed given shorter breakpoint criterion. Interresponse times greater than three minutes for Jill (240 seconds in the top left panel of Figure 5) indicated that the highest ratio completed remained stable in the short and long conditions with breakpoint criterion ranging from three to ten minutes without a response. The intermediate condition for Jill was characterized by variable interresponse times and reducing breakpoint criterion below ten minutes would have reduced the breakpoint value. For Ross, lowering the criterion would not have affected breakpoints in the intermediate or long conditions. Criterion less than four minutes would have decreased the breakpoint for Ross during the intermediate condition. Interresponse times from

Jason's short and long sessions (lower left panel of Figure 5) show that breakpoints were stable at criterion greater than three minutes. However, interresponse time reached nearly 10 minutes (594.2 seconds) during the FR 2 intermediate condition although Jason did not reach a breaking point until FR 5.

In general, the ten-minute breakpoint criterion was longer than necessary to obtain reliable breakpoint values. Lowering breakpoint criterion to five consecutive minutes without a response would have generated the same breakpoints for eight of the ten series of sessions conducted with the participants of Experiment 1. Hodos (1961) used ten minute breaking point criterion, while other studies varied breakpoint criteria (Stafford & Branch, 1998). In studies with persons with developmental disabilities, breakpoint criterion was set at five minutes without a response (Tustin, 1994; Roane, Lerman, & Vorndran, 2001). Individuals would be returned to their regular activities sooner and their overall participation time would decrease with lower requirements. Lowering the time requirement for the breaking point in future experiments could potentially reduce problem behavior occasioned by inattention or denied access to reinforcers.

Total participation time was an important consideration in developing a method for generating demand curves quickly in persons with developmental disabilities. Although the experimental task consisted of a pre-vocational skill, participants had other programmatic activities throughout their school day. Minimizing the time spent in experimental conditions allowed participants to maintain their typical schedules. The number of sessions completed in each session duration condition is depicted in Table 8. Fewer long sessions were conducted with all participants. Jason had the fewest sessions

Table 8
Number of Sessions Completed

Participant	15 Minute Short Sessions	30 Minute Intermediate Sessions	45 Minute Long Sessions	Total Sessions
Jason	5	5	2	12
Jill	9	9	7	25
Ross	16	2	9	27
Kyle	N/A	17	N/A	17
Average	10	8	6	20

with 12 and Ross the most with 27 sessions. A similar average number of sessions were completed in the short and intermediate conditions. Since session duration was varied, participation time varied depending on the number of sessions required in each condition (see Table 9). Jill and Ross spent nearly 12 hours completing all three duration conditions. Jason took the shortest time, 5.25 hours, to finish Experiment 1. Kyle was not allowed complete all session duration conditions because he spent over eight hours completing 17 intermediate sessions. If Kyle had been allowed to continue with short and long sessions and responded similarly, he could have taken a much as 17 more hours to finish. On average, participants took the longest time in the intermediate condition and the shortest time in the short condition. Short sessions were perhaps the most efficient

Table 9
Participation in Hours

Participant	15 Minute Short Sessions	30 Minute Intermediate Sessions	45 Minute Long Sessions	Total Hours
Jason	1.25	2.50	1.50	5.25
Jill	2.25	4.50	5.25	12.00
Ross	4.00	1.00	6.75	11.75
Kyle	N/A	8.50	N/A	8.50
Average	1.88	4.13	3.38	9.38

for generating usable demand curves, but the intermediate sessions provided more opportunities for participants to complete the response requirement without the extended time needed for long sessions.

The reinforcement interval was 30 seconds for both edible and tangible reinforcers. The duration of the reinforcement intervals was fixed to roughly equate the time available to respond for qualitatively different reinforcers. Often, small edibles were consumed quickly at the beginning the reinforcement interval while consumption of tangible items was distributed across the interval. Participants were likely to have more opportunities to complete the task requirement in lower FR sessions because of the shorter time necessary for completion. As the FR progression increased, putting the required number of blocks into the container took more and more time on each trial. Most participants spent the majority of session time in the reinforcement interval. In most instances work and reinforcement time was not distributed evenly until the participant reached FR 12 or FR 18 requirements, or 6 to 7 sessions of the schedule progression. To maximize participant responding, future behavioral economic studies could shorten the reinforcement interval. Both 20 and 30-second reinforcement intervals are commonly used with persons with developmental disabilities. Decreasing the 30-second reinforcement interval to 20 seconds could potentially give participants several additional minutes to earn reinforcement. Since edibles were typically consumed quickly and early in the reinforcement interval, shorter intervals could decrease the time that an individual had to wait between trials.

Three categories of problem behavior were recorded during Experiment 1. The operational definitions of aggression, self injury and disruption that were used in the study can be found in Appendix B. Minor, low intensity problem behavior was ignored and physically blocked if necessary to protect the individual from harm. At no time during Experiment 1 did problem behavior escalate to a degree requiring crisis intervention or discontinuation of a session. Figure 6 shows the rates of aggression, self

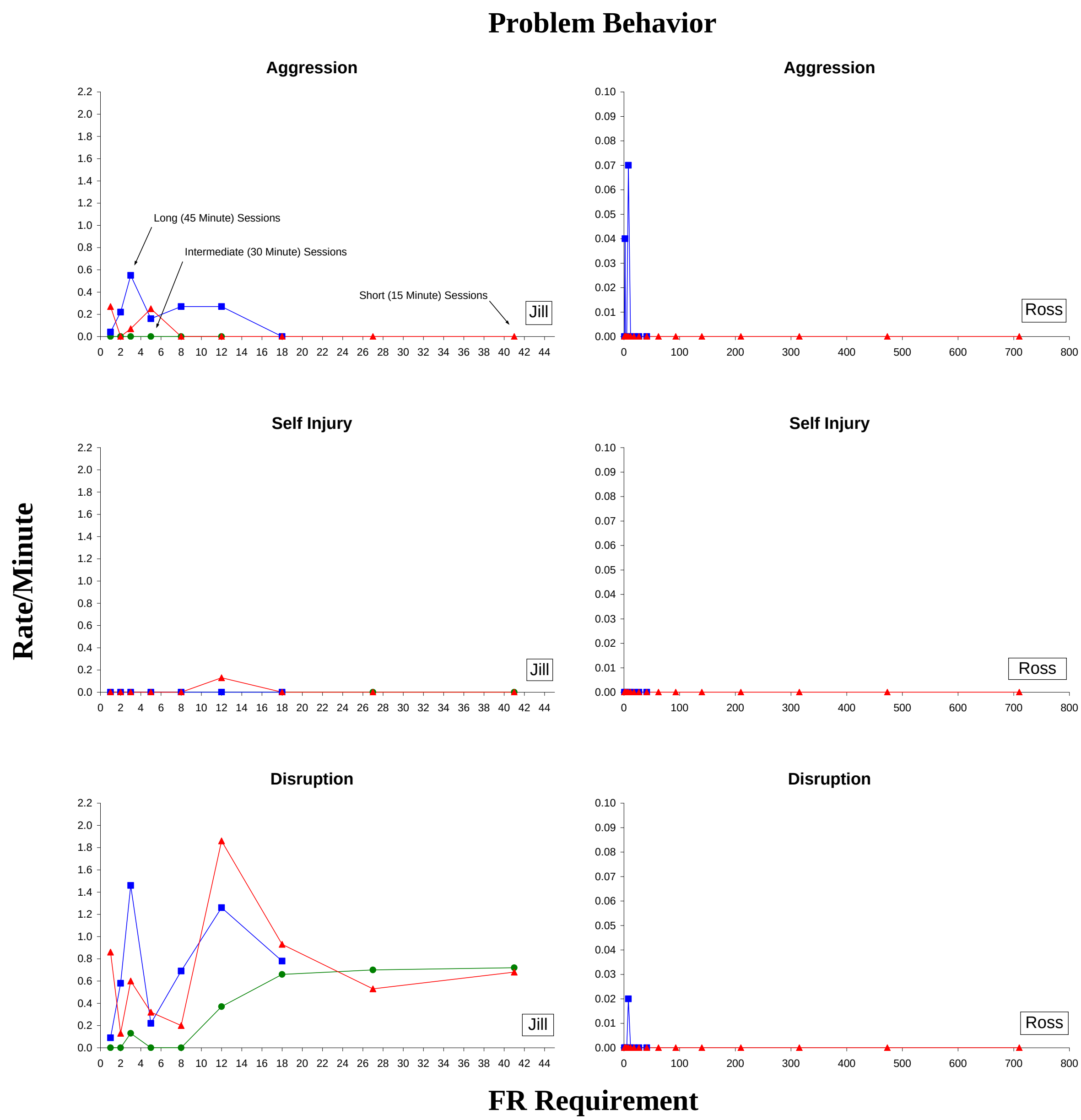

Figure 6. Rate of aggression, self injury and disruption for each participant. *Note*. The x- and y-axes differ in each column. Figure 6 is continued on the next page.

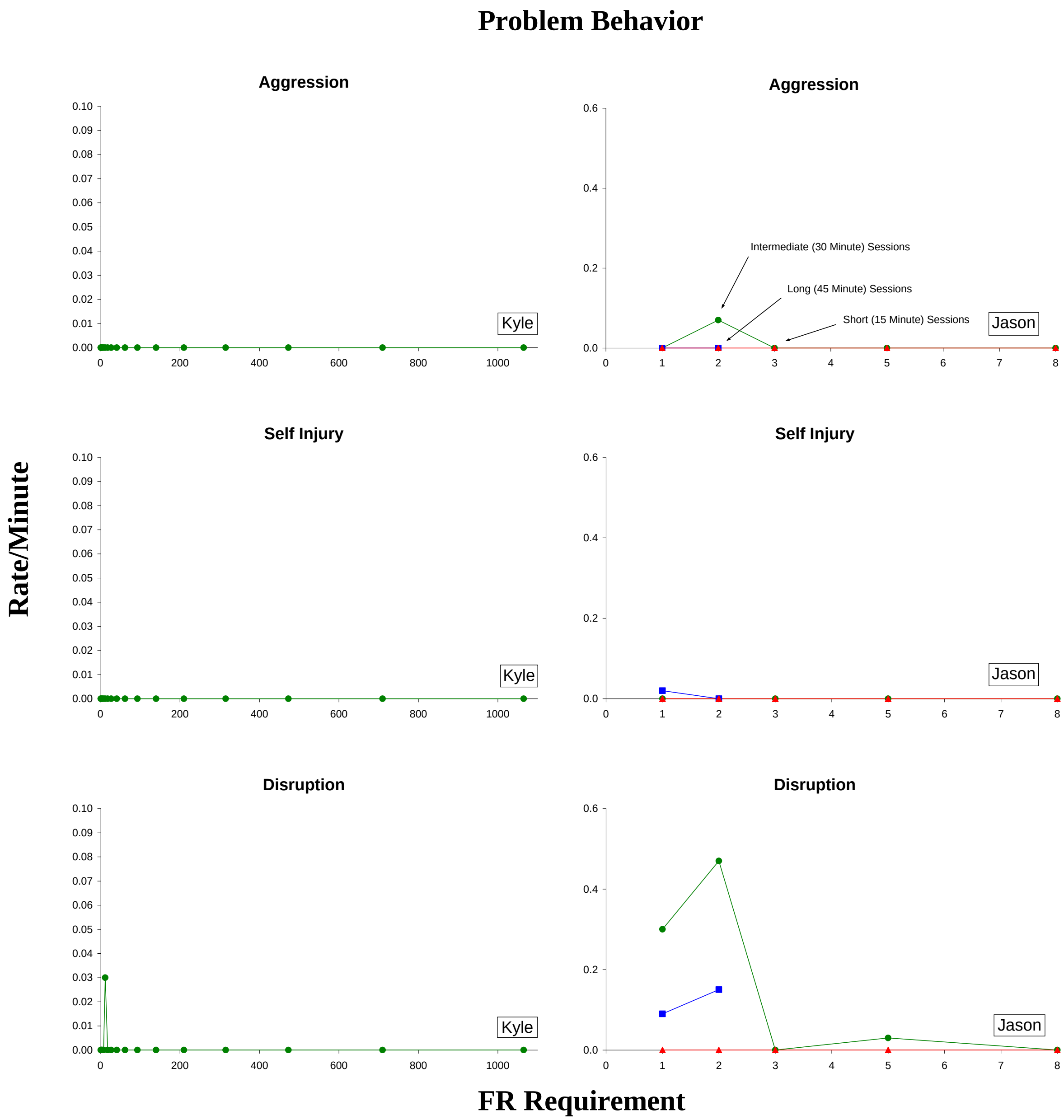

Figure 6. Rate of aggression, self injury and disruption for each participant. *Note*. The x- and y-axes differ in each column. Figure 6 is continued from the previous page.

injury and disruption for each participant. Jill had higher rates of problem behavior across all three conditions than the other participants, with the lowest rates observed in the intermediate condition. Her rates of aggression and disruption were variable and typically consisted of low intensity aggression towards the staff member using the beads and repetitive disruption such as dropping the container, throwing blocks, or banging the container against the table. Jill's self injurious behavior was typically banging her hand on the table. Ross, Jason and Kyle demonstrated lower overall rates of problem behavior. Ross displayed some minor aggression and disruption using the blocks in the long condition. Jason had elevated rates of disruption during the initial intermediate sessions as well as long sessions. Kyle's problem behavior consisted of a few disruptions during the FR 12 session. No aggressive or self-injurious behavior was recorded for Kyle.

The FR schedule progression used was FR 1, FR 2, FR 3, FR 5, FR 8, FR 12, FR 18, FR 27, FR 41, FR 62, FR 93, FR 140, FR 210, FR 315, FR 473, FR 710, and FR 1065. This schedule progression was chosen because of its similarity to other schedule arrangements used in other behavioral economic preparations with persons with developmental disabilities (DeLeon, Iwata, Goh, et al., 1997; Tustin, 1994). However, the increasing ratio schedule used in Experiment 1 progressed more gradually than the schedules used by DeLeon, Iwata, Goh, et al and Tustin. This systematic schedule progression yielded high response rates on the block task and very high ratio breaking points. The use of increasing FR requirements across sessions with one exposure to each ratio during a single session, and sessions separated by a minimum of 60 minutes provided a rapid method for generating demand curves without disrupting the daily educational and vocational activities of the participants. Future behavioral economic studies in developmental disabilities should continue building systematic methods for obtaining demand curves. Other areas of study might include evaluating the effect of varying ratio step size on breakpoints or direct comparison of demand curves generated by fixed and progressive ratio schedules of reinforcement.

EXPERIMENT 2: BEHAVIORAL ECONOMIC REINFORCER ASSESSMENT

METHOD

Participants and Setting

Four individuals took part in Experiment 2. Participants were under the age of twenty-one years and diagnosed with developmental or other learning disabilities. Their diagnoses and functional levels were obtained from records maintained by The Learning Tree Tallassee Campus at which they receive services. All participants attended a daily six-hour educational program for children with intellectual disabilities and problem behavior such as aggression, disruption or self-injury. In addition to receiving educational services, participants lived in residential group homes within the local community. Participants were selected based on their performance on a vocational skill assessment (Lerman, Vorndran, Addison, and Kuhn, 2004).

Jason was a 12-year-old boy diagnosed with moderate mental retardation and autism, Jill was a 13-year-old girl diagnosed with severe mental retardation, Chad was a 17-year-old young man diagnosed with profound mental retardation and autism, and Grant was a 19-year-old young man diagnosed with profound mental retardation, autism, and epilepsy. Jason and Jill participated in both Experiment 1 and 2. Exact Intelligence Quotient scores were unavailable for the participants. Jason communicated using spontaneous and prompted vocal speech and demonstrated good receptive language skills such as following two-step instructions. Jill was non-verbal and was able to follow one-step instructions. Chad and Grant were non-verbal with good receptive language skills and could follow two-step directions. Chad communicated using some basic sign language. Throughout the duration of Experiment 2, Jason and Chad took medication to control problem behavior. Grant took antiepileptic medication to control seizures. The medications taken by each participant during Experiment 2 are listed in Table 10.

Table 10
Medication Taken by Participants

Participant	Medication
Jason	Risperidone 1 mg twice daily, Risperidone 0.5 mg once daily
Chad	Olanzepine 10 mg once daily, Olanzepine 5 mg once daily, Clonidine 0.1 mg three times daily, Clonidine 0.2 mg once daily, Fluoxetine 30 mg once daily
Grant	Phenytoin 150 once daily, Phenytoin 100 once daily, Levetiracetam 500 twice daily, Oxcarbazepine 600 mg twice daily

Annual testing of the students at The Learning Tree was conducted by case managers from the Alabama Department of Human Resources using the Inventory for Client and Agency Planning (ICAP) (Bruininks, Hill, Weatherman, and Woodcock, 1986). The ICAP is a comprehensive 123-item standardized instrument to assess the adaptive functioning, maladaptive problem behavior, functional characteristics and service needs of individuals with developmental disabilities. The ICAP general score ranges from 0 to -74 with a standard deviation of -10. For example, no maladaptive problems would be a zero and serious maladaptive behavior problems would be reported with increasingly larger negative numbers. The ICAP service score ranges from 0 to 100 and level score ranges from 1 to 9. The ICAP service score is an overall measure of the individual's need for care, support, supervision and training that is based on the combined adaptive and maladaptive behavior scores. Persons receiving an ICAP service score less than 20 are assigned a level 1 score meaning that they require total personal care and intensive supervision while level 9 represents total independence. Levels 4 through 6 identify supervised intermediate care and levels 7 through 9 indicate that limited care is required. Participants' current ICAP results and age equivalents are shown in Table 11. The general and service level scores indicate that all participants have very serious maladaptive behavior, and they require total personal care and intensive supervision.

Table 11
Inventory for Client and Agency Planning (ICAP) results for participants

Participant	General Score Range 0 to -74	Service Score Range 0 to 100	Service Level Score Range 1 to 9	Overall Age Equivalent
Jason	-47	7	1	1 year, 8 months
Jill	-66	1	1	1 year, 6 months
Chad	-50	5	1	1 year, 9 months
Grant	-20	25	2	1 year, 5 months

Sessions were conducted in a small, 3 meter by 4 meter, classroom of The Learning Tree Tallassee containing a table, chairs, video camera, laptop computer, task materials and stimuli necessary for assessment. Other objects such as storage bins, a fan, and a trash can were also present; however, participants were blocked from interacting with these items when necessary. One to two sessions were conducted each day with the first in the morning and the second in the afternoon. None of the sessions were conducted within an hour of the student's lunch time. Participants were exposed to six series of sessions: responding for two edible items at low and high magnitudes and one tangible item at low and high magnitudes.

Informed Consent and Minor Assent for Participation

Written consent was obtained for each individual prior to his or her participation in the study. A parent provided informed consent for Jill, Chad and Grant. A state-appointed social worker consented for Jason's participation. In addition to parent or guardian consent, all participants were read and asked to sign an assent form to take part in the study. A staff member was present while consent/assent documentation was obtained to assist the experimenter in determining whether the individual demonstrated an understanding of the form. A representative from The Learning Tree also provided written informed consent for each individual to participate. Caregivers were asked to sign a consent form before giving information about the preferences of the participants. All consent documents used in the study are included in Appendix A.

The experimenter obtained consent from the participant before each session. The individual was asked if he or she wanted to work with the blocks. If the individual agreed, he or she went to the session room. A refusal resulted in the individual remaining in the present location and continuing the current activity. A staff member was present at all times to assist with determining the participant's ongoing consent.

Data Collection and Interobserver Agreement

Observers trained in behavioral observation collected pen-and-paper data during skill and preference assessment procedures. Interobserver agreement data were collected for 100% of skill assessment and 75% of preference assessment trials by having a second observer simultaneously and independently record a participant's target responses. Agreement was calculated on a trial-by trial basis for skill and preference assessments. For the skill assessment, agreement was defined as both observers recording the occurrence or non-occurrence of the response. Preference assessment agreement was defined as both observers recording the same stimulus chosen on the trial or that no choice was made. Interobserver agreement for the skill and preference assessments was calculated by dividing the number of trials with agreements by the total number of trials then multiplying the quotient by 100%. Interobserver agreement was collapsed across participants and across the skill probe and extinction conditions of the skill assessment. There was 97% agreement on skill assessment trials with a range of 88% to 100%. For preference assessment, interobserver agreement was collapsed across participants and across six administrations. Observers agreed on 100% of preference assessment trials.

During the behavioral economic assessment, observers collected data on laptop computers. Frequency measures were aggression, self injurious behavior, disruption, and the target functional response. Duration measures in seconds were taken on response completion, latency between responses, the reinforcement interval, and reinforcer consumption if applicable (see Appendix B for the operational definitions used during computerized data collection. A portion of the behavioral economic assessment was videotaped (93% of sessions), and a second observer collected data on 42% of videotaped sessions. Interobserver agreement was calculated by dividing each session into 10-second intervals and comparing the data of the two observers. Agreements were defined as the same responses scored within a 10-second interval, and disagreements were defined as a different responses scored within the interval. Interobserver agreement was calculated by dividing the number of 10-second intervals with agreement by the number of 10-second intervals with agreements plus the number of 10-second intervals with disagreement, multiplied by 100%. Interobserver agreement was collapsed across the frequency and duration measures with an average of 93% for Jason (range 85% - 100%), 92% for Jill (range 86% - 100%), 95% for Chad (range 87% - 99%), and 94% for Grant range (85%-100%). Only interobserver agreement greater than or equal to 80% was included in the averages.

The Economic Context

Ethical issues could arise if all food and leisure items were only available during experimental conditions, so the overall economic context was an open economy. Participants continued to receive their typical reinforcers in the classroom. However, access to the specific reinforcers under evaluation was limited during the school day; but total restriction of all substitutes was impractical, if not impossible. For example, if chocolate chip cookies are used as reinforcers, free access to all cookies can be avoided; but a number of other sweet foods may be substitutable when the availability of chocolate chip cookies is constrained. That is, reinforcement can be obtained through interaction with the experimental environment, but other effective sources of reinforcement may also be available outside the experimental context. The use of tangible and edible reinforcers for persons with developmental disabilities and the availability of substitutable sources of reinforcement make it difficult to approximate a closed economy in an applied setting (Roane et al., 2005).

Pre-Assessment Skill Probe and Extinction Procedure

Skill probes were completed prior to the behavioral economic reinforcer assessment. This determined whether each individual could perform a simple block sorting task when reinforcement was delivered following every correct response, and would cease responding when reinforcement was removed. The target response consisted of dropping a one-inch block through a slot in the top of a box. The task was a simple operant response that was already in the repertoire of the participants. This allowed practice of a pre-vocational skill that might have important potential implications for the individual as a prerequisite or component skill of a more complex response. The task also provided a discrete target response that the participant could complete correctly and independently following a one-step instruction. It has been shown that using simple operants and a continuous schedule of reinforcement may minimize the potentially confounding effects of other variables such as response difficulty or ratio strain (Fisher & Mazur, 1997; Piazza, Fisher, Hagopian, et al., 1996).

The skill assessment probes were conducted using methods similar to the rapid skill assessment procedure suggested by Lerman, Vorndran, Addison, and Kuhn (2004). Three consecutive sessions were conducted. Each session consisted of 10 trials presented approximately on a fixed-time 10-second schedule (FT 10-s). Prior to each session, the experimenter demonstrated the correct block-dropping response for the participant and then delivered a verbal prompt while physically guiding the individual to complete the response the same way. With the experimenter and participant seated on opposite sides of a table, one block and the slotted box were placed in front of the participant. Before the first trial of the session, the participant was verbally instructed to "Put the block in the box." After the first trial no additional prompts were given during the remainder of the session. Trials were scored as either correct, incorrect, or no response. Correct responding was defined as beginning the requested action (such as touching the block) within five seconds of the verbal instruction and independently completing the response within 10 seconds of the instruction (Lerman, et al.). If the participant had not attempted a response within five seconds or failed to complete the task within 10 seconds, the materials were removed and the trial was terminated. If the participant responded correctly to the task demand within the time limits, the materials were removed and the participant received descriptive praise and a reinforcer on a fixed ratio (FR 1) reinforcement schedule. The reinforcers used were listed on participants' Individual Educational Plans (IEPs) as highly-preferred stimuli identified via preference assessments previously conducted by behavior analysts at The Learning Tree. Reinforcers consisted of a small piece of food or 30-second access to a toy. Following correct block drops, Jason received half of a round fruit snack, Jill had access to a string of plastic beads for 30 seconds, Chad received a small chocolate cookie, and Grant had access to a tennis ball for 30 seconds.

Responses were evaluated based on the average percentage of correct responding across sessions calculated as the number of correct responses during the session (those initiated within five seconds of the verbal instruction and completed within 10 seconds) divided by the number of trials (10). Percentage of correct responding was then averaged across the three sessions. If the participant demonstrated an average of 80% or greater correct responding when reinforcing consequences were provided, then responding was evaluated in additional extinction trials.

The extinction procedure was similar to that of the skill probes described above with one exception - the participant did not receive descriptive praise on his or her performance or any other form of reinforcement following correct responding. Task demands were delivered consecutively, approximately on a fixed-time 10-second schedule (FT 10-s) with task materials briefly removed between trials. Sessions continued until responding ceased on five consecutive trials or 100 extinction trials (10 sessions) were completed. Correct responding was calculated for block drops on the extinction trials, and block dropping needed to rapidly extinguish for participants to reach zero response rates. To take part in the study, each participant had to have zero completion following extinction trials and an 80% or greater percentage of correct responding during sessions with reinforcing consequences.

Stimulus Preference Assessment Procedure

Caregiver Interview

Participants' caregivers were asked to generate a list of potential reinforcers during a structured interview called the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD) developed by Fisher et al.(1996) (see Appendix C for a copy of the RAISD). Caregivers were chosen who were very familiar with the participants and had worked at The Learning Tree for some time. The purpose of the RAISD was to facilitate identification of as many potential reinforcers for the individual's behavior as possible. The RAISD consisted of questions regarding preferred stimuli within the following general categories: visual, auditory, olfactory, edible, tactile, and social. Caregivers were asked to identify specific preferred stimuli and to describe the conditions under which those stimuli were preferred. Examples include: What specific TV shows are the person's favorite? What does he/she do when playing with a mirror? Does the individual prefer to do this activity alone or with another person? After the interview, caregivers ranked the stimuli generated from the assessment according to their predictions regarding child preference. For each participant, the five highest-ranking stimuli from the RAISD were used in later preference assessments.

Paired-Stimulus Preference Assessment

The paired-stimulus preference assessment was conducted in a similar manner to the procedure described by Fisher et al. (1992) using five stimuli identified from the RAISD (see Appendix D for the paired-stimulus preference assessment data collection sheet). The participant was allowed to sample each of the stimuli prior to preference assessment. During the choice assessment, each stimulus was paired twice with every other stimulus resulting in 20 trials. Each pair of stimuli was presented twice so that each stimulus of the pair was presented on both the left and right. In all cases, the actual stimuli were presented to the participant. If the stimulus was visual such as a video, a portable DVD player was used and the video was on the screen but paused. Audio stimuli such as music were presented in a similar way using a portable CD player. Stimuli were presented in pairs 30 centimeters from each other on a table 30 centimeters in front of the participant with the experimenter seated on the opposite side of the table. The child was prompted to choose one of the stimuli when the experimenter said "Pick one." Approach responses toward one of the stimuli, such as pointing at or picking up a stimulus, resulted in 20 seconds of access to that stimulus and removal of the other from sight. If the individual did not approach either stimulus within five seconds, both stimuli were removed and he or she was prompted to sample each stimulus, individually, for five seconds. The same stimuli was then be presented a second time for five seconds using the same instructions, and approach responses resulted in 20 seconds of access to the chosen stimulus. If no response was made within five seconds, the stimuli were removed and the next trial initiated. Attempts to reach for both stimuli simultaneously were blocked by removing the stimuli, the trial disregarded, and the stimuli were re-presented until the trial was successful. This process continued until all pairs were presented. If necessary the paired-stimulus assessment was divided into 15 to 30 minute sessions. Stimuli were ranked according to their percentage of selection, the quotient of the number of times a particular stimulus was chosen divided by 8 (the number of presentations of the stimulus, 2N – 2, or two multiplied by the number of stimuli in the assessment minus two) multiplied by 100%.

As a control measure for the later behavioral-economic reinforcer assessment, a second paired-stimulus preference assessment was conducted using the same stimuli and procedure described above. However, the magnitude of each stimulus was tripled for the second paired-stimulus assessment. Paired-stimulus preference assessment rankings at different stimulus magnitudes could facilitate comparison to the results of the behavioral economic assessment. Approach responses to tangible items resulted in 60 seconds of access to the chosen stimulus. With edibles, roughly three times the amount of food was presented. Edibles used were very small portions and reduced calorie foods were used whenever possible to limit caloric intake and reduce the potential for satiation. Stimuli were ranked according to their percentage of selection.

When both edible and tangible stimuli were included in the original paired-stimulus choice assessment, additional separate food and nonfood paired-choice assessments were conducted. DeLeon, Iwata, and Roscoe (1997) demonstrated that some individuals have a general preference for food and that edibles may displace tangibles when presented together in a multiple-stimulus format. The additional edibles-only and tangibles-only paired-stimulus assessments were conducted using the procedure described above. Stimuli within each assessment were ranked according to their percentage of selection. When stimuli were combined in the original paired stimulus, a total of six paired-stimulus assessments were conducted because of the different stimulus magnitudes: two combined, two edibles-only, and two tangibles-only. If stimuli were not intermixed in the original five-stimulus paired-stimulus, no additional assessments were conducted. The three highest preferred stimuli for each participant were used in subsequent behavioral economic reinforcer assessments.

Behavioral Economic Reinforcer Assessment Procedure

Following successful completion of skill probes and extinction trials, participants began a behavioral economic reinforcer assessment. The purpose of this assessment was to obtain demand curves representing consumption of each reinforcer with increasing price that could be used to evaluate various behavioral economic measures and the utility of the exponential demand model to identify highly valued reinforcers for children, adolescents, and young adults with developmental disabilities. Participants completed a simple operant task to earn reinforcers that were previously identified by standard preference assessment. They had previous experience with the block-dropping task from the screening procedures; however, during the behavioral economic assessment the FR requirement increased systematically across sessions until the individual stopped responding for the reinforcer. The behavioral economic reinforcer assessment procedure utilized the method for generating rapid demand curves developed in Experiment 1.

Two demand curves were generated for each reinforcer; one with the reinforcer at low magnitude and another with the reinforcer at high magnitude. Demand curves for each reinforcer were estimated using progressively increasing FR schedules of reinforcement across sessions (DeLeon, Iwata, Goh, et al., 1997; Foster, Blackman, et al., 1997; Foster, Temple,, et al., 1997; Raslear et al., 1988; Tustin, 1994). Under increasing FR schedules, participants had to meet increasing response requirements to earn a reinforcer. The way in which schedules are programmed to generate demand curves has varied considerably across applied and basic behavioral economic research applications. Both FR and PR schedules have been used, and share many common characteristics. Stafford et al. (1998) reviewed the use of PR schedules in the drug self-administration literature and outlined the procedural issue associated with these schedules. Additive or proportional progressions have typically been used in behavioral economic research using persons with developmental disabilities (DeLeon, Iwata, Goh, et al.; Roane et.al., 2005; Roane et al., 2001; Tustin). Basic research involving FR and PR schedules have also included exponential and logarithmic proportional progressions (reviewed by Stafford et al.). There is no clear consensus on how the schedule steps should be increased when the participants are persons with developmental disabilities. However, basic research indicates that ratio step size does not significantly change the breaking points obtained on PR schedules (Stafford & Branch, 1998). Tustin used an increasing FR schedule across sessions with three exposures to each ratio requirement (FR 1, FR 2, FR 5, FR 10, FR 20) presented in an ascending order, descending order, and again in ascending order; however other studies have shown that repeated, extended exposure to a single ratio may be unnecessary (Raslear et al., 1988; Foster, Blackman, et al., 1997). Other arbitrary schedules have been used for individual participants (Roane et al., 2001). The goal is to choose the most efficient procedure to evaluate consumption under increasing schedule constraint in order to reach the breakpoint of the reinforcer and to generate demand curves for the reinforcer.

Progressively Increasing Fixed-Ratio Schedules

Participants were exposed to a series of FR schedule requirements that increased by a fixed proportion across experimental sessions. Completion of the ratio requirement resulted in the removal of task materials and access to the reinforcer. The FR was gradually increased by multiplying each step value by 1.5 to obtain the subsequent response requirement until the maximum FR was reached, when responding ceased for 5 consecutive minutes. The FR schedule progression was FR 1, FR 2, FR 3, FR 5, FR 8, FR 12, FR 18, FR 27, FR 41, FR 62, and continued by multiplicative steps of 1.5 until the breaking point was reached. The breaking point was defined as the largest ratio requirement that the participant completes (Hodos, 1961), and the breaking point criteria were five minutes without a response or three consecutive sessions in which responding was insufficient to earn a single reinforcer. This schedule progression is similar to but more gradual than those used by DeLeon, Iwata, Goh, et al., (1997) and Tustin, (1994). Participants were exposed to each ratio requirement during a single session. This procedure has been found to yield similar demand curves as repeated, lengthy exposure to ratio requirements (Raslear et al., 1988, Foster, Blackman, & Temple, 1997).

As per the method described by Hursh and Silberberg (2008), one dimension of reinforcement must then be changed - the FR procedure must be repeated to generate a second data set, and a second demand curve estimated for each stimulus. For the present assessment, the magnitude of reinforcement was increased by tripling the amount of reinforcement available on each trial. For example, if the magnitude of reinforcement used to generate the data for the first demand curve was 20 seconds of access to a Barney video, then the magnitude used for the additional data set was 60 seconds of video. Two demand curves for different magnitudes of reinforcement were estimated for each of the three stimuli used in previous preference assessments.

All sessions were 30 minutes. The order of reinforcers and magnitudes was randomly selected for each participant. The schedule progression began at FR 1 and advanced by multiplicative steps of 1.5 for each session. The experimental session was terminated when one of the following conditions were met: the participant stopped responding for 5 consecutive minutes, 30 minutes had elapsed since the task materials were placed in front of the participant, or the participant’s maladaptive behavior was uncontrollable. Sessions were also terminated after three consecutive sessions without reinforcement. While data was collected on inappropriate behavior, no programmed consequences were provided for problem behavior during assessments. Minor problem behavior was ignored or physically blocked so the individuals did not hurt themselves. In the event of continuous aggression, self injury or high magnitude disruption, crisis procedures designated by The Learning Tree were implemented and the experimental session was immediately terminated. Participants were able to earn the three highest preferred items identified via paired-stimulus preference assessment. The stimuli used were cinnamon cereal, grapes and toy cars for Jason; graham cracker cookies, shortbread cookies, and plastic beads for Jill; fruit snacks, cheese balls, and a small ball for Chad; and popcorn, chocolate chip cookies, and a small ball for Grant. Each reinforcer was presented in low and high magnitude conditions for a total of six series of sessions. The magnitude of reinforcement remained constant for the series as the response requirement increased. Dropping blocks into a slotted container was used as the operant response requirement on the FR.

Sessions were separated by at least a 60 minute timeout period in which the participant was returned to his or her regular school activities. In most instances, sessions were conducted approximately two hours apart. The purpose of the timeout was to minimize the time that the participant was removed from standard classroom instruction and to minimize the probability that the repetitive task might become aversive to the individual. In the event that the task became overly aversive, problem behavior was likely to increase and responding could stop because of the punishing effects of the task rather than because the schedule requirement was too large to maintain responding for the reinforcer. Sessions were conducted in the morning and the afternoon during the school day. Sessions were counterbalanced across time of day with the exception of Jason's sessions. The majority of Jason's sessions took place in the morning because of his academic schedule.

Instructions to Participants

A school staff member familiar with the individual brought the participant to the session room. The staff member and participant were seated on opposite sides of a table. The participant was given one minute of access to the stimulus prior to beginning each session. This allowed the participant to sample the item under evaluation. Latency since the participant last consumed or interacted with the item was standardized which was important since participants had access to items throughout the school day that might function as substitutes for that stimulus (Bickel & Madden, 1999; DeGrandpre et al., 1994; Shahan et al. 1999). The participant was instructed that he or she could work to obtain the item; could work as much or as little as they wanted; but were not required to complete any work. The staff member read the following instructions at the beginning of the session: "You can have _____ if you put the blocks in the box. You can work as much as you want or not work at all." The required number of blocks for the FR requirement and the box were placed in front of the individual. Completion of the response requirement resulted in the removal of the task materials and access to the preferred item for 20 seconds in low magnitude conditions and 60 seconds in high magnitude conditions. No verbal praise or other social reinforcement was provided. The reinforcement interval remained 20 or 60 seconds regardless of how long the participant actually interacted with the reinforcer. Following the reinforcement interval, the blocks and box were placed in front of the participant again but no further instructions were given. The procedure continued until one of the session termination criteria was met and then the participant returned to educational and vocational activities.

The data collector was seated with a laptop computer at the far end of the table out of reach of the participant. The data collector did not interact with the participant but provided verbal prompts to the staff member to begin the session, end a reinforcement interval or end the session.

RESULTS AND DISCUSSION

Pre-Assessment Skill Probe and Extinction Sessions

All four participants met the criteria for inclusion in the study. Jason, Jill, and Chad correctly dropped the block in the box on all 30 skill probe trials. Grant failed to drop the block within the time limit on one trial during session one. The range of average correct responding on skill probe sessions was 97% to 100%. The results of the skill probe sessions are shown in Table 12. Participants took between 18 and 30 minutes to complete the skill probe assessment.

Table 12
Performance on Pre-Assessment Skill Probe Sessions

	Percentage Correct Responding				
Participant	Session 1	Session 2	Session 3	Average	Duration in Minutes
Jason	100%	100%	100%	100%	18
Jill	100%	100%	100%	100%	27
Chad	100%	100%	100%	100%	18
Grant	90%	100%	100%	97%	30

Extinction trials were conducted with the four participants because all exceeded an average of 80% correct responding on the skill probes. Table 13 shows the results of extinction trials. The number of extinction trials required varied across participants. Jason and Grant stopped responding after only 15 and 17 trials, respectively. Jill and Chad continued to correctly drop the block into the container on a relatively high percentage of trials. Average correct responding ranged from 28% to 67%. The duration

Table 13
Performance on Pre-Assessment Extinction Trials

Participant	Number of Extinction Trials	Average Percentage Correct Responding	Duration in Minutes
Jason	15	45%	11
Jill	48	67%	18
Chad	42	28%	29
Grant	17	47%	10

of extinction sessions was similar to skill probe sessions. Participants completed extinction sessions in less than 30 minutes. No maladaptive behavior was recorded for any participant during the pre-assessment skill probes or extinction trials.

Stimulus Preference Assessment

Caregiver Interview

The RAISD interview (Fisher et al., 1996) was used to generate a list of potential reinforcers identified by participants' caregivers. The caregivers chosen for the interview were very familiar with the participants. All worked with the participants in their residential settings and had been with The Learning Tree for a considerable time. Caregivers from the residential rather than the educational setting were chosen because there was a larger array of preferred stimuli in the home than at school, and they were more likely to have opportunities to observe the participants during free time. Caregivers were asked a series of structured interview questions to identify participants' preferred stimuli. Following the interview, caregivers ranked the stimuli generated from the RAISD according to their predictions of the participant's preference. Only stimuli that could be efficiently delivered as reinforcers were included in the rankings. For example, outings, playing outside, fast food meals, and the like were eliminated from the list. The highest ranking stimuli derived from the RAISD are listed in Table 14. For Jason, Jill and Grant, the five highest-ranking stimuli were used in later preference assessments. In Chad's case, the three most highly preferred edibles and two most highly preferred tangibles were used in subsequent assessments to limit his consumption of high calorie foods. Jason's caregiver identified an action figure that was commonly played with and carried to school, toy cars, baked potato chips, grapes and dry cinnamon cereal. The items generated for Jill included any flavor of dried fruit roll, plastic beads, shortbread and graham cracker cookies and gospel music similar to that played during church services. Chad's preferred stimuli were fruit snacks, cheese ball, chocolate cookies, a foam call and musical toy car. Chad's caregiver noted that most edible items were highly preferred and little interaction occurred with tangible items. Grant's items were a foam ball, any cartoon, gospel music similar to that played during church services, popcorn and chocolate chip cookies. See Table E-1 in Appendix E for a complete list of stimuli generated using the RAISD.

Table 14
Highest-Ranking Preferred Stimuli Identified by Caregivers Using the RAISD

Rank	Jason	Jill	Chad	Grant
1	Action Figure	Dried Fruit Roll	Fruit Snacks	Foam Ball
2	Toy Cars	Plastic Beads	Cheese Balls	Cartoon DVD
3	Baked Potato Chips	Shortbread Cookies	Chocolate Cookies	Gospel Music
4	Grapes	Graham Cracker Cookies	Foam Ball	Popcorn
5	Cinnamon Cereal	Gospel Music	Musical Toy Car	Chocolate Chip Cookies

Paired-Stimulus Preference Assessment

The five stimuli identified using the RAISD (Fisher et al., 1996) were used in a series of paired-stimulus preference assessments using a similar procedure to that of Fisher et al. (1992). Stimuli were presented at low and high magnitudes in separate assessments. One small piece of edibles and 20 second access to tangibles were used in the low magnitude assessment. In the high magnitude assessment the magnitude of each stimulus was tripled, so three small pieces of edibles and 60 seconds of access to tangibles were used. The portions of edible stimuli were very small and reduced calorie foods were used throughout the study. In addition to the two assessments in which edible and tangible stimuli were presented in combination, separate edibles-only and tangibles-only paired-stimulus assessments were conducted. The additional assessments were completed using low and high magnitude stimuli. A total of six paired-stimulus assessments were conducted with each participant.

Stimuli were ranked according to their percentage of selection, the quotient of the number of times a particular stimulus was chosen divided by 2N – 2 (two multiplied by the number of stimuli in the assessment minus two) multiplied by 100%. The paired-stimulus preference results for the combined stimuli, edibles-only, and tangible-only assessments are in Table 15. Participants' preferences for some stimuli varied across both assessment composition and stimulus magnitude. Preference remained stable across assessments in only a few instances. The percentage of selection was the same for some of the stimuli across assessments. For example, there was agreement on grapes for Jason in LM and HM edibles-only assessments, cinnamon cereal in LM and HM combined stimuli assessments and the action figure in LM combined stimuli and LM tangibles-only

Table 15

Percentage of Trials Each Stimulus Was Chosen Across Preference Assessments

	Combined Stimuli		Edibles Only		Tangibles Only	
Participant/Reinforcer	LM	HM	LM	HM	LM	HM
Jason						
Grapes	88	75	100	100		
Cinnamon Cereal	63	63	50	25		
Baked Potato Chips	38	75	0	25		
Toy Cars	63	25			100	50
Action Figure	0	13			0	50
Jill						
Shortbread Cookies	63	25	75	75		
Graham Cracker Cookies	38	75	75	25		
Dried Fruit Roll	63	50	0	50		
Plastic Beads	88	88			100	100
Gospel Music	0	13			0	0
Chad						
Cheese Balls	75	75	50	50		
Fruit Snacks	63	63	50	75		
Chocolate Cookies	75	88	50	25		
Foam Ball	38	25			0	100
Musical Toy Car	0	0			100	0
Grant						
Popcorn	88	63	50	50		
Chocolate Chip Cookies	75	100	50	50		
Foam Ball	25	38			100	100
Gospel Music	25	0			25	50
Cartoon DVD	38	50			25	0

Note. LM and HM indicate whether low or high magnitude reinforcement was used in the paired-stimulus preference assessment.

assessments. Given that there were four preference results for each of five stimuli, Jason had 6 agreements for percentage of selection out of 20 possible results or 30% preference stability. Jill had the greatest consistency with 13 agreements or 65% stability across assessments. Chad showed stable preference percentages on 9 opportunities for 45% stability. Grant had 40% preference stability with 8 agreements across assessments. The range of preference stability for the participants was 30-65%. Caution should be used when interpreting stability of preference from percentages across assessment composition and stimulus magnitude because the stimuli were not presented an equal number of times across assessments. Five stimuli were used in the combined assessments while two or three stimuli were used in the edibles- and tangibles-only assessments. Because of this, a comparison of rankings across assessments might be more useful for determining preference shifts for a given stimulus. This method looks at changes in preference of a given stimulus relative to the other stimuli without confounding the relationship with the number of opportunities available to select that stimulus. Ranks were assigned to each stimulus within an assessment based on the associated percentage of selection (see Table 16). In instances in which the percentage of selection was the same for multiple stimuli, the same rank was assigned to each. The relative rank ordering of stimuli was much more stable than the percentage of selection across assessments. Preference stability based on rank was 70% for Jason, 65% for Jill, 45% for Chad, and 80% for Grant. While percentage of selection was variable across assessments, the relative preference ranking among stimuli was considerably more consistent.

Some persons with developmental disabilities show a general preference for food items as a class of reinforcers according to DeLeon, Iwata, and Roscoe (1997). Edibles can displace tangibles downward when presented together during preference assessment. Displacement by edibles was evaluated in the present study, and Jason, Chad and Grant demonstrated this pattern in preference (see Tables 15). Assessment results for Jill did not indicate a general preference for edibles. For Jason toy cars were low preferred

Table 16
Preference Rankings Derived From Paired-Stimulus Preference Assessments

	Combined Stimuli		Edibles Only		Tangibles Only	
Participant/Reinforcer	LM	HM	LM	HM	LM	HM
Jason						
Grapes	1	1	1	1		
Cinnamon Cereal	2	2	2	2		
Baked Potato Chips	3	1	3	2		
Toy Cars	2	3			1	1
Action Figure	4	4			2	1
Jill						
Shortbread Cookies	2	4	1	1		
Graham Cracker Cookies	3	2	1	3		
Dried Fruit Roll	2	3	2	2		
Plastic Beads	1	1			1	1
Gospel Music	4	5			2	2
Chad						
Cheese Balls	1	2	1	2		
Fruit Snacks	2	3	1	1		
Chocolate Cookies	1	1	1	3		
Foam Ball	3	4			2	1
Musical Toy Car	4	5			1	2
Grant						
Popcorn	1	2	1	1		
Chocolate Chip Cookies	2	1	1	1		
Foam Ball	4	4			1	1
Gospel Music	4	5			2	2
Cartoon DVD	3	3			2	3

Note. LM and HM indicate whether low or high magnitude reinforcement was used in the paired-stimulus preference assessment. Stimuli with the same percentage of selection were assigned the same rank.

stimuli in both combined assessments but were chosen on 100% of presentations in the low magnitude tangibles-only assessment. Chad showed displacement with the foam ball and musical toy car, which were the lowest preferred stimuli in both of the combined assessments. Each toy was chosen on 100% of presentations in a tangibles-only assessment. During both combined assessments with Grant, the foam ball was a low preferred item. However, the ball was chosen on 100% presentation in both the low and high magnitude tangibles-only assessments. Three of four participants showed a general preference for edible stimuli over tangible stimuli. The findings were consistent with the results of DeLeon, Iwata, et al. In order to more effectively identify potential reinforcers, separate paired stimulus assessments for edibles-only and tangibles-only were used to identify preferred stimuli used in the behavioral economic reinforcer assessment.

The results from the low and high magnitude paired-stimulus assessments were combined to yield an overall ordering of preference across the array of stimuli (see Table 17). The percentage of selection across low and high magnitude assessments was the quotient of the number of trials in which a stimulus was chosen and the number of presentations of the stimulus. The number of times the participant selected a particular item on the low magnitude assessment was added to the number of times that item was chosen on the high magnitude assessment. The percentage of selection across the low and high magnitude assessments was calculated by dividing the total number of times the stimulus was chosen by the number of presentations of that stimulus (two times 2N – 2) multiplied by 100%. For example, if the item was chosen three times at low magnitude and four times at high magnitude, the item was selected a total of seven times across assessments. Participants had four opportunities to select each stimulus on a three-item assessment (2N – 2, 2 x 3 – 2 = 4), so each item was presented a total of eight times across assessments (2 x 4). Once the paired-stimulus preference assessment results were collapsed across different magnitudes of reinforcement, the stimuli were ranked according to their percentage of selection on the edibles-only and tangibles-only

Table 17

Paired-Stimulus Preference Assessment Results Collapsed Across Reinforcer Magnitudes

Participant/Reinforcer	Edibles/Tangibles Only
Jason	
Grapes	*100*
Toy Cars	*75*
Cinnamon Cereal	*38*
Action Figure	25
Baked Potato Chips	13
Jill	
Plastic Beads	*100*
Shortbread Cookies	*75*
Graham Cracker Cookies	*50*
Dried Fruit Roll	25
Gospel Music	0
Chad	
Fruit Snacks	*63*
Cheese Balls	*50*
Foam Ball	*50*
Musical Toy Car	50
Chocolate Cookies	38
Grant	
Foam Ball	*100*
Popcorn	*50*
Chocolate Chip Cookies	*50*
Gospel Music	38
Cartoon DVD	13

Note. Italicized stimuli were used in the behavioral economic reinforcer assessment.

assessments. It is common practice in applied behavior analysis to use potential reinforcers with an 80% or greater percentage of selection on the paired- stimulus preference assessment (Pace et al, 1985; Fisher et al., 1992). However, it was unnecessary in the present study to have cutoff criteria for predicting effective reinforcers. Given that it can be difficult to establish cutoff criteria and lower ranking stimuli may also functions as reinforcer (DeLeon & Iwata, 1996), the three highest preferred stimuli for each participant were used in the behavioral economic reinforcer assessment (shown in italics in Table 17). Because Chad chose three items on 50% of trials, two of these items were randomly selected for inclusion in the subsequent assessment. The stimuli used were grapes, toy cars and cinnamon cereal for Jason; plastic beads, shortbread cookies and graham cracker cookies for Jill; fruit snacks, cheese balls and a foam ball for Chad; and a foam ball, popcorn, and chocolate chip cookies for Grant.

Behavioral Economic Reinforcer Assessment

The purpose of the assessment was to evaluate behavioral economic models of demand and the utility of these types of methods to identify highly valued reinforcers for children, adolescents, and young adults with developmental disabilities. The linear-elasticity and exponential demand models were used to fit demand curves to the data generated for each reinforcer. Participants were given opportunities to drop blocks into a slotted container to earn reinforcers that were previously identified by standard preference assessment procedures used by applied behavior analysts. Low and high magnitude reinforcers were used in the behavioral economic reinforcer assessment to generate two demand curves for each reinforcer. Three stimuli at low and high magnitudes were evaluated for each participant for a total of six series of sessions. The FR requirement systematically increased across sessions until the participant ceased responding for the item and a ratio breakpoint was reached.

Ratio Breakpoint Evaluation

The FR was gradually increased by multiplying each step value by 1.5 to get the next response requirement until the maximum FR breakpoint was reached. The breakpoint indicated the highest ratio completed on the FR progression. Table 18 contains the ratio breakpoint values for each participant's reinforcers. Ratio breakpoint

Table 18
Ratio Breakpoints Across Reinforcer Magnitudes

Participant/Reinforcer	Low Magnitude Reinforcer	High Magnitude Reinforcer
Jason		
Cinnamon Cereal	FR 3	FR 3
Grapes	FR 5	FR 12
Toy Cars	FR 1	FR 1
Jill		
Graham Crackers	FR 18	FR 93
Shortbread Cookies	FR 41	FR 62
Plastic Beads	FR 41	FR 41
Chad		
Fruit Snacks	FR 41	FR 93
Cheese Balls	FR 41	FR 93
Foam Ball	FR 1	FR 1
Grant		
Popcorn	FR 62	FR 210
Chocolate Chip Cookies	FR 140	FR 210
Foam Ball	FR 1	FR 210

Note. Breakpoints values indicate the highest ratio completed by the participant. The value does not represent the highest ratio to which the participant was exposed.

criteria were five minutes without a response or three consecutive sessions without the participant earning a reinforcer. All participants' breakpoint values were identified via the first criterion, responding stopped for five minutes. Generally, the breakpoints were larger for high magnitude food reinforcers than for low magnitude food reinforcers. This indicated that participants responded more for larger quantities of food and that high magnitude food reinforcers have more inelastic demand than smaller amounts of food. However, Jason's breakpoint values for cinnamon cereal were very low and remained the same across magnitude. Similarly, the maximum ratio completed to obtain toy cars was FR 1 regardless of magnitude. Breakpoint analysis for Jason reveals that cinnamon cereal and toy cars were weak reinforcers at best for block dropping. Grapes were a more potent reinforcer for Jason's behavior but only when given three at a time. For three participants, Jason, Jill and Chad, ratio breakpoints for tangible reinforcers were the same across magnitudes. Longer access to tangibles did not increase responding for these individuals. Chad did not respond beyond the FR 1 for a foam ball. In contrast, the maximum ratio Grant completed for a foam ball increased from FR 1 at low magnitude to FR 210 at high magnitude, an increase of 12 schedule progressions. The ball was a potent reinforcer only when Grant was able to play with it for 60 seconds. A general preference for edible reinforcers, especially at high magnitudes, was evident in the breakpoint values for all participants. Grant demonstrated the most responding, FR 210, for all high magnitude reinforcers. This represents 13 iterations of the progressively increasing FR schedule of reinforcement. Ratio breakpoints were much larger for participants in the behavioral economic reinforcer assessment than breakpoint values reported in other behavioral economic studies conducted with persons with developmental disabilities (DeLeon, Iwath, Goh et al.; Roane et al., 2005; Roane et al., 2001; Tustin, 1994). The procedure utilized in the present study consistently yielded high levels of responding for reinforcers. While the reinforcement schedule was similar to those used in previous applied behavioral economic studies, the progressively increasing FR schedule of reinforcement increased the response requirement more systematically and gradually. The gradual schedule progression allowed participants' responding to stabilize during each 30-minute session.

Demand Curve Estimation Using the Linear-Elasticity Demand Model

The linear-elasticity equation has been the long standing model for behavioral-economic demand curves since the late 1980's (Hursh et al., 1989). Demand curves for participants' reinforcers were estimated using the linear-elasticity demand equation, $\ln Q = \ln L + b\ln P - aP$ (Hursh, et al., 1989). Demand for low and high magnitude reinforcers was plotted on logarithmic coordinates (See Figure 7). The parameters of the linear-elasticity equation are price (P), consumption (Q), level of consumption as the price approaches zero (L), initial slope of the demand curve after an imperceptibly small increase from zero-level price (b), and a coefficient that defines the acceleration of the curve (a). Visual inspection revealed demand curves that were highly representative of participants' responding under progressively increasing FR requirements. The linear-elasticity equation predicted more consumption than that of participants' actual consumption at higher FR requirements. Jill's consumption dropped below predicted levels at FR 18 for low magnitude graham crackers, FR 41 for high magnitude graham crackers, FR 41 for low magnitude shortbread cookies, FR 93 for high magnitude shortbread cookies, FR 41 for low magnitude beads, and FR 62 of high magnitude beads.

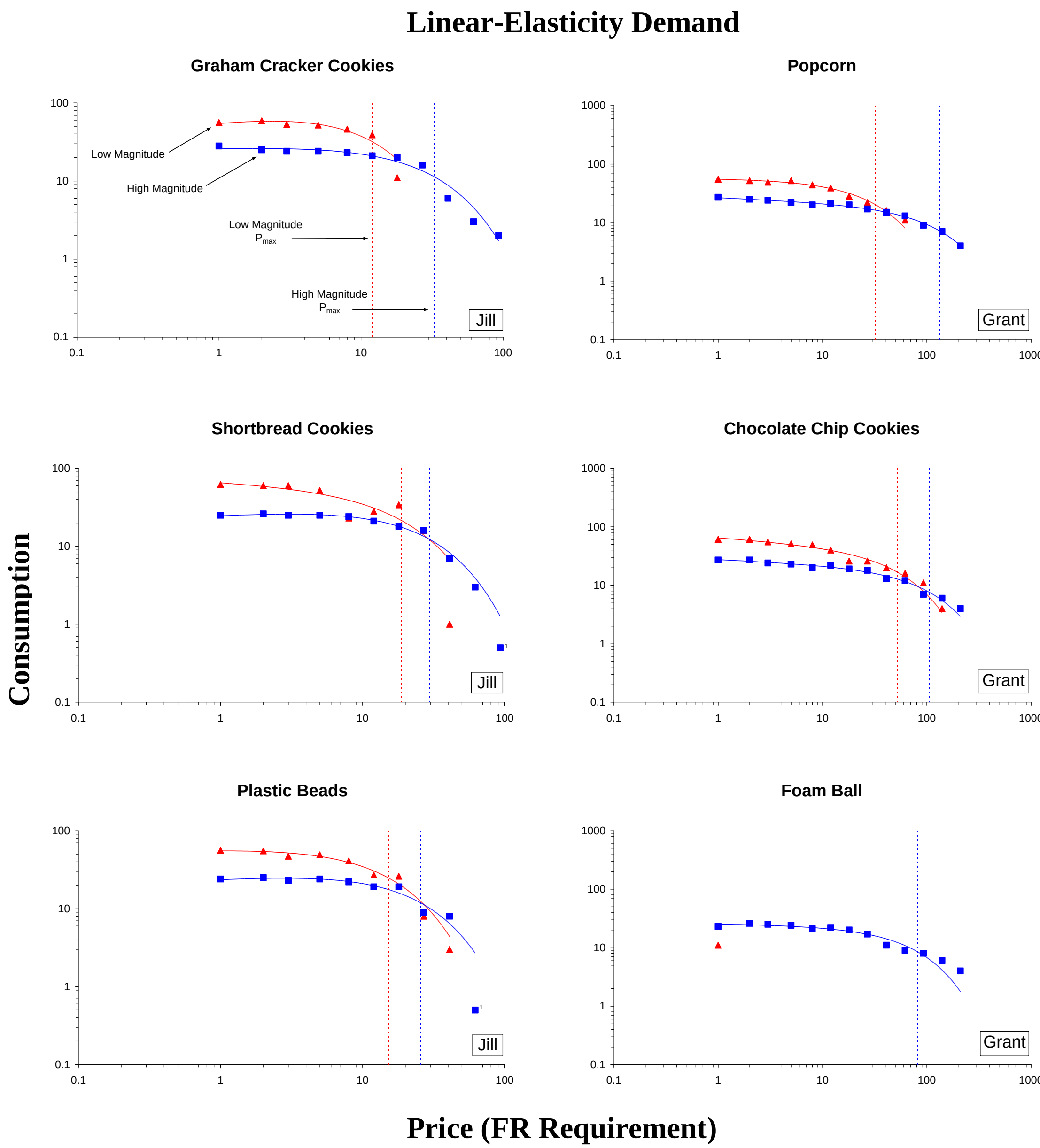

Figure 7. Raw data from each reinforcer plotted on log-log coordinates with curves fit using the linear-elasticity model. Vertical dashed lines indicate the point of unit elasticity for conditions with more than two data points. [1]Zero consumption during the session is represented as a value of 0.5 on the graph. Figure 7 is continued on the next page.

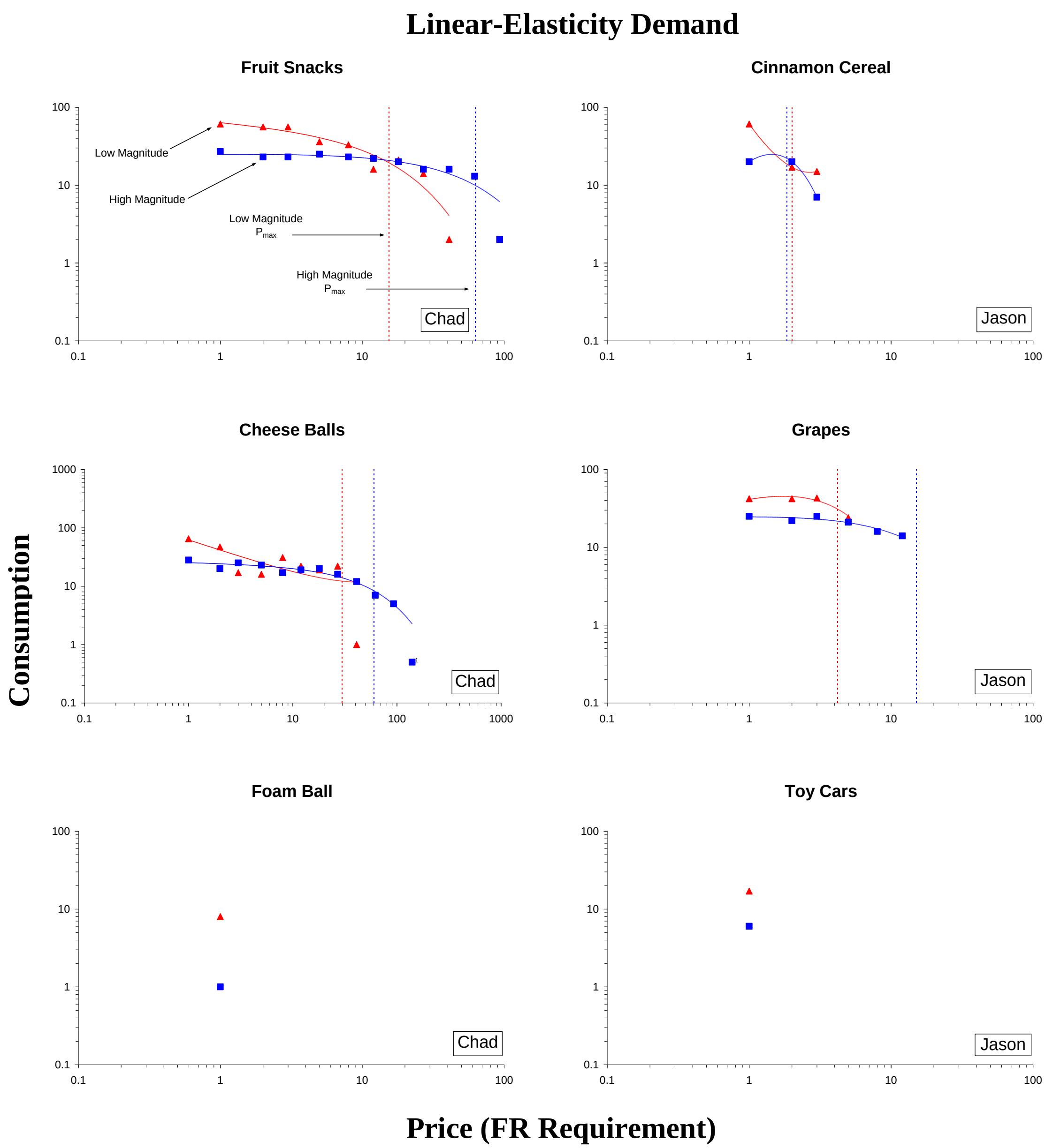

Figure 7. Raw data from each reinforcer plotted on log-log coordinates with curves fit using the linear-elasticity model. Vertical dashed lines indicate the point of unit elasticity for conditions with more than two data points. [1]Zero consumption during the session is represented as a value of 0.5 on the graph. Figure 7 is continued from the previous page.

For Chad, consumption was far below predicted levels at FR 41 for low magnitude fruit snacks, FR 93 for high magnitude fruit snacks, FR 41 for low magnitude cheese balls, and FR 140 for high magnitude cheese balls. Grant and Jason's consumption remained similar to linear-elasticity predictions until ratio breakpoints were reached. Consumption of the ball by Grant at FR 140 and FR 210 was above predicted consumption. Values of the coefficient of determination (R^2) from each demand curve provided a quantitative measure for the goodness of fit of the linear-elasticity demand model.

Table 19 shows the R^2 values and the parameters derived from the linear-elasticity model for each low and high magnitude demand curve. R^2 represents the proportion of variance accounted for by the statistical model. No curves were fit, R^2 coefficients, or unit elasticity values calculated when only one or two sessions were conducted with a particular reinforcer, although other linear-elasticity parameters were estimated. The variance accounted for ranged from 73% (Chad, low magnitude cheese balls) to 100% (Jason, low and high magnitude cinnamon cereal). R^2 values derived from the linear-elasticity equation were above 0.90 for 17 out of 19 demand curves. The model had difficulty fitting Chad's data from low magnitude cheese ball sessions which were highly variable with consumption increasing at FR 8 through FR 27 then dropping significantly at FR 41. This pattern of responding was unusual for Chad and may have been the result of extra-experimental variables such as differing motivating operations. The model underestimated unconstrained consumption (*L*) for low magnitude cereal by Jason and high magnitude graham cracker cookies for Jill. The linear-elasticity model grossly overestimated Jason's consumption of high magnitude cinnamon cereal. The linear-elasticity equation predicted positive values of *b* for most of the participants' reinforcers.

Table 19

Variance Accounted for (R^2) and Linear-Elasticity Model Parameters

Participant/Reinforcer	R^2	*L*	*b*	*a*	Unit Elasticity (P_{max})
Jason					
Low Magnitude Cinnamon Cereal	1.00	13.62	-4.01	-1.50	2.01
High Magnitude Cinnamon Cereal	1.00	250.94	3.65	2.53	1.84
Low Magnitude Grapes	0.92	62.08	0.71	0.41	4.18
High Magnitude Grapes	0.90	26.36	0.07	0.07	15.06
Low Magnitude Toy Cars	N/A	20.00	0.07	0.16	N/A
High Magnitude Toy Cars	N/A	11.42	0.07	0.64	N/A
Jill					
Low Magnitude Graham Crackers	0.91	60.28	0.24	0.10	11.98
High Magnitude Graham Crackers	0.96	26.67	0.06	0.03	32.58
Low Magnitude Shortbread Cookies	0.87	68.30	-0.08	0.05	18.73
High Magnitude Shortbread Cookies	0.99	25.50	0.12	0.04	29.43
Low Magnitude Plastic Beads	0.97	59.06	0.07	0.07	15.31
High Magnitude Plastic Beads	0.96	24.49	0.12	0.04	25.62
Chad					
Low Magnitude Fruit Snacks	0.95	67.23	-0.14	0.06	15.40
High Magnitude Fruit Snacks	0.91	25.30	0.02	0.02	62.90
Low Magnitude Cheese Balls	0.73	61.34	-0.60	-0.01	29.76
High Magnitude Cheese Balls	0.93	25.72	-0.04	0.02	60.31
Low Magnitude Ball	N/A	13.38	0.07	0.51	N/A
High Magnitude Ball	N/A	4.15	0.07	1.42	N/A
Grant					
Low Magnitude Popcorn	0.98	56.65	-0.01	0.03	32.03
High Magnitude Popcorn	0.99	26.72	-0.08	0.01	131.67
Low Magnitude Chocolate Chip Cookies	0.97	65.56	-0.12	0.02	52.47
High Magnitude Chocolate Chip Cookies	0.98	27.64	-0.08	0.01	106.83
Low Magnitude Ball	N/A	15.90	0.07	0.37	N/A
High Magnitude Ball	0.95	25.63	-0.03	0.01	81.01

Note. No R^2 coefficients or unit elasticity estimates were reported when two or fewer sessions were conducted during a condition.

Recall that the *b* parameter was the initial slope of the demand curve at a low price so positive predictions indicated that consumption increased with price. According to economic theory, the *b* parameter would be expected to be negative or equal to zero.

Elasticity of demand refers to the relationship between changes in demand and changes in price of a commodity. The slope of the demand curve shown in Figure 7 and the price at maximum expenditure indicated the degree to which consumption was sensitive to price increments along the progressively increasing FR schedule. All participants' demand curves move downward. Elasticity of demand calculated from the linear-elasticity equation is $b - aP$. The price point of unit elasticity was determined by setting elasticity equal to -1 and solving for P. Unit elasticity coefficients for session duration conditions consisting of more than two data points are listed in Table 19 and are graphed as vertical dashed lines in Figure 7. This value is also the point of maximal responding and can also be defined as P_{max} (Hursh & Winger, 1995). Larger values of unit elasticity indicate more inelastic demand for the commodity. The stimuli with the most inelastic demand as indicated by the highest P_{max} for each participant were high magnitude grapes for Jason, high magnitude graham cracker cookies for Jill, high magnitude fruit snacks for Chad, and high magnitude popcorn for Grant. As in standard preference assessment procedures, the participants showed a general preference for edible reinforcers over tangible items in the behavioral economic reinforcer assessment. Grant demonstrated the most inelastic demand among the participants for all three of his high magnitude reinforcers. Grant's demand for the low magnitude ball was very elastic; whereas, demand was extremely inelastic when the ball was available for three times at long. Responding for all three reinforcers was generally lower for Jason than for the other participants. The highest P_{max} for Jason was for three grapes, and grapes were the only reinforcer to have higher P_{max} in the high magnitude condition. Behavioral economic theory would predict more responding and higher P_{max} values for high magnitude reinforcers. P_{max} was higher when reinforcer magnitude was tripled for Jill, Grant, and for Chad's edible reinforcers.

Demand Curve Estimation Using Exponential Demand Model

Hursh and Silberberg (2008) proposed the exponential demand equation as another behavioral-economic model that could predict consumption of a reinforcer under increasing price/response requirements. They assert that because the exponential demand model consists of a single free parameter that it is preferable to the linear-elasticity model of demand which has two free parameters. The exponential demand model was evaluated using the same data from the behavioral-economic reinforcer assessment on actual responding for each low and high magnitude reinforcer under progressively increasing FR requirements. Using the method described by Hursh and Silberberg, a dimension of reinforcement (magnitude) was changed and the procedure was repeated to generate a second data set and demand curve estimation for each item. Because a demand curve is dependent on the dimensions of the commodity that is purchased, the size of the reinforcer will affect the elasticity of demand. Directly using the consumption of each reinforcer at each fixed ratio requirement would confound comparison of demand elasticity and essential value across commodities because the demand curves should be different because of the different reinforcer size (Hursh et al., 1988). To eliminate the potential confound, the normalization procedure described by Hursh and Winger (1995) and Hursh and Silberberg was used to generate normalized demand for the reinforcers.

Normalization of demand facilitates essential value determination by eliminating the confounding influence of variations in the dimensional properties of the reinforcer. According to Hursh and Silberberg, dimensional variations such as amount, size, dose, or concentration of a reinforcer are variations in the constraint on obtaining the reinforcer rather than variations in the essential value of the reinforcer. The normalization process can control for dimensional differences of a reinforcer, does not obscure differences in essential value, and can detect differences in essential value due to the quality or context of reinforcement. The two original demand curves for each stimulus must approximately superimpose upon one another after normalization in order to utilize the exponential demand model to make essential value comparisons among stimuli.

Figure 8 shows the raw data from the behavioral-economic reinforcer assessment transformed into scalar equivalents expressed in terms of percentages of maximal consumption (Hursh & Winger, 1995; Hursh & Silberberg, 2008). Hursh and Silberberg defined reinforcement in units of percent of the level of consumption at zero price, Q_0 in the exponential demand equation. The scalar constant q was the ratio of 100 to baseline consumption at the lowest response requirement. The constant q was then multiplied by the sum of the total number of reinforcers obtained at each FR schedule requirement to obtain a value of normalized consumption. The scaling procedure was equivalent to transforming each magnitude of reinforcement to a constant q percent of baseline satiation. Price was also transformed into scalar equivalents by dividing each FR value by q to scale price as responses per percent of baseline consumption. The value of baseline consumption at FR 1 was a constant 100 for all reinforcers regardless of magnitude. Once the conversions were completed, the exponential demand equation was

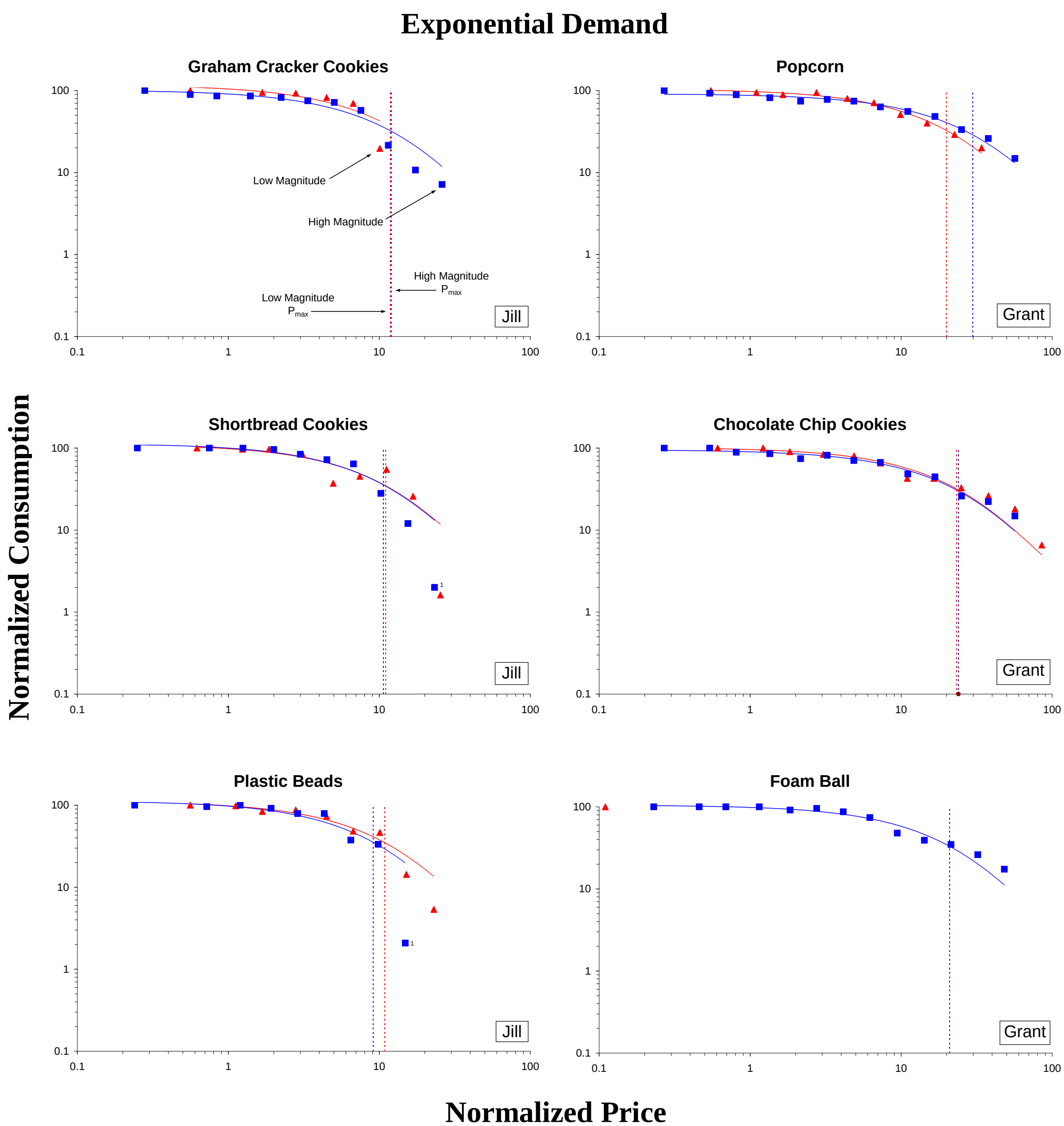

Figure 8. Normalized data from each reinforcer plotted on log-log coordinates with curves fit using the exponential demand model. Vertical dashed lines indicate the point of unit elasticity for each condition. [1]Zero consumption during the session is represented as a value of 0.5 on the graph. Figure 8 is continued on the next page.

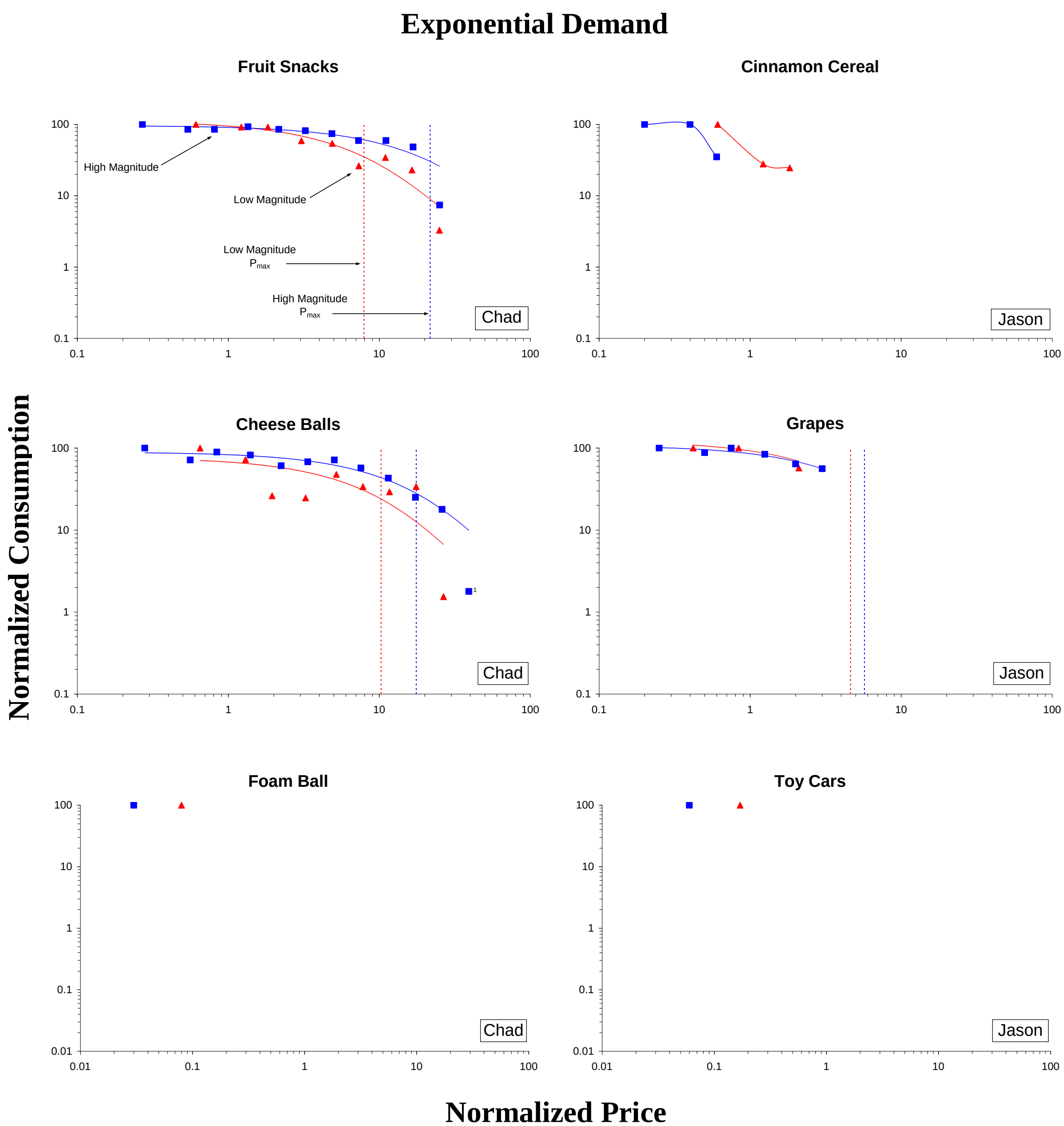

Figure 8. Normalized data from each reinforcer plotted on log-log coordinates with curves fit using the exponential demand model. Vertical dashed lines indicate the point of unit elasticity for each condition. [1]Zero consumption during the session is represented as a value of 0.5 on the graph. Figure 8 is continued from the previous page.

fit to the normalized data. This allows the exponential demand equation to fit the value of the free parameter α of a particular reinforcer independently of the magnitude of the reinforcer. Convergence of the demand functions indicated that the only apparent effect of magnitude was a scalar change in price and consumption (Hursh & Silberberg). If the exponential demand curves generated for the reinforcer at different magnitudes superimposed on each other as a single demand curve, then the value of the α parameter of the exponential functions was closely approximated. Hursh and Silberberg did not establish criteria for determining approximate superimposition of demand curves so it was uncertain whether the exponential demand model should be evaluated in all cases. Ultimately, the coefficients of determination (R^2) for each exponential demand curve were the measure of how well the model predicted actual responding.

The exponential demand function in logarithmic coordinates is $\log Q = \log Q_0 + k(e^{-\alpha P} - 1)$. Consumption of the commodity when it is free, at a price of zero, is represented by the parameter Q_0. The level of Q_0 is estimated based on the participant's baseline consumption at FR 1. As in the linear-elasticity demand equation, P was the price of the commodity. The α parameter determined the rate of decline in relative consumption (log consumption) with increases in price. Hursh and Silberberg proposed that α provides a unitary measure of the essential value of a reinforcer. The k value specified the range of the dependent variable in logarithmic units. The constant k was set at 2 across comparisons because the conditions were scalar examples of the same reinforcer under similar conditions (Hursh & Silberberg). Figure 8 shows demand curves for low and high magnitude reinforcers that were estimated by fitting the exponential demand equation to participants' actual responding for the reinforcers under progressively increasing FR schedules during the behavioral-economic reinforcer assessment. Visual inspection of the normalized demand curves in Figure 8 indicated that all the low and high magnitude reinforcer curves approximately superimposed for Jill. Superimposition is less clear in the case of Grant's normalized demand for the foam ball because only one low magnitude session was completed. The exponential demand equation was not fit to Chad's consumption of the ball or Jason's consumption of toy cars because prediction can not be made from a single data point in each magnitude condition. The top panel for Jason shows normalized responding for cereal. The exponential function could not be used for demand of cinnamon cereal by Jason because low and high magnitude consumption did not superimpose. Evaluation of the exponential demand model was possible for all three of Jill's and Grant's reinforcers, two of Chad's reinforcers, and one of Jason's reinforcers.

The predictive capability of the exponential-demand equation has been evaluated by fitting the equation to existing demand curves generated by data from previous behavioral economic research studies (Hursh & Silberberg, 2008) and more recently by fitting the equation to new demand curves for cocaine and food in rats (Christensen, Silberberg, Hursh, Huntsberry, & Riley, 2008; Christensen, Silberberg, Hursh, Roma, & Riley, 2008; Christensen, Kohut, Handler, Silberberg, & Riley, 2009). The present study was the first evaluation of the exponential demand model with human participants and the first application of the model outside of basic animal research in pharmacology.

Variance accounted for and the parameter estimations for the exponential function are listed in Table 20. For most reinforcers the exponential-demand equation was just as predictive as the linear-elasticity equation even though it has one less parameter.

Table 20

Variance Accounted for (R^2) and Exponential Demand Model Parameters

Participant/Reinforcer	R^2	Essential Value (α)	Q_0	Unit Elasticity (P_{max})
Jason				
*Low Magnitude Cinnamon Cereal	N/A	N/A	N/A	N/A
*High Magnitude Cinnamon Cereal	N/A	N/A	N/A	N/A
*Low Magnitude Grapes	0.66	0.0628	122.22	4.62
High Magnitude Grapes	0.89	0.0508	107.17	5.71
*Low Magnitude Toy Cars	N/A	N/A	N/A	N/A
*High Magnitude Toy Cars	N/A	N/A	N/A	N/A
Jill				
Low Magnitude Graham Crackers	0.82	0.0246	116.69	11.79
High Magnitude Graham Crackers	0.95	0.0241	101.06	12.03
Low Magnitude Shortbread Cookies	0.87	0.0263	110.53	11.03
High Magnitude Shortbread Cookies	0.95	0.0272	113.04	10.66
Low Magnitude Plastic Beads	0.96	0.0266	110.90	10.90
High Magnitude Plastic Beads	0.92	0.0318	112.48	9.12
Chad				
Low Magnitude Fruit Snacks	0.95	0.0367	111.83	7.90
High Magnitude Fruit Snacks	0.90	0.0133	96.26	21.80
Low Magnitude Cheese Balls	0.50	0.0283	76.55	10.25
High Magnitude Cheese Balls	0.92	0.0165	89.39	17.58
*Low Magnitude Ball	N/A	N/A	N/A	N/A
*High Magnitude Ball	N/A	N/A	N/A	N/A
Grant				
Low Magnitude Popcorn	0.98	0.0146	104.14	19.86
High Magnitude Popcorn	0.97	0.0097	91.14	29.90
Low Magnitude Chocolate Chip Cookies	0.97	0.0125	101.57	23.20
High Magnitude Chocolate Chip Cookies	0.97	0.0121	95.06	23.97
*Low Magnitude Ball	N/A	N/A	N/A	N/A
High Magnitude Ball	0.97	0.0138	104.82	21.01

Note. No R^2 coefficients were reported when two or fewer sessions were conducted during a condition. *Condition with five or fewer data points.

Regression analyses revealed that the exponential model did not account for the same high degree of variance for all reinforcers. The fit of the linear-elasticity model was better for low magnitude grapes (Jason), low magnitude graham crackers (Jill), and low magnitude cheese balls (Chad). Values of R^2 ranged from 0.50 (Chad, low magnitude cheese balls) to 0.98 (Grant, low magnitude popcorn). For 12 of 17 estimated demand curves, the exponential model accounted for 90% or greater variance. Of the remaining curves, two had R^2 values below 0.70. The percentage of demand curve estimations with R^2 greater than or equal to 0.90 were 89% for the linear-elasticity model and 71% for the exponential model. A scatterplot comparison of the R^2 values across the economic models show the high degree of correspondence between the fit of both models with the fit of the data favoring the linear-elasticity model (see Figure 9). With the exception of two reinforcers, both equations were able to account for 80% or more of the variance.

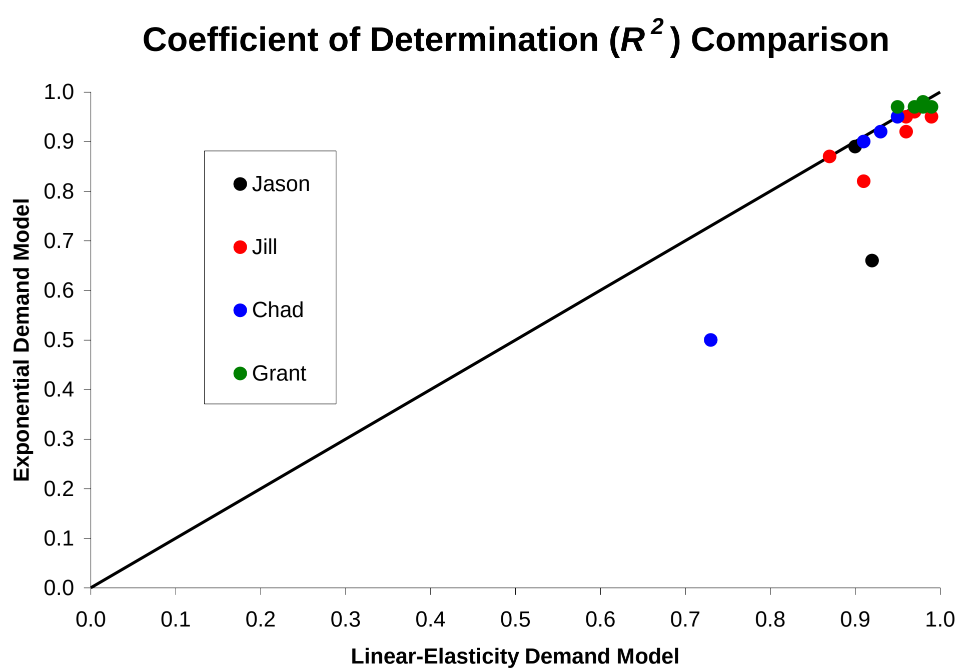

Figure 9. Scatterplot comparison of the coefficient of determination (R^2) values across the linear-elasticity and exponential demand models.

The linear-elasticity model was applicable to more of participants' reinforcers than the exponential model. Although R^2 was not reportable for conditions with one or two data points with either model, the linear-elasticity model adequately estimated the other parameters of demand; whereas, the exponential function had difficulty fitting the data or was unusable when there were few data points in a condition. Hursh and Silberberg evaluated the exponential model only when conditions had more than five data points. Requirements of demand curve convergence and a minimum number of data points per condition could make the exponential model less applicable to studies with persons with developmental disabilities. Seven reinforcer conditions contained five or fewer data points, and these reinforcers are marked with an asterisk in Table 20.

Both behavioral economic models estimated unconstrained consumption of a freely available commodity. Predicted consumption at zero price was represented by the Q_0 parameter in the exponential equation. When the data was transformed through normalization, Q_0 for each reinforcer was expected to be greater than or equal to 100 because unconstrained consumption should exceed consumption at FR 1. The exponential function underestimated Q_0 in five reinforcer conditions for Chad and Grant. The equivalent L parameter from the linear-elasticity model underestimated Jason's low magnitude cereal consumption while overestimating high magnitude cereal consumption. However, in all other instances, the linear-elasticity equation made plausible predictions of unconstrained consumption.

While the exponential-demand model utilizes the shape of the demand curve (determined by α) as the metric for essential value, there are other relevant measures of value. P_{max} was previously advanced as a measure value (Hursh et al., 1989; Hursh &

Winger, 1995) in the linear-elasticity model. Unit price summarized the free linear-elasticity parameters into a derived value to describe the shape of the demand curve. P_{max} was the price point of maximal responding, where the slope of the demand curve is equal to -1. P_{max} relates to the effects of price on consumption. Demand curves that are less sensitive to price will have higher P_{max} values. As a result, P_{max} is related to essential value but has new meaning in the exponential-demand model. P_{max} depends entirely on the value of the rate constant of exponential demand (α). Hursh and Silberberg (2008) suggested that P_{max} derived from a normalized demand curve has an inverse relationship to the α parameter in the exponential-demand model. Therefore the exponential-demand model provided a basis for also using P_{max} as a direct measure of essential value in terms of normalized price. Normalized P_{max} was calculated for each reinforcer condition by dividing the constant 0.29 by α (Hursh & Silberberg) and the results appear in Table 20. If elasticity of demand was constant for a reinforcer, then normalized P_{max} would be similar across different magnitudes. Similar low and high P_{max} values were calculated for grapes for Jason, all reinforcers for Jill, and chocolate chip cookies for Grant. P_{max} diverged at low and high magnitude for Chad's reinforcers and popcorn for Grant. For these commodities, elasticity of demand was variable across magnitude of reinforcement.

The exponential-demand equation provided a single parameter estimate (α) to scale elasticity of demand as a measure of essential value given a constant range of consumption (k = 2 in the present study). Thus, exponential demand provided a means for defining and comparing the essential value of reinforcers. Essential value comparisons can be made among any reinforcers that show dimensional indifference following the normalization process. The good with the highest essential value has the lowest elasticity of demand (Hursh and Silberberg). The parameter α represented the curvature of the demand curve with all magnitudes having the same essential value. An estimation of essential value (α) was calculated for each reinforcer using the exponential equation (see Table 20), so essential value can be ranked across qualitatively different reinforcers.

Generally α was similar for low and high magnitudes of the same reinforcer which indicated that demand elasticity was constant for that reinforcer. The exponential model provided quantifiable measure of essential value for Jason's reinforcer, all of Jill's reinforcers, and edibles for Grant. No final determination of value could be assigned to the foam ball for Grant because α was only available for the high magnitude condition. Essential value estimates for Chad showed that demand elasticity for edibles varied with reinforcer magnitude. However, visual inspection of the shape of the demand curves for fruit snacks indicated that elasticity was relatively constant at lower price/schedule requirements. Demand for cheese balls was more elastic at low magnitude. As measures of essential value, α and P_{max} values can be compared and reinforcers ranked according to the size of the values. Smaller values of α and larger values of P_{max} indicated lower elasticity of demand. Lower elasticity of demand represented a commodity with greater value, so reinforcers were ranked from highest to lowest value to the participant. The resulting rankings were compared to the rankings established through linear-elasticity demand analysis, and standard stimulus preference assessment procedures.

Comparison of Standard Preference and Behavioral Economic Assessments

The rankings assigned to each stimulus from the six paired-stimulus preference assessments, rankings from preference assessment results collapsed across low and high magnitudes, and rankings from the RAISD completed by caregivers are listed in Table 21. Rankings were also established for the ratio breakpoints, point of unit elasticity for each reinforcer calculated from both behavioral economic demand models as well as essential value from the exponential demand model. In situations when reinforcers had the same percentage of selection or breakpoint, the same ranking was assigned to all. Not all reinforcers could be assigned a rank in each assessment parameter. All stimuli were not included in all standard preference assessments. The exponential demand equation could not be used with all items used in the behavioral-economic reinforcer assessment, so ranks could only be assigned when P_{max} and α parameter values were estimated.

The relative ranking of reinforcers varied across different assessments and parameters and these changes were evaluated using rank-order correlations. Spearman's rank correlation coefficient is equivalent to Pearson’s correlation on ranks. The Kendall tau rank correlation coefficient (Kendall's tau) was used to objectively measure the degree of correspondence between two rankings and assess the significance of the correspondence. The Kendall tau coefficient has the following properties: if the agreement between the two rankings is perfect (the two rankings are the same) the coefficient has a value of 1; if the disagreement between the two rankings is perfect (one ranking is the reverse of the other) the coefficient has a value of -1; for all other arrangements the value lies between -1 and 1, and increasing values imply increasing agreement between the rankings. If the rankings are completely independent, the coefficient has a value of 0.

Table 21

Rankings Across Standard and Behavioral Economic Preference Assessments

Participant/Reinforcer	RAISD	Combined Stimuli	Edibles Only	Tangibles Only	Collapsed PS Results	Ratio Breakpoints	Linear Model Unit Elasticity (P_{max})	Essential Value (α)	Exponential Model Unit Elasticity (P_{max})
Jason									
Low Magnitude Cinnamon Cereal	5	2	2		3	3	3		
High Magnitude Cinnamon Cereal	5	2	2		3	3	4		
Low Magnitude Grapes	4	1	1		1	2	2	2	2
High Magnitude Grapes	4	1	1		1	1	1	1	1
Low Magnitude Toy Cars	2	2		1	2	4			
High Magnitude Toy Cars	2	3		1	2	4			
Jill									
Low Magnitude Graham Crackers	4	3	1		3	4	6	2	2
High Magnitude Graham Crackers	4	2	3		3	1	1	1	1
Low Magnitude Shortbread Cookies	3	2	1		2	3	4	3	3
High Magnitude Shortbread Cookies	3	4	1		2	2	2	5	5
Low Magnitude Plastic Beads	2	1		1	1	3	5	4	4
High Magnitude Plastic Beads	2	1		1	1	3	3	6	6
Chad									
Low Magnitude Fruit Snacks	1	2	1		1	2	4	4	4
High Magnitude Fruit Snacks	1	3	1		1	1	1	1	1
Low Magnitude Cheese Balls	2	1	1		2	2	3	3	3
High Magnitude Cheese Balls	2	2	2		2	1	2	2	2
Low Magnitude Ball	4	3		2	2	3			
High Magnitude Ball	4	4		1	2	3			
Grant									
Low Magnitude Popcorn	4	1	1		2	3	5	5	5
High Magnitude Popcorn	4	2	1		2	1	1	1	1
Low Magnitude Chocolate Chip Cookies	5	2	1		2	2	4	3	3
High Magnitude Chocolate Chip Cookies	5	1	1		2	1	2	2	2
Low Magnitude Ball	1	4		1	1	4			
High Magnitude Ball	1	4		1	1	1	3	4	4

Rank-order correlations are in Table E-2 and Table E-3 in Appendix E. The relationships among the relative ranks on the RAISD and standard preference assessments were mostly unrelated. The only correlations were between the collapsed paired-stimulus preference assessment and RAISD (.63, $p < .01$) and the edibles-only paired-stimulus preference assessment (.62, $p < .05$). The RAISD was inversely related to the combined-stimuli assessment. The correlations were high among all the behavioral economic parameters. Significant relationships existed among ratio breakpoints, unit elasticity (P_{max}) on the linear-elasticity and exponential demand models, and essential value (α). Kendall tau coefficients were the highest for the rank correlations between ratio breakpoints and the linear-elasticity P_{max} (.74, $p < .01$) and the correlation was perfect between essential value and exponential P_{max} (1.00, $p < .01$). While there was correspondence among some of the standard preference assessment ranks and among the behavioral economic ranks, there were no significant relationships among these very different measures of preference and value. The Kendall tau correlations indicated small levels of disagreement (ranging from -0.03 to -0.30) between most of the ranks from standard methods and ranks from the behavioral-economic reinforcer assessment. DeLeon et al (2001) found that stimuli identified through daily multiple-stimulus preference assessment have been found to function more effectively as reinforcers than those identified by paired-stimulus assessment. The MSWO yields ranked preference among stimuli presented in the array; whereas, ranks were derived from the results of the paired-stimulus preference assessment. Future studies should evaluate the relationship between multiple-stimulus preference assessment formats and economic demand curves. Because a very small number of stimuli were used for preference assessment in the present study, the error rate for the correlations may be increased. Larger numbers of stimuli might have improved the correlation coefficients for standard preference assessment.

Problem Behavior

Three categories of problem behavior were recorded during Experiment 2. The operational definitions of aggression, self injury and disruption that were used in the study can be found in Appendix B. Minor, low intensity problem behavior was ignored and physically blocked if necessary to protect the individual from harm. At no time during Experiment 2 did problem behavior escalate to a degree requiring crisis intervention or discontinuation of a session.

Figure 10 shows the combined rates of aggression, self injury and disruption for each participant. See Appendix E, Figure E-1 for additional single behavior rates for each participant. Jill had higher rates of problem behavior across all reinforcer and magnitude conditions than the other participants, with the lowest rates observed during conditions with edibles. Her rates of aggression and disruption were variable and typically consisted of low intensity aggression towards the staff member using the beads and repetitive disruption such as dropping the container, throwing blocks, or banging the container against the table. Jill's self injurious behavior was typically banging her hand on the table. Grant, Chad and Jason demonstrated lower overall rates of problem behavior. Grant displayed some minor disruptions using the blocks and routinely engaged in self-injurious hand biting that increase with price/response requirements. The hand biting was not a new problem behavior for Grant. He frequently engaged in this form of self injury and wore a custom-made glove at all times to protect his hand.

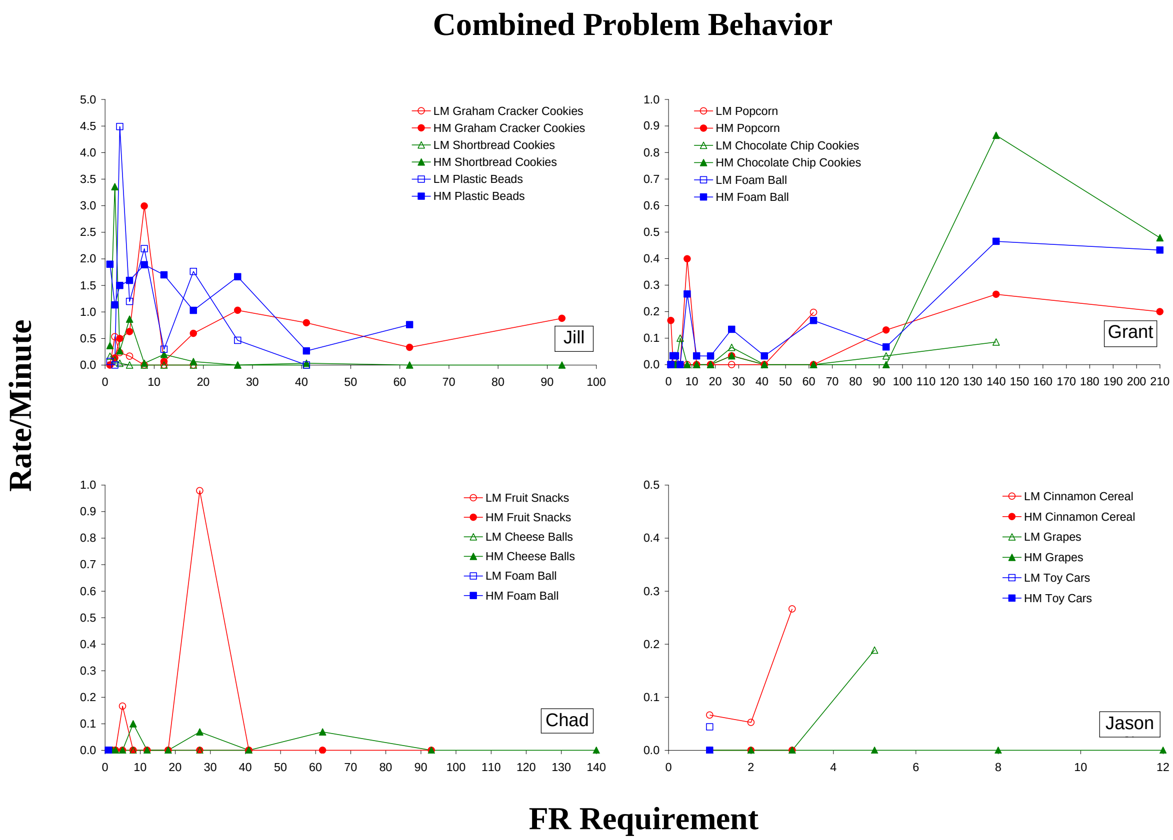

Figure 10. Combined problem behavior consisting of the total aggression, self injury and disruption for each participant. *Note.* The x- and y-axes differ in each column.

Chad and Jason showed minor self injury in only a few sessions. In general, problem behavior remained relatively low for all participants even though response requirements were increasing across sessions and they were required to complete a tedious, repetitive pre-vocational simple operant task.

GENERAL DISCUSSION

A large body of literature in the field of applied behavior analysis has established various methods for identifying highly valued and effective reinforcers for individuals with developmental disabilities (DeLeon & Iwata, 1996; Fisher et al., 1992; Windsor et al., 1994). Parents, teachers, or caregivers are typically asked to provide information regarding the individual's preferences if the person is unable to state his or her own preferences. Preference among the items and/or activities is then systematically assessed to identify potential reinforcer for the individual. Standard procedures consist of presenting stimuli in pairs or in a multiple array followed by an assessment to determine if the highly-preferred stimuli will increase and maintain responding. In most reinforcer assessments, a preferred stimulus is presented for every occurrence of a simple behavior that is already in the person's repertoire. Using simple operants and a continuous schedule of reinforcement may promote rapid identification of reinforcer efficacy while minimizing the potentially confounding effects of other variables such as response difficulty or ratio strain (Fisher & Mazur, 1997; Piazza, Fisher, Hagopian, et al., 1996). Schedule requirement has been shown to affect reinforcer efficacy (DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994). The relationship between reinforcer effectiveness and schedule requirement has important implications for the use of reinforcers with persons with developmental disabilities because schedule fading is typically incorporated in reinforcement-based treatment programs. Reinforcers must be identified that will maintain treatment effects across increasing schedule requirements. Unfortunately, standard reinforcer assessments may have limited generality when schedule thinning or differential reinforcement procedures are used (Fisher & Mazur). Thus, treatment efficacy may be compromised.

While commonly used stimulus assessment procedure can provide reliable preference ranks and consistency of ranks (DeLeon & Iwata, 1996; Fisher et al., 1992), it remains unclear whether currently used preference assessments make accurate predictions about reinforcement effects under varying schedule requirements – the condition under which reinforcement is often delivered to children, adolescents and adults with disabilities. It has been suggested that reinforcer efficacy under increasing schedule requirements should be assessed frequently as part of ongoing treatment development (Tustin, 1994; DeLeon et al., 1997) but methods employed in these studies requires repeated exposure to various schedule requirements over an extended period of time. Progressive-ratio schedules of reinforcement and basic behavioral economic analyses, such as work-rate functions and reinforcer-demand functions, have been utilized for reinforcer identification (DeLeon et al.; Tustin; Roane et al., 2001). PR schedules have been used in applied settings with persons with developmental disabilities (DeLeon et al.; Roane et al., 2005; Roane et al., 2001; Tustin) and research continues to evaluate the applied use of PR schedules (Francisco, Borrero & Sy, 2008; Glover, Roane, Kadey & Grow, 2008; Jerome & Sturmey, 2008; Penrod, Wallace, & Dyer, 2008; Roane, 2008; Trosclair-Lasserre, Lerman, Call, Addison, & Kodak, 2008). PR schedules and the resulting breakpoints can provide a measure of the strength of a reinforcer. Comparisons among relative ratio breakpoints on PR schedules have been used as a means of quantifying reinforcer efficacy (Hodos & Kalman, 1963; Johnson and Bickel, 2006; Francisco et al.; Jerome & Sturmey; Trosclair-Lasserre et al.). However, breakpoint analysis can be problematic because of the methods used to obtain it and because it is a discontinuous measure. The ratio size of the breakpoint has been shown to vary with the step size of the PR used (Hodos & Kalman). Stafford and Branch (1998) directly compared small and large step sizes and the findings indicated that step size did not greatly affect the ratio size of the breakpoint. Studies in applied behavior analysis have yet to evaluate the effect, if any, of PR step size. The breakpoint is a discontinuous measure because it only specifies the behavior at one price. It provides no further information about behavior at other prices. While the breakpoint may have certain problems, it does provide a capable method of scaling reinforcer strength that accommodates the prevailing economic constraints. An assumption of breakpoint analysis is that reinforcer value can be measured in terms of how much effort will be expended to earn it.

Measures of relative reinforcing efficacy have sometimes provided discordant results of value that cannot be easily explained (Arnold & Roberts, 1997; Stafford et al., 1998). However, behavioral economic measures have been found to be congruent with reinforcing efficacy measures, and behavioral economics can provide a parsimonious framework for evaluating and understanding reinforcer strength (Bickel et al., 2000; Johnson & Bickel, 2006). Recently, behavioral economic procedures and analyses have been utilized to assess preference and demand for qualitatively different reinforcers using single and concurrent schedules of reinforcement, thereby providing a novel scale for measuring the value of reinforcers.

Behavioral economic analyses have been undertaken in applied behavior analytic studies with persons with developmental disabilities; however, a general, systematic and effective method for generating rapid demand curves for reinforcers has not been established. The purpose of Experiment 1 was to develop such a procedure. Participants responded on a progressively increasing FR schedule to obtain reinforcers during sessions of differing durations. Increasing response requirements across successive sessions has been conceptualized as a form of PR schedule (Cooper, Heron, & Heward, 2007; DeLeon et al., 1997; Tustin, 1994) although PR schedules are typically characterized by within session increases in response requirements. As with traditional PR schedules, the use of a progressively increasing FR schedules across sessions allows for breakpoint comparisons as well as many of the economic demand analyses utilized in basic research studies of reinforcer efficacy. Demand curves and ratio breakpoints were compared across short, intermediate, and long session lengths. The results of Experiment 1 suggested the length of sessions; an appropriate FR schedule progression; the amount of reinforcement delivered and the duration of the reinforcement interval; the criteria for session termination; and the criteria for reaching a ratio breakpoint (ratio strain). The primary goal of Experiment 1 was accomplished. An efficient, effective, and systematic procedure was developed for data collection that facilitated behavioral economic analyses. The method developed in Experiment 1 was employed in the second part of the study as a means for obtaining demand curves to evaluate specific behavioral economic demand models in terms of their utility in identifying highly-valued functional reinforcers in persons with developmental disabilities.

Behavioral economic procedures derived from basic research provided novel methods for identification of reinforcers under increasing schedule requirements. Specifically, the exponential-demand model (Hursh & Silberberg, 2008) provided a single quantitative measure of the essential value of reinforcers independent of the dimensional properties of reinforcement. The model adequately predicted responding for qualitatively different reinforcers by persons with developmental disabilities in Experiment 2. Essential value as calculated by the exponential function may be a means of identifying functional reinforcers that may generalize to common treatment situations. The linear-elasticity demand model (Hursh et al., 1989) was also successfully fit to the data from Experiment 2 and may also facilitate the identification of effective reinforcers under increasing schedule requirements.

Standard preference assessment procedures were used in conjunction with a behavioral economic reinforcer assessment in Experiment 2. Reinforcer were ranked based on the results of the RAISD interview (Fisher et al., 1996), the results of multiple paired-stimulus assessments (Fisher et al., 1992) conducted with food and non-food items separately and in combination using two magnitudes of reinforcement, and behavioral economic parameters estimated by the linear-elasticity and exponential demand models. Reinforcer rankings among the standard preference and behavioral economic assessments were compared using rank-order correlations. Standard preference assessment procedures have difficulty predicting preference among qualitatively different reinforcers such as edibles and tangibles. Behavior economic measures of preference and value from the reinforcer assessment were able to define the relationships among different types of reinforcers and allowed for direct comparisons of preference for food and non-food items. Standard preference assessment procedures had difficulty identifying items that would function as the most potent reinforcers under increasing schedule requirements. The behavioral economic reinforcer assessment provided information about each participant's reinforcers that would suggest which items and at what magnitude should be used in treatment settings. Those working with persons with developmental disabilities may want to consider using behavioral economic demand analyses in addition to standard preference assessment to better predict effective reinforcers.

Future Research Directions

Procedural Considerations

The paired-stimulus format of preference assessment used in the current study and the relatively small number of stimuli used may have affected subsequent comparison to behavioral economic demand parameters. DeLeon et al (2001) found that stimuli identified through daily multiple-stimulus preference assessment have been found to function more effectively as reinforcers than those identified by paired-stimulus assessment. The MSWO yields ranked preference among stimuli presented in the array; whereas, ranks were derived from the results of the paired-stimulus preference assessment. Future studies should evaluate the relationship between multiple-stimulus preference assessment formats and economic demand curves. Another procedural consideration is the number of stimuli used in the stimulus preference assessment. Because a very small number of stimuli were used for preference assessment in the present study, the error rate for the correlations may be increased. Only five stimuli were used in the initial combined assessments, so some individual edibles-only or tangibles-only assessments were conducted with only two items. Larger numbers of stimuli might have improved the correlation coefficients for standard preference assessment and behavioral economic analyses.

The step size used in the progressively increasingly FR schedule of reinforcement yielded high responding from most participants. The method developed and used in the present study supported sustained responding across sessions that lead to much larger breakpoints than have been obtained on PR schedules in previous applied studies in developmental disabilities. Further research should directly compare breakpoints for the same stimulus on schedules of reinforcement that increase across and within sessions. Consideration should be given to how many sessions must be conducted under each schedule arrangement to minimize total participation time. To this end, shorter 15-minute sessions might be useful while still providing opportunities to use economic demand analyses beyond breakpoint analysis. The target response could be varied to more closely approximate the therapeutic setting. A relatively simple operant block-sorting response was used, but research could investigate reinforcer value when more complex operants are required - similar to those responses required from the participant in the natural, educational, or vocational setting.

Choice is a complex derivation underlying demand relationships. Because consumption at a particular price is dependent on the prices of alternatives and possible interactions with other available substitutes and complements (Hursh, 1978, 1980, 1984), the outcome of concurrent choice procedures is not reliably related to simple comparisons of essential value (Hursh & Silberberg, 2008). Basic researchers have already begun to explore how choice between two commodities is accommodated within the context of exponential demand (Hursh & Silberberg, 2006, 2008; Hursh & Spiga, 2009). A cross-price extension of exponential equation has been proposed for use with multiple reinforcers. Hursh and Silberberg provide a brief review of demand analyses from two commodities which indicated that the consumption of one of two reinforcers is the weighted sum of two exponentials. One exponential is related to the price of the target commodity, and the second is related to the price of the alternative. The sign of the weighting factor determines whether the two reinforcers interact as substitutes or complements. If the constant has a negative sign, then consumption of one commodity subtracts from consumption of the other and the two commodities are defined as substitutes. The degree of the substitution is determined by the size of the weighting factor. If the weighting factor is zero, then demand for one of the reinforcers is independent of the price of the other (Hursh & Silberberg, 2008; Hursh & Spiga).

An applied research study of PR schedules assessed the extent to which responding for low and high stimuli on single or concurrent PR arrangements would produce differential outcomes (Glover et al., 2008). The results suggest that similar breakpoint values were obtained whether participants responded for stimuli on single or concurrent PR schedules. Applied research in developmental disabilities should evaluate the applicability of cross-price extensions of exponential demand. The method developed in Experiment 1 could be used to evaluate essential value of commodities presented in concurrent choice arrangements.

Applied behavior analysts have used preference on standard preference assessments (Fisher et al., 1992; DeLeon & Iwata, 1996) as a measure of the value of a good. When an item is chosen, why should its value among alternatives be questioned?

Do demand curves really need to be generated to define the value of a good? The relative reinforcer strength or value measured in choice situations fails because it is not independent of income or price. Data from Elsmore et al. (1980) fit with the exponential demand model showed that there is no direct relationship between essential value and the outcome of a preference test (Hursh & Silberberg, 2008). The results of Elsmore et al. illustrate the effects of an income variable on choice. Baboons choose more drugs than food when income was high (many opportunities to spend) but this preference reversed when income was low. Similar preferences shifts among reinforcers have been noted in the applied literature (Tustin, 1994; Fisher & Mazur, 1997; DeLeon et al., 1997). Experiment 2 of the current study shows the effects of price on preference. Preference shifted as price increased due to increasing FR schedules of reinforcement. From the economic demand perspective, preference is a derived outcome of comparative levels of consumption. The demand curves of the good chosen describe the more general impact of different reinforcers on behavior across the full spectrum of constraint (Hursh & Silberberg). Because of this, essential value rather than preference is a superior approach for defining and scaling reinforcer value.

Translational Research Between Applied and Basic Studies

The present study was able to integrate basic and applied methods for identifying reinforcer value. A primary goal was to form stronger connections between applied work in developmental disabilities and behavioral economic work in the basic laboratory and applications with other populations. It has been recommended that integration of basic and applied research may promote the development of applied technologies and reveal new basic relations through application (Mace & Wacker, 1994; Roane et al., 2001).

Behavioral economic analyses are not new to applied behavioral analytic research studies in developmental disabilities; however, the present study was the first to evaluate the utility of the linear-elasticity and exponential demand models. Both the linear-elasticity and exponential demand models were able to generalize to commodities and populations in applied settings and can serve as additional analytic tools for determining highly effective reinforcers for persons with disabilities. Because the exponential demand model provides a rate constant capable of scaling the essential value of a reinforcer independently of the scalar dimensions of the reinforcer, this approach permits comparison of qualitatively different reinforcers. This allows researchers as well as practitioners a means of scaling reinforcer value in terms of α.

In the present study, demand was assessed for a single good (reinforcer) that did not interact with another, so the capacity to scale demand in terms of α is absolute rather than relative. That is, the larger the value of the α parameter for any good, the lower its reinforcing strength or essential value. Additional evaluations must show that the value of α for a good is largely invariant across manipulations of cost and reinforcement (Christensen et al., 2008). As further basic research is conducted on cross-price interactions between reinforcers using concurrent schedules, applied research should similarly proceed to evaluate choice in terms of exponential demand.

Clinical Applications

The exponential model of demand has been used to compare essential value across populations in the basic laboratory using different strains of rats (Christensen et al., 2009). It might be possible to behavioral economic analyses, specifically essential value, to differentiate among subpopulations within developmental disabilities. Perhaps essential value or elasticity of demand for commodities varies consistently across diagnoses or levels of functioning. While studies involving large numbers of participants with different diagnoses of developmental disabilities might be difficult, the implications of such research endeavors are interesting.

Future applications of the model in developmental disabilities could use essential value to assess the effects of pharmacological interventions for behavior disorders. Behavioral economic demand models are commonly used in psychopharmacological research to evaluate the reinforcing efficacy of different drugs or dosages (see Stafford et al., 1998 for a review) but these procedures have yet to be used to study to effects of pharmacological interventions in applied settings. Studies in applied behavior analysis have focused on the use of medications to treat destructive behavior (Gully & Northup, 1997; Northup, Fusilier, Swanson, Huete, Bruce, Freeland et al., 1999; Northup, Fusilier, Swanson, Roane, & Borrero, 1997; Northup, Jones, Broussard, DiGiovanni, Herring, Fusilier et al., 1997; Kelly, Fisher, Lomas & Sanders, 2006; LaRue, Northup, Baumeister, Hawkins, Seale, Williams et al., 2008; Yoo, Williams, Napolitano, Payton, Baer & Schroeder, 2003). Essential value or other behavioral economic analyses could contribute to this type of research. For example, methylphenidate and risperidone are commonly prescribed to treat behavior disorders in persons with developmental disabilities. These medications are associated with specific side effects (decreased appetite with methylphenidate and weight gain with risperidone) that could affect the reinforcing efficacy of certain stimuli such as food. For individuals undergoing medication evaluations, behavioral economic analyses could be used to assess treatment response – maintenance of responding across dosages or medications, the role of different dosages or medications on the efficacy of specific stimuli such as food or social interaction as reinforcers (LaRue et al), or the effect of dosages or medications on the essential value of goods consumed by the individual.

Behavioral economic analyses can have applications to treatment developments. Jerome and Sturmey (2008) investigated breakpoints when participants worked to obtain contingent interaction with either preferred or non-preferred staff who were identified via paired-stimulus preference assessment (Fisher et al., 1992). All participants responded more and achieved higher breakpoint when responding resulted in access to a highly preferred staff member (Jerome & Sturmey). Economic analyses are not limited to edible and tangible reinforcers. Demand analyses could be replicated using contingent access to social reinforcement and essential value assigned to interaction with different staff members. Results could have potentially important clinical implications because the efficacy of some reinforcement-based treatment interventions may be affected by the value of those implementing the program.

Other clinical applications of behavioral economic demand analyses may be forthcoming as research continues in the basic laboratory and in applied settings. Quantitative demand models such as the linear-elasticity and exponential demand models from the basic behavioral economic literature can provide a novel approach to determining the value of reinforcers beyond the results of standard stimulus preference assessments commonly conducted with persons with developmental disabilities.

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APPENDIXES

Appendix A

INFORMED CONSENT FOR YOU TO BE A RESEARCH PARTICIPANT

INFORMED CONSENT FOR PARENTS OR GUARDIANS

MINOR ASSENT TO BE A RESEARCH PARTICIPANT

INFORMED CONSENT FOR A CAREGIVER TO BE A RESEARCH PARTICIPANT

INFORMED CONSENT FOR YOU TO BE A RESEARCH PARTICIPANT
In a Study Entitled
The Assessment of Preference for Qualitatively Different Reinforcers in Persons with Developmental Disabilities: A Comparison of Value Using Behavioral Economic and Standard Preference Assessment Procedures

We are asking you to be in a research study. It is being done by Jennifer Bredthauer and James Johnston from Auburn University. We want to learn about what you like. We are asking you because you are at The Learning Tree, Inc.

Why we are doing this:
We want to learn how to find out what your favorite things are. We also want to know why you pick one thing over another. Sometimes you might pick differently. This is a problem because we need to know what you really want.

What you have to do:
We will find out what you like to play with, eat, and do. You can pick what you want. We will also ask your staff what you like.

Your work will be to put blocks into a box to get things you like. Your staff will be with you the whole time. You can work with the blocks each day. There will be more and more blocks. You do not have to do it. You can stop at any time. It will keep going as long as you work. Then you will go back to what you were doing. We will be making a video of you working. No one else will see it. We will keep the video safe and throw it away at the end.

Bad stuff:
You will be asked if you want to work with the blocks. You can stop and nobody will get mad. If you get upset we will stop and help you calm down. We will make sure you do not eat anything you should not. We will make sure you do not eat too much. We are going to keep you safe and try to do what is best for you. Your staff will stay with you. We may stop you from working with the blocks if we think it is best.

Good stuff:
You will get to play with things you like. You will get to eat and drink things you like. You can make choices. Working with the blocks may help you. You may help The Learning Tree, Inc. or other people. You might not get all these things.

If you do not do this:
It is OK if you do not want to do this. You will still get to stay at The Learning Tree, Inc. Nothing will change. No one will be mad at you.

Who will know about you:
Only Jennifer Bredthauer will know how you do. All your work will be kept safe. When it is over, your work will be thrown away. Your work will be used to write a paper.

Other people may want to know how you did. We will tell them but they will not know your name.

Stopping after you say yes:
If you say yes now you can still stop later. You will not get in trouble. If you stop we will not use your name or your work. No one at Auburn University, the Psychology Department, or The Learning Tree, Inc. will get mad at you.

Who can tell you more:
You can ask any questions you want. You can ask your staff and they will tell us. Do you understand? Is this OK?

NOW THAT YOU KNOW ABOUT THE STUDY, YOU NEED TO SAY IF YOU WANT TO DO IT. IF YOU PUT YOUR NAME BELOW YOU ARE SAYING YOU WILL BE IN THE STUDY.

____

Participant's Signature or Mark Print Name Date

_____ It is the opinion of the team that this individual cannot give informed consent.

Reason(s):____

____

Participant Representative's Signature Print Name Date

____

TLT, Inc. Representative's Signature Print Name Date

____

Investigator's Signature Print Name Date

INFORMED CONSENT FOR PARENTS OR GUARDIANS
For a Study Entitled
The Assessment of Preference for Qualitatively Different Reinforcers in Persons with Developmental Disabilities: A Comparison of Value Using Behavioral Economic and Standard Preference Assessment Procedures

Your son or daughter is invited to take part in a research study being conducted by Jennifer Bredthauer, a graduate student at Auburn University, under the supervision of James Johnston, Ph.D. We hope this study will help us better understand preference in persons with developmental disabilities. Students with developmental and other learning disabilities from The Learning Tree, Inc. may participate in the study.

Purpose of the Study:
This research is being done to compare different ways to identify favorite toys, foods, and activities. Sometimes individuals pick depending on how they are asked or what the choices are. This can cause problems because interventions often require using something that the person really wants. We hope to suggest new ways of determining these preferences.

Procedure:
The study will start with some assessments of toys, foods, and activities that your son or daughter may like. He or she can play with or eat whatever is picked, and can keep picking until everything is gone. These choices will help us find out the things your son or daughter likes from most to least. We will also ask caregivers questions to help identify your son or daughter's favorite things.

Then we will see how much work your son or daughter will do to get the chosen items. The work task will be sorting blocks by putting them through a slot in the top of a box. At first, the child can get a small amount of food or a short time with a toy by doing one task on their own. Then the amount of work will gradually be increased to get the same amount of snack or toy. The individual does not have to do any work and can stop at any time. Sessions will last only as long as your son or daughter responds. No more than four sessions with a maximum length of 20 minutes will take place in one day. There will be at least an hour between sessions when the child will go back to their regular activities. Sessions will occur five days a week for about two months. Staff will be in the room during the sessions. Participants will be videotaped by the investigators so session data can be checked later. The video tapes will be locked up and destroyed at the end of the study.

Risks:
The potential risks of this project are similar to the risks of typical services at The Learning Tree, Inc. Appropriate steps will be taken to reduce or eliminate any risks. Your son or daughter will be asked if he or she would like to play with the blocks before each session and told that they can stop at any time. Your son or daughter will be watched closely by staff from The Learning Tree, Inc. to make sure that they are safe and

want to continue. A session will be stopped and staff will use Professional Crisis Management techniques if necessary. These are the crisis procedures that you have already authorized The Learning Tree, Inc. to use for continuous aggression, self injury or high magnitude disruption. Known food allergies and dietary restrictions will be followed. Only small amounts of high calorie snacks will be given to avoid weight gain. The Principle Investigator and all personnel working with the students at The Learning Tree, Inc. are trained to respond to choking and to provide CPR. The Campus Supervisor or Principle Investigator may stop your son or daughter from taking part in the study at any time if they decide it is best for your son or daughter.

Benefits:
Your son or daughter will have additional or new food and drink items and activities and will be able to make choices between them. He or she will be able to practice a sorting task that may improve vocational skills. The Learning Tree, Inc. may benefit by using the results of this study to help your son or daughter as well as other children. We cannot promise that your son or daughter will receive any or all of these benefits. Your son or daughter's participation in this study will not involve any costs to you or your insurance company above the usual costs of services at The Learning Tree, Inc.

Alternatives:
If you decide not to let your son or daughter join this study, his or her care at The Learning Tree, Inc. will not be affected. We will not use his or her personal information in the research.

Confidentiality:
Any information that can identify your son or daughter will remain confidential. Each participant will be assigned a code name. All information and all data collected will use this code. Only the Principle Investigator will have access to the codes. All identifying information, videotape, and data will be protected and will be destroyed at the end of the study. The results of this study will be used for a dissertation to complete the Doctor of Philosophy degree in psychology. The results may also be submitted for presentation at a professional meeting and publication in a professional journal. None of your son or daughter's identifiable information will be included.

Voluntary Participation and Withdrawal:
Your son or daughter's participation is completely voluntary. He or she can stop at any time, even after consent is given. You can also withdraw any information about your son or daughter for the study. Your decision whether or not to let your son or daughter take part will not affect your future relations with Auburn University, the Psychology Department, or The Learning Tree, Inc.

Contact Information:
If you have questions, please contact Jennifer Bredthauer by phone (334) 332-5716 or email at bredtje@auburn.edu or Dr. James Johnston by phone (334) 844-6487 or email at johnsjm@auburn.edu. For more information regarding your rights as a research participant you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WANT YOUR SON OR DAUGHTER TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO ALLOW YOUR SON OR DAUGHTER TO PARTICIPATE.

____

Parent’s or Guardian’s Signature   Print Name   Date

____

TLT, Inc. Representative’s Signature   Print Name   Date

____

Investigator’s Signature   Print Name   Date

MINOR ASSENT TO BE A RESEARCH PARTICIPANT
In a Study Entitled
The Assessment of Preference for Qualitatively Different Reinforcers in Persons with Developmental Disabilities: A Comparison of Value Using Behavioral Economic and Standard Preference Assessment Procedures

We want to find out what you like. You will get to pick things that you want to play with or eat. You will be putting blocks in a box. You can work with the blocks each day to get things you like. Your name will not be written anywhere. We will be making a video of you working. No one else will see it. We will keep the video safe. We will throw it away at the end.

You can stop at any time. Nobody will be mad. You will not be in trouble if you do not want to do this. You can ask as many questions as you want.

Do you understand? Is this OK?

____

Participant's Signature or Mark   Print Name   Date

_____ It is the opinion of the team that this individual cannot give informed assent.

Reason(s):____

____

TLT, Inc. Representative's Signature   Print Name   Date

____

Investigator's Signature   Print Name   Date

INFORMED CONSENT FOR A CAREGIVER TO BE A RESEARCH PARTICIPANT
In a Study Entitled
The Assessment of Preference for Qualitatively Different Reinforcers in Persons with Developmental Disabilities: A Comparison of Value Using Behavioral Economic and Standard Preference Assessment Procedures

You are invited to take part in a research study being conducted by Jennifer Bredthauer, a graduate student at Auburn University, under the supervision of James Johnston, Ph.D. We hope this study will help us better understand preference in persons with developmental disabilities. Staff members who provide care for the students with developmental and other learning disabilities from The Learning Tree, Inc. may participate in the study.

Purpose of the Study:
This research is being done to compare different ways to identify favorite toys, foods, and activities. Sometimes individuals pick depending on how they are asked or what the choices are. This can cause problems because interventions often require using something that the person really wants. We hope to suggest new ways of determining these preferences.

Procedure:
The study will start with some assessments of toys, foods, and activities that the child may like. He or she can play with or eat whatever is picked, and can keep picking until everything is gone. These choices will help us find out the things the child likes from most to least.

We will also ask caregivers questions to help identify the child's favorite things. You will be interviewed about what a particular child likes to play with, eat, and do for fun. You will also be asked to describe the conditions under which the child likes the items. You will then be asked to rank the items according to much how much you think the child likes them. Several caregivers may provide suggestions about things the child likes. Your responses might be combined with information from other staff members. The items may be used in later parts of the study.

Risks:
There are no known risks to answering questions about what a child that you work with likes.

Benefits:
The Learning Tree, Inc. may benefit by using the results of this study to help the children that you work with as well as other children.

Confidentiality:
Any information that you give will be anonymous. Your name will not be used. The results of this study will be used for a dissertation to complete the Doctor of Philosophy degree in psychology. The results may also be submitted for presentation at a professional meeting and publication in a professional journal. None of your identifiable information will be included.

Voluntary Participation and Withdrawal:
Your participation is completely voluntary. You can stop at any time, even after consent is given. Your decision whether or not to answer questions about the children that you work with will not affect your future relations with Auburn University, the Psychology Department, or The Learning Tree, Inc.

Contact Information:
If you have questions, please contact Jennifer Bredthauer by phone (334) 332-5716 or email at bredtje@auburn.edu or Dr. James Johnston by phone (334) 844-6487 or email at johnsjm@auburn.edu. For more information regarding your rights as a research participant you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WANT TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

____

Caregiver's Signature Print Name Date

____

Investigator's Signature Print Name Date

Appendix B

Behavior	Operational Definitions
Aggression	Hitting-contact of client's hand to another individual from a distance of 6 inches or greater; kicking-contact of client's foot to another individual from a distance of 6 inches or greater; grabbing-closure of client's hands and fingers around any part of another individual; throwing objects-picking up item and projecting the item in an outward motion in a distance of 6 inches or greater towards another individual; biting-closure of client's upper and lower teeth on any part of another individual; hair pulling-grasping and pulling of another individual's hair in an outward, upward, or downward direction; pinching-closure of client's thumb and forefinger to any part of another person; scratching-contact of client's nails in an up and down motion on another individual; cursing, name calling, physical threats.
Self Injury	Head-banging, eye-poking, slapping and hitting self with the hand, an object, or against an object, kicking, biting and pinching self, picking at the skin or scabs, and any behavior that has potential to cause personal injury.
Disruption	Hitting or kicking objects-client's hand or foot comes in contact with an object from a distance of 6 inches or greater; throwing objects-picking up item and projecting the item in an outward motion away from the body in a distance of 6 inches or greater.
Block Drop	Releasing the block from the hand through the opening at the top of the box. The drop is typically audible.
Consumption	Item manipulation or engagement with the stimulus in its intended manner. Any part of the client's body coming in contact with a toy (Immediate on/3 second off). Visual stimuli-making eye contact with visual stimuli such as a movie or video game for a minimum of 3 consecutive seconds without an interruption in eye contact for greater than 3 seconds; auditory stimuli-orienting towards the sound or interacting with music by rocking, clapping, humming, or singing with the music; edible stimuli-piece of food passing the plane of the lips without spitting or removing any portion from the mouth; smelling, touching, holding, and sitting, rocking, or swinging on an object would be additional means of consumption.
Response Interval	Interval beginning when the block(s) are placed on the table and ending when the response requirement has been completed (Immediate on/off).
Drop Latency	The time between block drops (3 second on/immediate off). Note: termination criteria were 10 minutes without a response during Experiment 1 and 5 minutes without a response during Experiment 2.
Reinforcement	Reinforcement interval beginning with the delivery of the reinforcer following completion of the target response and ending at 30 seconds during Experiment 1 and either 20 or 60 seconds during Experiment 2.

Appendix C

The Reinforcer Assessment for Individuals with Severe Disabilities (RAISD)

Student's name: ______________________________________ Date: _____________________

Caregiver(s): ____

Interviewer: ____

The purpose of this structured interview is to get as much specific information as possible from caregivers as to what they believe would be useful reinforcers for the student. Therefore, this survey asks caregivers questions about categories of stimuli (e.g., visual, auditory, etc.). After the caregiver has generated a list of preferred stimuli, additional probe questions are asked to get more specific information on student preferences and the stimulus conditions under which the object or activity is most preferred (e.g., What specific TV shows are the child's favorite? What does he/she do when playing with a mirror? Does the child prefer to do this alone or with another person?)

We would like to get some information on _______'s preference for different items and activities.

1. Some children really enjoy looking at things such as a mirror, bright lights, shiny objects, spinning objects, TV, etc. What are the things you think __________ most likes to watch?

   ____

   RESPONSE TO PROBE QUESTIONS:

   ____

2. Some children really enjoy different sounds such as listening to music, car sounds, whistles, beeps, sirens, clapping, people singing, etc. What are the things __________ most likes to listen to?

____

RESPONSE TO PROBE QUESTIONS:

____

3. Some children really enjoy different smells such as perfume, flowers, coffee, pine trees, etc. What are the things you think __________ most likes to smell?

____

RESPONSE TO PROBE QUESTIONS:

____

4. Some children really enjoy certain foods or snacks such as ice cream, pizza, juice, graham crackers. McDonald's hamburgers, etc. What are the things you think __________ most likes to eat?

____

RESPONSE TO PROBE QUESTIONS:

____

5. Some children really enjoy physical play or movement such as being tickled, wrestling, running, dancing, swinging, being pulled on a scooter board, etc. What activities like this do you think __________ most enjoys?

____

RESPONSE TO PROBE QUESTIONS:

____

6. Some children really enjoy touching things of different temperatures, cold things like snow or an ice pack, or warm things like a hand warmer or a cup containing hot tea or coffee. What activities like this do you think __________ most enjoys?

____

RESPONSE TO PROBE QUESTIONS:

____

7. Some children really enjoy feeling different sensations such as splashing water in a sink, a vibrator against the skin, or the feel of air blowing on the face from a fan. What activities like this do you think __________ most enjoys?

____

RESPONSE TO PROBE QUESTIONS:

____

8. Some children really enjoy when others give them attention such a hug, a pat on the back, clapping, saying "Good job", etc. What forms of attention do you think __________ most enjoys?

____

RESPONSE TO PROBE QUESTIONS:

____

9. Some children really enjoy certain toys such as puzzles, toy cars, balloons, comic books, flashlights, bubbles, etc. What are __________'s favorite toys or objects?

____

RESPONSE TO PROBE QUESTIONS:

____

10. What are some other items or activities that __________ really enjoys?

____

RESPONSE TO PROBE QUESTIONS:

____

After completion of the survey, select all the stimuli which could be presented or withdrawn contingent on target behaviors during a session or classroom activity (e.g., a toy could be presented or withdrawn, a walk in the park could not). Write down all of the specific information about each selected stimulus on a 3” x 5” index card (“Having a female adult read him the “Three Little Pigs’ story”). Have the caregivers select the top ten stimuli and rank them using the cards. Then list the top-ten ranked stimuli below.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

7. ______________________________

8. ______________________________

9. ______________________________

10. ______________________________

Appendix D

Paired-Stimulus Preference Assement Data Sheet

Student's Name: ____

Date: ______________________ Observer(s): ______________________________

	1	2	3	4	5	6	7	8	9	10
1		1&2	1&3	1&4	1&5	1&6	1&7	1&8	1&9	1&10
2	2&1		2&3	2&4	2&5	2&6	2&7	2&8	2&9	2&10
3	3&1	3&2		3&4	3&5	3&6	3&7	3&8	3&9	3&10
4	4&1	4&2	4&3		4&5	4&6	4&7	4&8	4&9	4&10
5	5&1	5&2	5&3	5&4		5&6	5&7	5&8	5&9	5&10
6	6&1	6&2	6&3	6&4	6&5		6&7	6&8	6&9	6&10
7	7&1	7&2	7&3	7&4	7&5	7&6		7&8	7&9	7&10
8	8&1	8&2	8&3	8&4	8&5	8&6	8&7		8&9	8&10
9	9&1	9&2	9&3	9&4	9&5	9&6	9&7	9&8		9&10
10	10&1	10&2	10&3	10&4	10&5	10&6	10&7	10&8	10&9	

	Item	Times Chosen (A)	Presented (2N – 2) (B)	Consumption (A/B x 100%)	Percent	Ranking
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Agreements _______ Disagreements _______ A + D _______ IOA _______

Appendix E

Table E-1
All Preferred Stimuli Identified by Caregivers Using the RAISD

Rank	Jason	Jill	Chad	Grant
1	Action Figure	Dried Fruit Roll	Fruit Snacks	Foam Ball
2	Toy Cars	Plastic Beads	Cheese Balls	Cartoon DVD
3	Baked Potato Chips	Shortbread Cookies	Chocolate Cookies	Gospel Music
4	Grapes	Graham Cracker Cookies	Jelly Beans	Popcorn
5	Cinnamon Cereal	Gospel Music	Peanut Butter Crackers	Chocolate Chip Cookies
6	Vanilla Sandwich Cookies	Splashing in Water	Juice	Splashing in Water
7	Cartoon DVD	Toy Drum	Foam Ball	Teddy Bear
8	Animated Movie	Mirror	Musical Toy Car	Baked Chips
9	Splashing in Water	Water Baton	Cartoon DVD	Peanut Butter and Jelly Sandwich
10	R&B Music	Pinwheel		

Table E-2

Spearman Rank-Order Correlations (rho) Among Standard Preference and Behavioral Economic Assessments

	RAISD	Combined Stimuli	Edibles Only	Tangibles Only	Collapsed PS Results	Ratio Breakpoints	Linear Model Unit Elasticity	Essential Value (α)	Exponential Model Unit Elasticity (Pmax)
RAISD		-0.26	0.25	0.53	.63**	-0.04	0.03	-0.32	-0.32
Combined Stimuli	-0.26		0.14	0.00	0.12	0.20	-0.05	-0.07	-0.07
Edibles Only	0.25	0.14			.62*	-0.04	-0.14	-0.33	-0.33
Tangibles Only	0.53	0.00			0.38	-0.18	0.00		
Collapsed PS Results	.63**	0.12	.62*	0.38		0.20	0.15	-0.22	-0.22
Ratio Breakpoints	-0.04	0.20	-0.04	-0.18	0.20		.82**	.61**	.61**
Linear Model Unit Elasticity	0.03	-0.05	-0.14	0.00	0.15	.82**		.65**	.65**
Essential Value (α)	-0.32	-0.07	-0.33		-0.22	.61**	.65**		1.00**
Exponential Model Unit Elasticity (Pmax)	-0.32	-0.07	-0.33		-0.22	.61**	.65**	1.00**	

$^{**}p < .01$. $^{*}p < .05$.

Table E-3

Kendall Rank-Order Correlations (tau) Among Standard Preference and Behavioral Economic Assessments

	RAISD	Combined Stimuli	Edibles Only	Tangibles Only	Collapsed PS Results	Ratio Breakpoints	Linear Model Unit Elasticity	Essential Value (α)	Exponential Model Unit Elasticity (Pmax)
RAISD		-0.22	0.21	0.51	.57**	-0.04	0.01	-0.25	-0.25
Combined Stimuli	-0.22		0.12	0.00	0.10	0.17	-0.04	-0.06	-0.06
Edibles Only	0.21	0.12			.58*	-0.03	-0.13	-0.30	-0.30
Tangibles Only	0.51	0.00			0.38	-0.17	0.00		
Collapsed PS Results	.57**	0.10	.58*	0.38		0.18	0.13	-0.20	-0.20
Ratio Breakpoints	-0.04	0.17	-0.03	-0.17	0.18		.74**	.52*	.52*
Linear Model Unit Elasticity	0.01	-0.04	-0.03	0.00	0.11	.74**		.55**	.55**
Essential Value (α)	-0.25	-0.06	-0.30		-0.20	.52*	.55**		1.00**
Exponential Model Unit Elasticity (Pmax)	-0.25	-0.06	-0.30		-0.20	.52*	.55**	1.00**	

$^{**}p < .01$. $^{*}p < .05$.

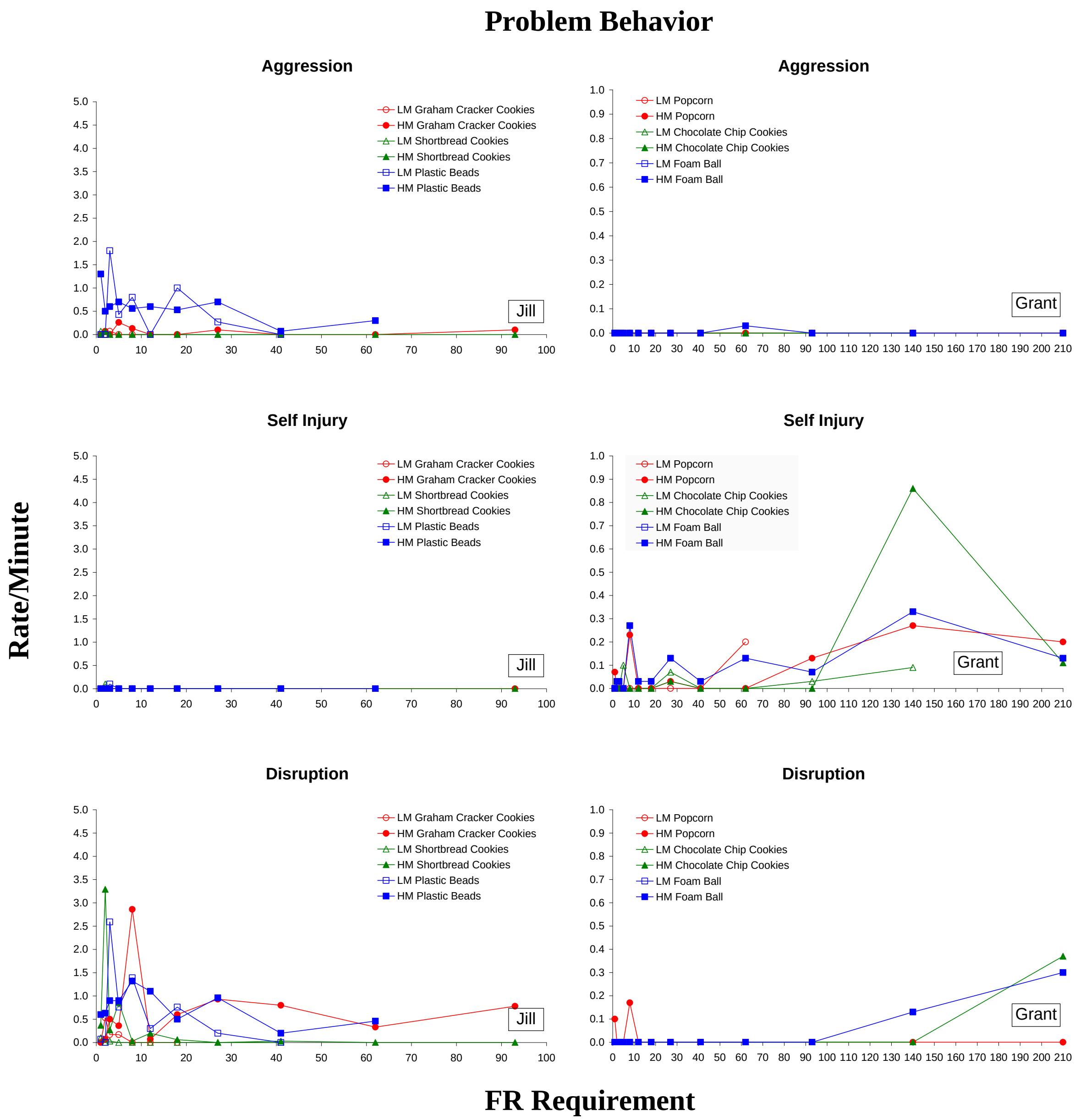
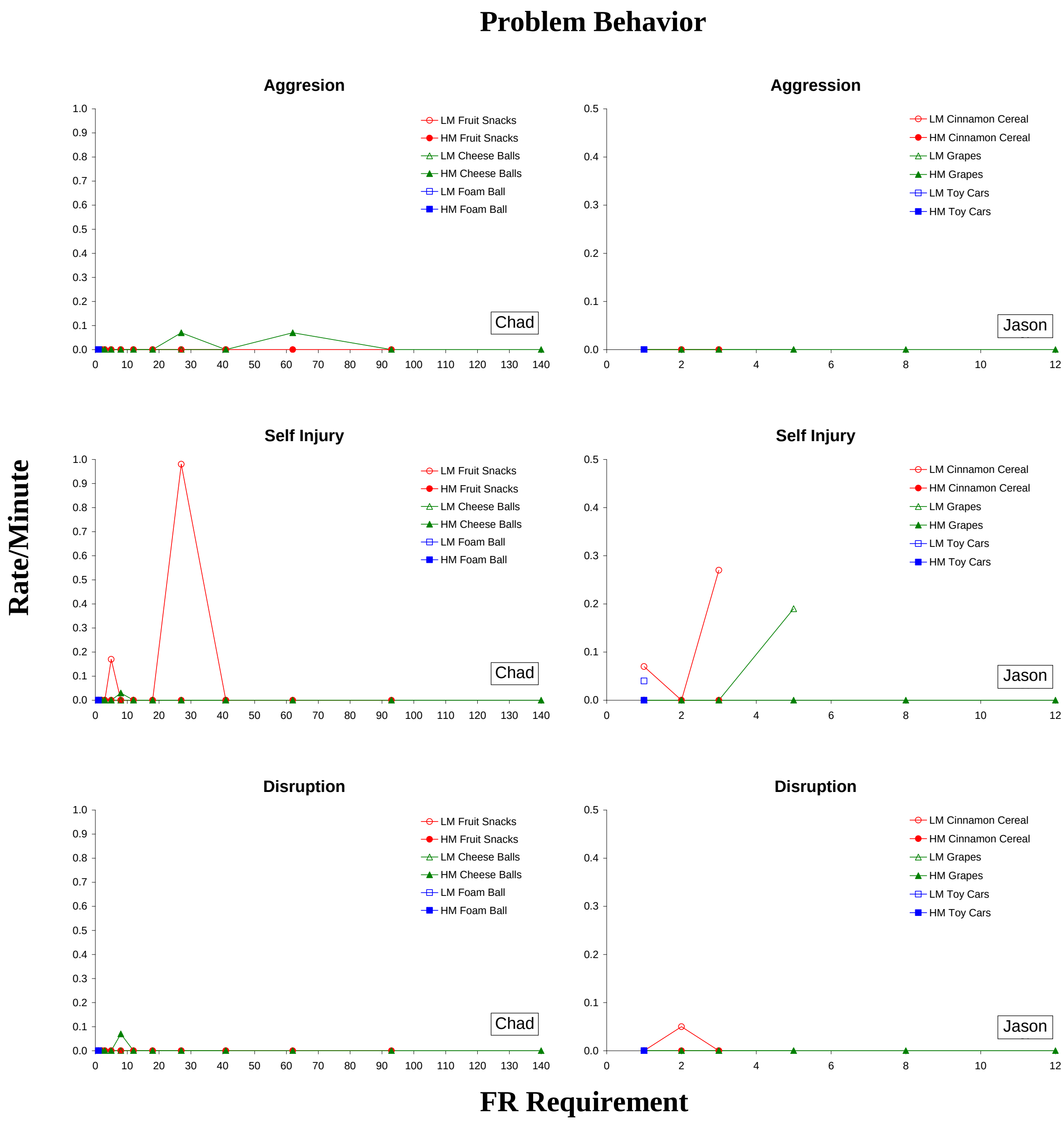


Figure E-1. Combined problem behavior consisting of aggression, self injury and disruption for each participant. *Note.* The x- and y-axes differ in each column. Figure E-1 is continued on the next page.



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