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Running head: Effort and Food Choice

Effects of Monetary and Effort-Based Price on Food-Related Decision Making in Obese and Healthy-Weight Humans: A Behavioral Economic Approach

Jennifer Peterson, M.S.

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

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RE: Your application dated 9/5/2012 regarding study number 3698M: Effects of Effort on Choice for Food in Humans

Dear Ms. Stoll:

I have reviewed your application for revision of the study listed above. The requested revision involves changes to the protocol by adding waist measurement timing of experimental tasks and adding a measurement of demand.

You are granted permission to conduct your study as revised effective immediately. The date for renewal remains unchanged at 2/17/2013, unless closed before that date.

Notify the HSC of any adverse events. Serious, unexpected adverse events must be reported in writing within 10 business days.

Submit progress reports on your project in six months. You should report how many subjects have participated in the project and verify that you are following the methods and procedures outlined in your approved protocol. Then, report to the Human Subjects Committee when your project has been completed. Reporting forms are available on-line.

Please note that any further changes to the study must be promptly reported and approved. Contact Patricia Hunter (208-282-2179; fax 208-282-4529; email: humsubj@isu.edu) if you have any questions or require further information.

Sincerely,

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TABLE OF CONTENTS

List of Figures.................... viii

List of Tables........................ x

Abstract..xii

Chapter I: Review of the Literature 1

Behavioral Economics...1

Demand... 2

Present Study..18

Chapter II: Effects of Effort on Choice for Food In Obese and Healthy-Weight Humans: A Behavioral Economic Approach. ………………………………………20

Introduction 20

Method...26

Results.......... 36

Discussion 59

References....................... 71

Appendices......................... 79

LIST OF FIGURES

Figure		Page
1	Differences in session 2 glucose by predictors of weight status	41
2	Purchases and responses of low-magnitude Food Purchasing Task as a function of low versus high waist circumference	42
3	Purchases and responses of high-magnitude Food Purchasing Task as a function of low versus high waist circumference	45
4	Purchases and response on low-magnitude and high-magnitude Food Purchasing Tasks	47
5	Purchases and responses of low-effort Food Climb Task as a function of low versus high PBF for males	50
6	Purchases and responses of high-effort Food Climb Task as a function of low versus high PBF for all participants	52
7	Purchases and responses on low-effort and high-effort Food Climb Tasks	54
8	Purchases and responses of low-magnitude Food Purchasing Task as a function of BMI	107
9	Purchases and responses of low-magnitude Food Purchasing Task as a function of low versus high PBF for females	109
10	Purchases and responses of low-magnitude Food Purchasing Task as a function of low versus high PBF for males	110
11	Purchases and responses of high-magnitude Food Purchasing Task as a function of BMI	112
12	Purchases and responses of high-magnitude Food Purchasing Task as a function of low versus high PBF for females	114
13	Purchases and responses of high-magnitude Food Purchasing Task as a function of low versus high PBF for males	115
14	Purchases and responses of low-effort Food Climb Task as a function of BMI	117
15	Purchases and responses of low-effort Food Climb Task as a	119

	function of low versus high waist circumference	
16	Purchases and responses of high-effort Food Climb Task as a function of BMI	121
17	Purchases and responses of high-effort Food Climb Task as a function of low versus high waist circumference	123

LIST OF TABLES

Table		Page
1	Mean(SEM) for demographic variables across BMI	37
2	Correlation matrix of predictor variables	38
3	Mean(SEM) of calories consumed across BMI	39
4	Preference ratings for food items	39
5	Mean(SEM) for free parameter values for linear elastic and exponential demand for low and high waist circumference on low-magnitude Food Purchasing Task	43
6	Mean(SEM) of free parameter values for linear elastic and exponential demand for low waist and high waist circumference on the high-magnitude Food Purchasing Task	46
7	Free parameters of linear and exponential demand for the low- and high-magnitude Food Purchasing Tasks	48
8	Mean (SEM) of free parameter values for linear elastic and exponential demand for lower PBF vs upper PBF on the low-effort Food Climb Task	51
9	Mean (SEM) of free parameters for linear elastic and exponential demand for lower PBF vs upper PBF on the high-effort Food Climb Task	53
10	Free parameters of linear and exponential demand for the low- and high-magnitude Food Climb Tasks	55
11	Correlations of variables associated with consumption at low prices: kcals consumed on the FPTT and *L* and *Q0* values for all demand measures	56
12	Correlations of variables associated with monetary elasticity: P_{max} and α for low- and high-magnitude Food Purchasing Tasks	57
13	Correlations of variables associated with effort-based elasticity: Total stairs traversed, P_{max} and α values for the low- and high-effort Food Climb Tasks	58
14	Free parameters for linear elastic and exponential demand for	108

	Normal vs. Obese BMI on the low-magnitude Food Purchasing Task	
15	Free parameters for linear elastic and exponential demand for lower PBF vs upper PBF on the low-magnitude Food Purchasing Task	111
16	Free parameters for linear elastic and exponential demand for Normal vs. Obese BMI on the high-magnitude Food Purchasing Task	113
17	Free parameters for linear elastic and exponential demand for lower PBF vs upper PBF on the high-magnitude Food Purchasing Task	116
18	Free parameters for linear elastic and exponential demand for Normal vs. Obese BMI on the low-effort Food Climb Task	118
19	Free parameters for linear elastic and exponential demand for lower waist circumference vs upper waist circumference on the low-effort Food Climb Task	120
20	Free parameters for linear elastic and exponential demand for Normal vs. Obese BMI on the high-effort Food Climb Task	122
21	Free parameters for linear elastic and exponential demand for Lower waist circumference vs upper waist circumference on the high-effort Food Climb Task	124

Abstract

The continued rise of obesity has prompted researchers to identify contributing factors and mechanisms of over-consumption of food. The present study aims to contribute to these pursuits by using a behavioral economic approach in assessing the roles effort and monetary price on choices for food. Two hundred twenty-seven participants completed a behavioral measure, the Effort Task, in which they chose between a larger amount of preferred food with an effort (climbing stairs) component vs. a smaller amount of food without effort. Participants also completed a set of behavioral economic demand questionnaires querying how many portions of food they would purchase at systematically increasing monetary (Food Purchasing Task) and effort-based (Food Climb Task) prices. Across all demand tasks, increases in price resulted in a decrease in consumption and responding for all participants that mirrored behavioral economic demand models. For the Food Purchasing Task, healthy-weight individuals reported greater consumption at low prices and greater elasticity of demand than obese individuals; there were no body-mass differences with the Stair Climb Task. Further, body-mass did not predict behavioral differences with the Effort Task. These data suggest, then, that monetary price, not effort, is a better predictor for weight-related differences in sensitivity to price.

Key words: behavioral economics, demand, effort discounting, food choice, obesity

CHAPTER 1

Review of the Literature

Obesity can be conceptualized as an outcome of positive energy balance in which the amount of food energy consumed exceeds the amount of physical energy expended (Epstein, Leddy, Temple, & Faith, 2007). The positive balance results in excess energy stored as fat, also known as weight gain. Obesity is quantified as a Body Mass Index (BMI) equal to, or greater than, 30 (Center for Disease Control, 2006). BMI is the relationship between weight and height and can provide a reliable (though not perfect) indicator of body fat and is used to screen susceptibility to health concerns and problems (Center for Disease Control, 2006). Obesity prevalence in the United States has risen steeply within the last two to three decades (Center for Disease Control, 2006). Consequences of obesity are vast, including overall poor physical health and an increased risk of cardiovascular disease and diabetes mellitus (Center for Disease Control, 2006). Given the outcomes associated with obesity and its prevalence, current research has focused on identifying and understanding the contributing factors to its development (Epstein et al., 2007a; Epstein, Roemmich, Stein, Paluch, & Kilanowski, 2005; Mobbs, Crepin, Thiery, Golay, & Van der Linden, 2010; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006).

Behavioral Economics

Different theoretical frameworks have been utilized to understand mechanisms of obesity. One such framework that has been proposed is behavioral economics. The field of behavioral economics uses well-established economic principles to explain and predict choices for outcomes, such as food (Bickel, Green, & Vuchinich, 1995; DellaVigna, 2009). Specifically, the research of behavioral economics evaluates the extent to which economic or environmental features affect allocation of time and behavior among available alternative commodities or outcomes (Bickel, Green, & Vuchinich, 1995). Some examples of choice behaviors that have been explained through behavioral economics include illicit drug use (Bickell, Marsh, & Carroll, 2000; MacKillop, Monti, Murphy, Miranda, Ray, Rohsenow, McGeary, & Swift, 2010; Spiga, Martinetti, Meisch, Cowan, & Hursh, 2005), and more recently, food consumption applied to obesity (Epstein, Dearing, & Roba, 2010; Rasmussen, Lawyer, & Reilly, 2010; Rasmussen, Reilly & Hillman, 2010; Rasmussen, Reilly, Buckley, & Boomhower, 2012). With eating, the choice to eat takes place in a variety of contexts. These contexts include, but are not limited to, competing activities during consumption (Coon, Goldberg, Rogers, & Tucker, 2001), the amount of food available (Sanchez-Vazquez, Zamora, & Madrid, 1995), the effort required to obtain food (Salamone & Correa, 2009), and the variety of food options available (Epstein, et al, 2007a; Salamone & Correa, 2009). The phenomenon of obesity may be best considered as an outcome of a series of choices in which eating is a highly probable behavior. In order to explicate the relationship between obesity and a pattern of food choice, the proposed research uses a behavioral economic framework.

Demand

Many procedures, such as delay discounting, exist that quantify the subjective value of food. In delay discounting, individuals are presented with choices between smaller, sooner rewards (the impulsive choice) vs. larger rewards after a delay (Charlton & Fantino, 2008; Critchfield & Kollins, 2001; Epstein, et al, 2010; Fields, Sabet, Peal, & Reynolds, 2011; Odum & Rainaud 2003; Rasmussen, et al, 2010; Rollins, Dearing, & Epstein, 2010). This theoretical model and procedure quantifies an individual's level of impulsive responding using a series of choices to determine sensitivity to delayed outcomes. Some research shows that obese individuals make more impulsive choices for food (Batternik,Yokum, & Stice, 2010; Rasmussen, Lawyer, & Reilly, 2009) and money (Fields, Sabet, Peal, & Reynolds, 2011; Weller, Cook, Avsar, & Cox, 2008).

The progressive ratio schedule is another procedure used to quantify the subjective value of a reinforcer (Bickel, Marsch, & Carrol, 2000; Epstein et al, 2007; Hodos & Kalman, 1963; Rasmussen & Huskinson, 2008; Rollins et al, 2010; Stafford, LeSage, and Glowa, 1998). Under the progressive ratio schedule, the subject must emit responses at increasing response requirements within a single session to obtain successive reinforcement. The response requirement systematically increases until the requirement becomes too high to maintain behavior. This point is known as breakpoint, and serves as the measure for the subjective value of a reinforcer. Reinforcers with higher breakpoints are considered to be stronger than those reinforcers with lower breakpoints (Bari & Pierce, 2005).

While breakpoint can give a strong quantitative measure for the value of a reinforcer by an organism, it occurs under limited conditions. Consider that that the value of a reinforcer can only be determined in a stable condition (Bickel, et al, 2000; Hursh & Silberberg, 2008). A reinforcer, such as food, may be highly valued when under the state of deprivation, but the subjective value of food decreases when an organism is in a satiated state (Hodos & Kalaman, 1963). Further, the subjective value of the reinforcer alters in the presence of other available reinforcers (Bickel, et al, 2000). This becomes a problematic form of assessment when considering human beings are in constant interaction with a number of reinforcers and have limited resources (e.g., time, money) to allocate among the options. Furthermore, Killeen and colleagues (2009) identified factors that impact behavior under a progressive ratio schedule. The progression of the schedule—whether exponential or arithmetic, can result in different breakpoints for the same reinforcer. Comparing breakpoint values among reinforcers becomes complex, as the type of progression for which the schedule operates under impacts the yielded value. As such, reinforcing value is not constant and breakpoint offers a limited view of measuring the efficacy of a reinforcer (Hursh & Silberberg, 2008; Killeen, Posadas-Sanchez, Johansen, & Thrailkill, 2009).

Economic demand addresses these limitations by describing the relationship between consumption and price. In addition, this framework also factors in the presence of multiple competing reinforcers that are available concurrently and their respective prices. The value of a reinforcer can be determined by its sensitivity to price increases, in the context of other reinforcers. These ideas are explicated next.

Economic demand refers to the relation between consumption and price (Bickel, Marsch, & Carroll, 2000; Hursh, 1980; Hursh, 1984; Hursh, 2000; Madden, 2000). In behavioral terms, unit price refers to the response cost (physical effort) required to produce one unit of a good or reinforcer. The value of a reinforcer can be determined by examining the relation between the consumption of the reinforcer in relation to the price. In general, as price increases, consumption of the reinforcer decreases in a predictable fashion. The degree of sensitivity to price represents demand. Consumption of higher-valued commodities are typically less sensitive to price increases, therefore the demand is higher for these commodities.

The shape of the linear-elasticity (Hursh, 1980; Hursh, 1984; Hursh 2000) demand curve describes the value of a commodity or reinforcer. Consumption (number of reinforcers) is plotted logarithmically against price (which can be monetary cost or effort requirements). The equation that characterizes the demand curve is

$$\ln(Q) = \ln(L) + b(\ln \mathrm{P}) - a(\mathrm{P}) \quad (1)$$

in which P represents price and Q representing quantity of the commodity. As P increases, Q decreases. The free parameters describe the shape of this decline. *L* is the level of demand at a minimal price (y-intercept of the curve), *b* is the slope of the demand curve at small prices, and *a* represents the acceleration or increase in slope of the demand curve that occurs with increasing price (Hursh, 2000).

The value of the reinforcer is determined by the level of elasticity or rate of decline (sensitivity to price). A demand curve that demonstrates low elasticity will exhibit relatively low decline with price. Conversely, a demand curve that depicts a steep decline indicates high elasticity (Hursh, 1980). An arbitrary value on the demand curve, at which the slope is equal to -1, refers to the point of unit elasticity. A slope of -1 means that a one-unit increase in price will result in a one-unit decrease in consumption; this point represents a shift from a good being inelastic to becoming elastic. The price that corresponds to this value is called P_{max} (Bickel, et al., 2000; Hursh,1980; Hursh 1984; Hursh 2000). P_{max} is expressed through the equation

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

and can be thought of as the value that corresponds to the slope of the curve at minimal price over the slope of the curve with increasing prices.

Whereas P_{max} serves at the point in which consumption becomes elastic, the output level (responses, as opposed to reinforcers) of a demand curve is characterized by O_{max}. The output (responses at each price), O, can be predicted by the equation

$$\ln(O) = \ln(L) + (b\text{-}1)(\ln P)\text{-}aP \quad (3)$$

with O_{max} being the solution to the equation at P_{max}. Though these measures capture different phenomena, they are not unrelated. O_{max} refers to the maximal number of responses and is the peak level of the response output curve at P_{max}.

Stated differently, when consumption of a good declines as a function of price and moves towards elasticity, the level of responding to continue to defend the consumption of the commodity is at its maximum point (O_{max}).

As the values of P_{max} and O_{max} explain different elements of demand, the generated curves of these functions are expected to be different. The shape of a demand curve is constructed through plotting price on the x-axis and reinforcers earned on the y-axis. Thus the shape of the curve displays reinforcers positively accelerating in a decreasing fashion. In this curve, more reinforcers are earned at lower price values, and a decline in reinforcers obtained is observed as price increases to higher values. The output curve, however, plots responses against price, and the shape of the curve is an inverted U-shape, in which the peak of the curve is the point at which maximal output (O_{max}) occurs.

An alternative conceptualization of O_{max} is spending, which can broadly be defined as the amount of work, effort, money, or time that is allocated towards obtaining a particular reinforcer or good (Madden, 2000). Consider gasoline as an example. Gasoline is an inelastic good, as increases in price result in small decreases in consumption. This is largely due to the lack of alternatives available to substitute gasoline in human transportation needs. While the consumption level of gasoline remains the same at higher prices, the spending for gasoline (or the output of responses, in this case money) will increase in order to maintain the previous level of consumption. Output, then, is changes in responding to increases in price (Madden, 2000).

The linear-elasticity model of demand results in the use of multiple parameters that describe changes in consumption of goods. These include three parameters from the model itself that describe slope, intercept and acceleration of change (*L*, *b*, and *a*) and two others that are derived from the equation—P_{max} and O_{max}. A more recent approach (Hursh & Silberberg, 2008) posits that a single parameter can account for the rate of change in elasticity. This approach, called the exponential model of demand (or essential value), contains one free parameter that represents the decay of consumption with price increases. This single parameter simplifies quantification of demand. In addition, it allows for cross comparison of demand for goods through eliminating scalar differences of goods. The equation that defines exponential demand follows:

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

(4)

Here, Q_0 represents consumption at the lowest price (the y-intercept), C is defined as the cost of each reinforcer (e.g., fixed ratio schedule), k is a constant and represents the range of the dependent variable in logarithmic units, and α is the fitted parameter that represents the rate of decline in consumption, or the essential value. The essential value parameter can be used to make comparisons between two goods to determine which has more value. Larger α values reflect greater elasticity, or a reinforcer that is more sensitive to price increases; therefore a reinforcer that has a lower α value can be said to be less elastic and has more value.

While demand curves represent the value of a commodity based upon the response cost for the reinforcer, other variables impact the demand curve beyond prices and amount. Hursh (1984) identified four variables that alter the elasticity of demand: economic context, nature of the commodity, species of the consumer, and the availability of substitutes. The first element-- the economic context—refers to whether the economy is closed or open. In a closed economy, total consumption of a reinforcer occurs only within a specified session. If food were the reinforcer, for example, access to food in a closed economy would only occur within the experimental session with no opportunity for food outside of the session (Collier, Johnson, & Morgan, 1992; Hursh, 1980). An open economy, however, exists when the experimental session allows access to a reinforcer that is also present at other times outside of the session. Closed economies, therefore, require an organism to obtain all daily consumption within the experimental session, whereas open economies do not.

Economy type affects elasticity of demand. Closed economies will often show high rates of responding over time, whereas open economies tend to show an initially high rate of response followed by a decline (Hursh, 1980). In terms of elasticity, goods provided in closed economies are more inelastic than in open economies. Collier, Johnson, and Morgan (1992) demonstrated the impact of closed and open economies on responding for varying sizes of food pellets in rats. Three conditions were used. First, in the closed economy/free-feeding condition, no restrictions existed on the frequency and size of the meal, or total food intake. Second, in the closed economy/restricted condition, rats' weights were maintained at 85% body weight in order to assess the effects of deprivation on demand for food. Third, in the open economy/restricted condition, rats earned food pellets during experimental conditions and were given an additional supplement of food to maintain body weight at 85%. Six combinations of pellet prices (FR 10 and FR 40) and three pellet sizes (20, 45, and 97 mg) served as the foraging conditions, and each rat received each condition randomly. Results showed that both closed economies resulted in higher response rates for higher priced and smaller pellets than the open economies. Further, rats in the closed/restricted condition responded at a slightly higher rate than those in the closed/free-feeding condition. Behavior corresponding with the principle of demand was also observed: Rats in closed economy/free-feeding and those in the open economy conditions consumed more food when the pellet size was large and pellet price was low and consumed less when the price was higher (Collier, et al, 1992). Demand curves, then, are not only a function of the availability of the commodity and unit price, but also of the constraints and design of the experiment.

The nature of the commodity, or type of good, affects demand. Demand for goods that are primary reinforcers , such as food and water, tend to be more inelastic, compared to demand for secondary reinforcers, such as reading books, which may be more sensitive to price change (Hursh; 1984; Madden, Dake, Mauel, & Rowe, 2005). This is likely because reading books is a leisure activity and an activity that requires conditioning to become a reinforcer. As the presence of alternatives can alter the demand for a good, further information on the relations of a target good and alternatives must be understood.

The presence and availability of alternative reinforcers can impact demand. The purchase and consumption of goods almost always occurs in the presence of alternatives. The potential relationships between alternative goods are substitutes, complements, and independents. Substitution occurs between two goods when the increasing price of good A results in a decrease in the consumption of good A, and an increase in consumption of good B. In other words, resources that were previously allotted towards the consumption of one good are reallocated to the consumption of another good. In this case, good B is an economic substitute for good A. Bauman, Raslear, Hursh, Shurtleff, and Simmons (1996) found sucrose to be a substitute for standard rat food (chow) in rats. Madden and colleagues determined the extent to which fat and standard chow could serve as substitutes for one another in rats (Madden, Smethells, Ewan, & Hursh, 2007a). A liquid fat mixture and standard food pellets were available concurrently during a session and the price (FR schedule requirement) of each good was systematically manipulated to establish the relationship between the goods as substitutes. They found that price increases in the fat substance resulted in a decrease for fat and an increase in consumption of chow. Further, when the price of chow was increased, a subsequent decrease in responding for chow was observed and an increase in responding and consumption of fat occurred (Madden et al, 2007a). They concluded that chow served as a substitute for fat and vice versa.

In some cases, a substitute can be unidirectional. In a study by Petry and Bickel (1998), heroin users were given $30 and asked to allocate their money across heroin and valium provided at varied costs. It was found that when the price of heroin, which was the initially preferred drug of the participants, increased, the consumption of heroin decreased. As this decrease occurred, a corresponding rise in the consumption of valium was observed. However, when the price of valium was increased, heroin consumption was unaffected. Based on these observations, valium served as a substitute for heroin, yet heroin did not serve as a substitute for valium at altered prices (Petry and Bickel 1998).

A complementary relationship occurs when the consumption of one good increases the probability of consuming another good. Stated differently, a complementary relationship is defined as when the introduction of a reinforcer increases the consumption and allocation of resources to obtaining another reinforcer. For example, cigarettes and alcohol have been observed to be complements, wherein increased levels of consumption of alcohol correspond with an increase in the rate of cigarettes smoked (Madden, 2000). In another study (Madden, Smethells, Ewan, & Hursh, 2007b), the economic relationship between food and water were assessed in six Sprague-Dawley rats. Food and water were available concurrently, and price (response requirement) was systematically manipulated. It was observed that both goods were highly inelastic, indicating that increases in price did not result in large decreases in consumption. One statistically significant finding was observed between the two goods; the O_{max} values for food were higher than that for water. This finding indicates that rats defended the level of food consumption more than that of water. (Madden, et al, 2007b). Taken together, these findings demonstrate that while food and water serve as complements-- increased consumption of food was related to an increased consumption in water.

The last economic relationship between goods is that of independents. Independents are goods that are do not demonstrate alterations in consumption based on changes in price of one another (Madden, 2000). An example of this could be aspirin and toothpaste. Both of these goods are types of health care products, however, the increase in prices of aspirin does not impact the extent to which toothpaste will be purchased or consumed. Likewise, increases in price for toothpaste will not impact the probability of purchasing aspirin.

While the aforementioned variables are conceptualized as important to the shape of demand curves for a good, another factor that should be taken into consideration is income (Madden, 2000; Petry, 2000). Income has an impactful role on consumption and allocation of funds to various purchases. For example, a graduate student may allocate money to the purchase of hamburger meat while earning a part-time income. Choices may shift after graduating and obtaining a higher full-time paying position, such that decreases in the consumption of hamburger meat are observed with corresponding increases in a more expensive alternative, such as filet mignon. Alterations in income, then, are a determining factor in the demand for a good.

Behavioral economic research studies historically has been applied to answer questions about substance abuse, such as demand for alcohol and drugs (Bickel & Marsch, 2001; Bickel, et al, 2000; Bickel, et al, 2007; Christensen, Silberberg, Hursh, Huntsberry, & Riley, 2008; Madden, 2000; Murphy, MacKillop, Skidmore, & Pederson, 2009). For example, Murphy and colleagues (2009) explored demand for alcohol in college students through a hypothetical drinking task. Participants were provided with a vignette describing access to alcohol beverages available at different prices. Participants were asked to endorse the number of drinks they would consume given the price per beverage. It was found that as the price of each drink increased, the number of drinks estimated to be purchased decreased. Moreover, ratings on hypothetical drinks were characterized nicely by the linear-elasticity demand curve and the exponential demand model (Murphy, MacKillop, Skidmore, & Pederson, 2009). Recently the application of economic principles has branched to obesity within both the animal and human literatures. Rasmussen, Reilly, & Hillman (2010) assessed differences in demand of sucrose between genetically obese Zucker (*fa/fa*) rats and lean Zucker rats. Both groups of rats pressed levers that produced food at different response requirements. Results demonstrated that obese rats earned more food than lean rats at lower response requirements, but were statistically indistinguishable at higher response requirements. Moreover, both groups were equally sensitive to increases in price, suggesting that the environmental arrangement of food (and not genetic factors that may alter the value of food) played the largest role in food consumption. In a second study (Rasmussen, Reilly, Buckley, & Boomhower, 2012) the cannabinoid antagonist, rimonabant, dose-dependently reduced the essential value of sucrose in lean and obese Zucker rats. The demand curves in both studies, however, were generated in closed economies, which may have underestimated elasticity of demand.

Epstein, Dearing, and Roba (2010) applied economic demand for food to human populations using both a laboratory task and questionnaire method. With the laboratory task, participants earned portions of “junk” foods (e.g., potato chips and candy) or access to reading material by key pressing in effort-based patterns. After each reinforcer was earned, the key-press pattern would increase in response requirement. With the questionnaire, participants were asked to identify how many portions of snack food they would consume at various monetary costs. Results indicated that amount of food decreased in both tasks as a function of increases in key-pressing requirements (price) and dollar amount. P_{max} and O_{max} values were generated for the questionnaire and laboratory task; results indicated correlations between the values of demand for both tasks. The authors concluded the behavioral and questionnaire tasks were both efficacious methods to obtain demand curves for food in human populations. Furthermore, an important finding was of a significant positive correlation between BMI and consumption. Specifically, participants with higher BMIs consumed more food within the session and exhibited lower elasticity values (i.e., paid higher prices) for unhealthy food on both the laboratory task and the hypothetical questionnaire task, than those with lower BMIs. These findings suggest the possibility that obese individuals may value food to a greater extent, as demonstrated by the higher levels of effort emitted in order to obtain food than those individuals of a healthier weight.

The literature presented thus far demonstrates that food consumption depends strongly on effort and this may be linked to weight status. Given that obese individuals consume more food at lower prices, and in some cases, demonstrate lower elasticity for food, one may consider that obese individuals show greater sensitivity to the reinforcing properties of food. A challenge that has been identified during the development of programs and procedures aimed at reducing and eliminating the problem of obesity is in reducing the rewarding properties of food and identifying alternative non-food rewards that can compete with food (Epstein, Roemmich, Stein, Paluch, & Kilanowski, 2005).

One method to decrease the reinforcing properties of food is to increase the effort required to obtain the food itself. This has been called effort discounting, which refers to the observation that effort diminishes the value of a reward (Botvinick, Huffstetler, & McGuire, 2009; Salamone Correa, 2009). Using animals, Salamone and Correa (2009) developed a T-maze paradigm in order to assess the effects of effort on food choice. A T-maze has two arms (the upper cross of the T), which represents two choice options, each differing in terms of food amount that is available at each end of the arm. Rats were placed in the stem of the T-maze and allowed to explore both arms. They demonstrated consistent preference for the arm with the larger amount of food. After contact had been made with each arm of the T-maze, a barrier was placed only in the arm with the larger amount of food. To access the food, the rat had to climb the barrier, which was varied in terms of height, and therefore effort. Salamone and Correa (2009) demonstrated that implementation of an effort component to attaining the larger food reinforcer decreased the extent to which rats accessed this preferred food reinforcer (low-dopamine rats demonstrated preference for the higher food amount when the barrier was not present and were less likely to climb the barrier to obtain the larger amount of food compared to rats with normal levels of dopamine).

Comparisons have also been made between hyperphagic rats and obese humans on a variety of dimensions pertaining to eating (Schachter, 1971). Based on reviewed empirical literature, under low-effort (i.e., free-feeding) conditions, obese rats and humans exhibited higher levels of consumption of fatty, palatable foods, greater overall caloric consumption per day, and an overall higher rate of consumption of food compared to lean counterparts (Schachter, 1971). Further, when access to food involved an effort component (e.g., lifting a lid covering a food dish for the rats, removing shells of nuts for humans) obese organisms consumed fewer calories than lean controls (Schachter, 1971).

From this research, Schachter developed the externality hypothesis with humans, which suggests that obese and/or overweight humans will select food items that are more accessible, and consume these items more frequently than lean humans. Meyers and Stunkard (1980) tested this by experimentally manipulating the availability of low- and high-calorie dessert options in a high-traffic cafeteria over a six-day period. Results demonstrated that increasing effortful requirements to obtain low-calorie desserts diminished dessert consumption among obese and healthy-weight individuals. High-calorie dessert options, however, were less susceptible to the increased effort requirement. While no weight differences were observed, and the Schachter externality theory was not supported, effort requirements were shown to differentially impact consumption of foods with differing palatability (Meyers & Stunkard, 1980).

In another study assessing the effects of effort on consumption, Painter, Wansink, and Hieggelke (2002) assessed whether visibility or accessibility of food contributed more to amounts consumed in ten human participants. Three experimental conditions were used in a within-subjects design: 1) a container of chocolates was placed on top of the participant's desk (visible and convenient), 2) the container was placed inside the participant's desk drawer (not visible but convenient), and 3) the container was placed on a shelf 2 meters away (visible, but inconvenient). Results indicated that participants with candy placed in a visible and convenient location consumed 2.9 times more than those participants who had the candy in their desk (convenient, but not visible). In addition, participants with candy in a visible and convenient location consumed 5.6 more times than those who had to walk to attain candy (visible, but inconvenient). Based on the results, the authors concluded that convenience of food contributed more to consumption than visibility (Painter, Wansink, & Hieggelke, 2002). Therefore, increasing effort requirements for food consumption may serve to diminish the overall amounts consumed. This tactic may be useful when conceptualizing interventions for obesity.

Present Study

The purpose of the present study is to examine the effects of effort on food choices in healthy-weight and obese humans using behavioral economic procedures and analyses. Based on the work by Salamone and Correa (2009) and others, we will assess the extent to which effort impacts consumption between obese and healthy-weight individuals. In this experiment, both obese and healthy-weight participants will be presented with choices between a larger quantity of food that varies in terms of effort versus a small amount available with little effort. It is hypothesized that as effort increases, both groups will switch preferences from the larger amount to the smaller, less effortful option. It also is hypothesized that obese individuals will switch to the smaller, less effortful outcome at higher response requirements later than the healthy-weight individuals. We will also query participants about their consumption based on an effort- and money-based questionnaire. We will fit demand curves to these data and compare them to the behavioral data.

This proposed study will contribute to the existing literature on obesity, food reinforcement, and effort in two primary ways. First, we will establish the use of an effort-based laboratory procedure to assess motivation for food in humans, which extends the animal literature and therefore qualifies as a translational study. To our knowledge, this has not been done with human participants. Second, the findings of this study may contribute to the existing research on obesity and provide implications for interventions and treatment. Specifically, the findings may provide information on behavioral mechanisms that establish food as a reinforcer in obese and normal weight populations.

CHAPTER 2

Effects of Monetary and Effort-Based Price on Food-Related Decision Making in Obese and Healthy-Weight Humans: A Behavioral Economic Approach

Obesity can be conceptualized as a positive energy balance, in which the amount of food energy consumed exceeds the amount of physical energy expended (Esptein, Leddy, Temple, & Faith, 2007). This pattern of behavior results in excessive stores of fat, or weight gain. Obesity prevalence in the United States has risen steeply within the last two to three decades (Center for Disease Control, 2006). Consequences of obesity are vast, including increased risk of cardiovascular disease and diabetes mellitus (Center for Disease Control, 2006). Given the rise of obesity and obesity-related health concerns, researchers have sought to identify contributing factors and interventions (Epstein et al., 2007a; Epstein, Roemmich, Stein, Paluch, & Kilanowski, 2005; Mobbs, Crepin, Thiery, Golay, & Van der Linden, 2010; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006).

Behavioral Economics

The field of behavioral economics uses well-established economic principles to explain and predict consumption patterns for specific outcomes. Economic demand refers to the relation between consumption of an outcome and price (Bickel, Marsch, & Carroll, 2000; Hursh, 1980; Hursh, 1984; Hursh, 2000; Madden, 2000). In behavioral terms, unit price is often conceptualized as response cost, that is, the physical effort required to produce one unit of an outcome or reinforcer. In general, as price increases, consumption of the reinforcer decreases in a predictable fashion. The degree of sensitivity to price represents demand.

Traditionally, the linear elasticity model has been used to characterize demand (Hursh, 1980; Hursh, 1984; Hursh, 2000). Consumption (number of reinforcers) is plotted logarithmically against price (which can be monetary cost or effort requirements) and equation 1 is fit to the data:

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

Here, P represents price and Q represents quantity of the commodity. The free parameters describe the shape of the curve, which positively accelerate in a decreasing manner. *L* is the level of consumption at a minimal price (y-intercept of the curve). The parameter *b* is the slope of the demand curve at small prices, and represents the inelastic part of the curve, in which consumption is insensitive to price. The parameter *a* represents the acceleration or increase in slope of the demand curve that occurs with increasing price and represents the more elastic part of the curve, in which consumption decreases dramatically with price (Hursh, 2000).

A referent for unit elasticity, the price at which a unit increase in price leads to a unit reduction in consumption (i.e., the point on the curve where the slope is -1) is called P_{max}, or maximal price (Bickel, et al., 2000; Hursh,1980; Hursh 1984; Hursh 2000). P_{max} values are calculated as:

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

where P_{max} serves at the point in which consumption becomes elastic, the maximal output (responses, as opposed to reinforcers) of a demand curve is characterized by O_{max}. The output (responses at each price), O, can be predicted by the equation

$$\ln(O) = \ln(L) + (b\text{-}1)(\ln P)\text{-}aP \qquad (3)$$

with O_{max} being the solution to the equation at P_{max}. Though these measures capture different phenomena, they are not unrelated. O_{max} refers to the maximal number of responses and is the peak level of the response output curve at P_{max}.

Linear elasticity has been used to describe and quantify the reinforcing properties of a number of outcomes, such as food (Epstein, Dearing, & Roba, 2010; Hursh, Raslear, Shurtleff, Bauman, & Simmons, 1988; Rasmussen, Reilly, & Buckley, 2012;) and drugs of abuse (Bickel, Green, & Vuchinich, 1995; Bickel, Marsh, & Carroll, 2000; Hursh, 1991; Hursh, Galuska, Winger,& Woods 2005; Spiga, Martinetti, Meisch, Cowan, & Hursh, 2005) . A more recent approach (Hursh & Silberberg, 2008) posits that a single parameter can account for the rate of change in elasticity. This approach, called the exponential model of demand (or essential value), contains one free parameter that represents the decay of consumption with price increases. In addition, it allows for cross comparison of demand for goods by eliminating scalar differences of outcomes. The equation that defines exponential demand is:

$$\log Q = \log Q_0 + k(e^{-\alpha Q_0 C\text{-}1)} \qquad (4)$$

Here, Q_0 represents consumption at the lowest price (the y-intercept), C is defined as the cost of each reinforcer (e.g., fixed ratio schedule), k is a constant and represents the range of the dependent variable in logarithmic units, and α is the fitted parameter that represents the rate of decline in consumption, or the essential value of the reward. The essential value parameter can be used to make comparisons between two goods to determine which has more value. Larger α values reflect greater elasticity, or a reinforcer that is more sensitive to price increases; therefore a reinforcer that has a lower α value can be said to be less elastic and has more value.

Both the linear and exponential models have been used to characterize the reinforcing properties of drugs (e.g., MacKillop, Monti, Murphy, Miranda, Ray, Rohsenow, McGeary, & Swift, 2010; Murphy, MacKillop, Skidmore, & Pederson, 2009). More recently, however, behavioral economic principles have been applied to obesity (Epstein, Dearing, & Roba, 2010; Rasmussen, Lawyer, & Reilly, 2010; Rasmussen, Reilly & Hillman, 2010; Rasmussen, Reilly, Buckley, & Boomhower, 2012). For example, Epstein, Dearing, and Roba (2010) applied economic demand for food to human populations using both a laboratory task and questionnaire method. With the laboratory task, participants earned portions of "junk" foods (e.g., potato chips and candy) or access to reading material by key-pressing in effort-based patterns. With the questionnaire, participants were asked to identify how many portions of snack food they would consume at various monetary costs. P_{max} and O_{max} values were generated for the questionnaire and laboratory task. Participants with higher BMIs consumed more food within the session and exhibited lower elasticity values (i.e., paid higher prices) for unhealthy food on both the laboratory task and the hypothetical questionnaire task, than those with lower BMIs. These findings suggest the possibility that obese individuals may value food more strongly than healthy weight individuals.

Other studies have used effort as a measure of price and found patterns that are consistent with behavioral economic studies: as effort is increased, consumption decreases. In Schachter's (1971) well-cited work, comparisons between obese humans and obese rats vs. and lean or healthy weight controls were made. Under low-effort (i.e., free-feeding) conditions, obese rats and humans exhibited higher levels of consumption of fatty, palatable foods, greater overall caloric consumption per day, and an overall higher rate of consumption of food compared to lean counterparts (Schachter, 1971). Further, when access to food involved an effort component (e.g., lifting a lid covering a food dish for the rats, removing shells of nuts for humans) obese organisms consumed fewer calories than lean controls (Schachter, 1971). Though these observations were not quantified using behavioral economic analysis, they are in line with general predictions of the model.

Behavioral economic aspects of consumption patterns related to food also were observed more recently with obese and lean Zucker rats (Rasmussen et al, 2010; Rasmussen et al, 2012). Under lower-effort fixed ratio (FR) schedules, obese Zucker rats earned more food reinforcers than lean rats, but under high-effort FRs, consumption between the two groups was no different. Obese Zuckers demonstrated significantly higher levels of consumption (*L* and *Q0* values) with the linear and exponential models, respectively, but did not differ in elasticity values for food.

Other studies show that when accessibility to food, such as chocolates, is challenged by containers or distance, people are less likely to eat them (Painter, Wansink, & Hieggelke (2002). Animal studies, such as Salamone and Correa (2009) also show similar findings in a laboratory context. Using a T-maze paradigm, rats demonstrated preference for a larger food reinforcer vs. a smaller food reinforcer in effort-free conditions. However, addition of a physical barrier to access the larger food reward led to a decrease in preference for the larger reward.

Present Study

The vast majority of effort-based and behavioral economic research applied to obesity has been conducted with animals, and the few used with humans have been conducted in more naturalistic, ecologically valid conditions. Therefore, the purpose of the present study was to compare demand for food between obese and healthy-weight humans under several types of tasks using money and effort as price in a laboratory setting. Obese and healthy-weight participants completed several tasks, including questionnaires in which they were asked how many portions of hypothetical food they would buy, or work for, when the food was available at different monetary and effort-based prices, respectively. In addition, participants were presented with actual choices between a larger quantity of food that varied in terms of effort (climbing stairs) versus a small amount available with little effort. It was hypothesized that as price increased, consumption would decrease across all tasks. In addition, we hypothesized that obese and healthy-weight participants would show differences in sensitivity to price increases.

Method

Participants

Two-hundred twenty-seven male and female undergraduate students from Idaho State University were recruited to participate in the study. In order to be eligible for participation, individuals were 18 years of age and consented to participate. Individuals who were pregnant or thought they may be pregnant were excluded from the study. Participants were recruited using a web-based sign-up system, SONA, and recruited from the Psychology Department's subject pool. All participants were eligible to earn bonus course credit.

Participants were asked to abstain from eating the following foods for 24 hours prior to their designated session: Goldfish® Crackers, Lay's® Potato Chips, Cool Ranch Doritos®, M&Ms®, and Skittles®. Participants were also asked to abstain from all foods and liquids, aside from water, for 3 hours prior to their session.

Materials*:*

Demographics and Lifestyle Questionnaire: The Demographics and Lifestyle Questionnaire queried participants on basic demographic information (e.g., age, height, education level, ethnicity) and health-oriented lifestyle questions (e.g., use of tobacco products, average servings of food groups consumed, duration of exercise) (see Appendix A).

Subjective Hunger Questionnaire: The Subjective Hunger Questionnaire asked participants to self-report time of consumption of last meal, time of last consumption of snack or caloric beverages , and their current subjective hunger rating at the time of the experimental session from 1 to 100, with 1 = not hungry and 100 = very hungry (see Appendix B).

Eating Disorder Examination Questionnaire (EDE-Q): The EDE-Q is a self-report version of a comprehensive diagnostic interview assessing for problematic eating behaviors as well as ratings on four dimensions: Restraint, Eating Concern, Shape Concern, and Weight Concern. The primary use of the EDE-Q within this study was to assess the possibility of Binge Eating Disorder, as individuals who engage in frequent binges have been demonstrated to value food highly and therefore may skew the overall findings (Wilfley, Schwartz, Spurrell, & Fairburn, 1997) (see Appendix C).

Food Preference Taste Test: The Food Preference Taste Test (FPTT) form required participants to rate five palatable food items on different taste dimensions, as well as rank food items from favored to least favored (see Appendix D.

Food Purchasing Tasks: (Epstein, Roba, & Dearing, 2010) Participants were instructed to endorse the number of servings they would purchase of a preferred food item (as determined by item of greatest caloric consumption in FPTT) at varying prices. One version used in the present study (Low Magnitude) was the original form created by Epstein, Roba, and Dearing (2010) and presented prices ranging from $0.01 to $1120. A second version developed by our laboratory (High Magnitude) presented prices ranging from $0.03 to $3360 (see Appendices E & F). Participants were presented with a 10 kcal portion, described as one standard bite, of the preferred food item for the Low Magnitude task. In the High Magnitude task (modified version for the present study), a 30 kcal portion, described as 3 standard bites, was presented. The prices were also multiplied by three, such that unit price (unit of money/bite) remained the same. Participants specifically were asked “How many bites of ______ (preferred food item) would you consume if they were ____each at the following price?” (see Appendices E & F).

Food Climb Tasks: The Food Climb Task was created to assess self-reported purchased servings of palatable foods available at varying effort-based costs (stair climbing). It is identical to the Food Purchasing Task except instead of monetary price, it asked participants to identify how many portions of food s/he would purchase if the price was climbing stairs. One version (Low magnitude) presented prices ranging from 1 to 100 stairs; a second version presented prices ranging from 3 to 300 stairs (see Appendices G & H). Participants were presented with a 10 kcal portion of preferred food (1 standard bite) for the Low Magnitude task and a 30 kcal portion of preferred food (3 standard bites) in the High Magnitude task. Participants were then asked “How many bites of ____ (preferred food item) would you consume if you had to climb ____ stairs for each bite?”

Feedback Questionnaires (Session 1 and 2): Feedback Questionnaires requested that participants rate their level of discomfort with procedures used in each session and queried if participants would engage in similar procedures in the future (see Appendices I & J)

Procedures:

Session 1. Demographics, Biometrics, and Food Preference Taste Test

In Session 1 participants completed informed consent, self-report measures, and biometric data were collected. In addition, participants also completed a Food Preference Taste Test in which a preferred food was identified for an effort-based demand task to be used for Session 2.

Each participant was individually scheduled to attend an experimental session. Prior to consent, participants were asked to recall when they last consumed any beverages or food items. Participants who consumed food or beverage in the past three hours prior to the session were directed to reschedule their appointment and were instructed to not consume any beverages or food three hours prior to participation. Participants who qualified for participation began the session with the process of Informed Consent (see Appendix K). The research assistant reviewed the information and consent form with the participant, and s/he read and signed the form.

Following informed consent, participants were asked to remove their shoes and socks. Body mass was weighed (in kg) and height was measured (in m) to calculate body mass index: BMI = body mass (kg)/height $(m)^2$. A Tanita 2204 Body Fat Scale was used to measure percent body fat (PBF) and weight. The scale measured PBF using bioelectrical impedance. Waist circumference was measured in cm. Following this, blood glucose levels were assessed to ensure participants had not eaten recently. Blood glucose level was obtained using an Accucheck glucometer, in which a small sample of blood was drawn from the finger. Participants who had normal BMI were asked to reschedule if their blood glucose values were above 100 mg/dl, which suggested recent eating; obese individuals who had values above 110 mg/dl were asked to reschedule for the same reason.

After measurement of blood glucose levels, participants were provided a snack bar of 90-100 calories to consume and instructed to eat the snack bar during a 10-min window of time. The purpose of the snack bar was to serve as a pre-load, which equates deprivation levels among participants prior to engaging in the Food Preference Taste Test and stimulates appetite (Allison & Baskin, 2009). Participants then completed the Demographics and Lifestyle Questionnaire, Subjective Hunger Questionnaire, and the EDE-Q (see Appendices A, B, and C).

Upon completion of the questionnaire packet, participants were given a clipboard with a questionnaire and read the following script:

> "We are conducting a taste test to see which snack food is the most preferred, or favored, among Idaho State University students. You may eat as much of any of the foods on the table, but please be sure to take at least one bite of each food. We will have you rate these foods on some different dimensions, such as sweetness and bitterness, and also ask you to rate how much you liked each food."

Participants were presented a plate with an array of 10-calorie samples of five foods that are similar in fat and carbohydrate concentration: Cheddar Cheese Goldfish® (5 grams fat; 20 grams carbohydrate), M&Ms® (10 grams fat; 34

grams carbohydrate), Skittles® (2.5 grams fat; 56 grams carbohydrate), Cool Ranch Doritos® (8 grams fat; 18 grams carbohydrate), and Lay's Potato Chips® (10 grams fat; 15 grams carbohydrate). Participants sampled each food item from the plate and were allowed to take additional samples from bowls on a nearby table if they chose.

Once each food item had been sampled and the Food Preference Taste Test questionnaire (see Appendix D) had been completed, participants filled out a brief feedback questionnaire regarding discomfort of being weighed and measured (see Appendix F). Participants then were informed of their selection for participation in the follow-up session (Phase 2). Participants received a handout for a reminder of their follow-up session, such as time and place, and information regarding abstinence of consumption of the foods from the Food Preference Taste Test for the 24-hour time period prior to their follow-up participation, and complete abstinence of food for 3 hours prior to the experiment. Participants were also asked to wear comfortable clothing that facilitates movement (such as tennis shoes) to their next session.

Once the participant left the laboratory, the amount of food remaining from each participant's Food Preference Taste Test (approximately 22 grams/100 kcals of each food item was initially presented) was weighed and subtracted against pre-session measurements. This amount was then converted to calories consumed. These data were used to analyze 1) differences between healthy weight and obese individuals' consumption amounts, and 2) to identify the preferred food for Phase 2. The preferred food item was identified as the highest (measured by kcals) consumed food item during the Taste Test.

Session 2: Demand tasks. Participants began the second session in the laboratory, where reports on food consumed within the past 24 hours and subjective hunger ratings were obtained. Participants were asked to reschedule their session if s/he consumed a target food or had consumed food and beverage during the restricted time frame. The average time between participation in session 1 and session 2 was 9.82 days (SEM=3.08).

Next, participants completed the two Food Purchasing Tasks and two Food Climb Tasks (low and high magnitude of each), which assessed demand for food at varying monetary and effort-based costs, respectively.

Demand questionnaires (Food Purchasing Tasks and Food Climb Tasks). Participants were presented with a 10 kcal portion of the preferred food item identified from Session 1, which represented one standard bite of food, though they were instructed not to eat it. They used this as a reference for completing all four questionnaires.

Effort task. Following completion of the demand questionnaires, participants were escorted to the first floor of Garrison Hall in the eastern stairwell, where the effort task took place.

The following script was read to the participants prior to beginning the experimental task:

“In this portion of the study we are interested in student choices for snack items. In the bowl next to you is 1 bite of the preferred snack item determined by the taste test from your last visit. However, in the other bowl also next to you is 3 bites of that same preferred snack item. You have the option to eat the contents of either bowl, but you cannot choose both."

Participants were then given a choice between 1 bite (10 kcals) of the preferred food option (determined from Phase 1) vs. 3 bites (30 kcals) of the same food option. Participants were instructed to consume their choice and proceed to the next choice. Subsequent choices were given between the two amounts, but climbing a subsequently larger number of stair flights was required to access the larger food option. The number of flights required to climb began with one flight (8 steps), and increased at each trial by one flight until the choice for the smaller, less effortful choice was made. After ascending each flight, the participant would descend the stairs to the initial floor level to make the next choice. The increase in one flight of stairs with each trial is similar to a progressive ratio schedule, in which the effort requirement is systematically increased within a single session (Hodos & Kalman, 1963; Stafford, LeSage, and Glowa, 1998). The maximum number of flights to ascend was 14.

Participants were given a bell and colored chip at the beginning of the task. Participants were instructed to ring the bell when they ceased climbing stairs and place the colored chip on the stair in which they stopped. A research assistant timed the participant. The bell signaled the end of the trial. The latency from when the choice was presented until the trial ended by participants ringing the bell to signal trial completion was measured. From this, response rate (total stairs per second) was calculated.

The effort task ceased under one of the following four situations: 1) If the participant climbed all fourteen flights of stairs; 2) when the participant chose the smaller food object available at no effort (preference reversal); 3) when the participant decided to stop the task; or 4) if the experimenter noticed visible signs of extreme physical exertion such as difficulties with walking or breathing. Participants received a water bottle at the beginning of the experimental session in order to have access to water *ad libitum* during all phases of each experiment.

Debriefing. Following completion of the experiment, participants completed a final Feedback questionnaire (Appendix K) assessing their experience within the laboratory. This feedback questionnaire was used to assess self-reported perceptions of the task difficulty, the extent to which the food item was deemed rewarding, and to identify any unanticipated discomforts experienced during the task. In order to avoid contamination of the data, participants were informed of the nature of the tasks upon request after data collection for both experiments were completed. Participants were asked at the end of their session if they would like to receive information on the purpose and findings of the study in the future and asked to provide the PI with their email for this information to be sent.

Statistical Analyses. The outcome variables for the Effort Task were the number of flights of stairs, the number of stairs traversed, and response rate.

The three predictor measures of obesity used in the analyses were: BMI, PBF, and waist circumference. For BMI, obese participants (BMI > 30) were compared to non-obese participants (BMI 18.5-24.9). For PBF, high vs. low PBF (highest vs lowest third of distribution) were compared for males and females separately; However, when significant was not observed on outcome variables, high vs. low PBF (highest vs lowest third of distribution) was computed for the total sample. Finally, the upper vs lowest thirds of waist circumference were also compared. For the stair-climbing task, independent samples t-tests were conducted on the relationship between predictors and outcome variables.

To assess demand from the two Food Purchasing Tasks and two Food Climb tasks, values for portions were plotted against unit price for each participant for each task (four plots per participant). Consistent with previous literature, participants who had fits of 0.30 were included in the linear demand analyses (MacKillop, Monti, Murphy, Miranda, Ray, McGeary, & Swift, 2010; Smith, Martens, Murphy, Buscemi, Yurasek, & Skidmore, 2010). The linear elasticity (Equation 1) and exponential elasticity (Equation 2) models were fit to each participant's values obtained from four tasks. The free parameters (*L*, *a*, *b* for Equation 1, and *Q0* and *α* for Equation 2) were determined for each individual and compared across three measures of obesity using independent-samples t-tests. Independent t-tests were also conducted on data from the Effort (stair task) on: the number of stairs traversed, number of stair flights traversed, and response rate (stairs climbed divided by time).

Finally Pearson *r* correlations were conducted on the relations among each task (amount consumed on the Food Preference Taste Test; number of total stairs traversed during the experimental task; the *L* and *Q0* values of the linear and exponential tasks (both measure consumption at a low price), and P_{max} and *α*-values (measures of elasticity) of the Food Purchasing Task. The same values for the Food Climb Task were also analyzed for correlations. It was hypothesized that statistically significant positive correlations would exist among level of consumption measures, measures of elasticity, and measures of effort with the Food Climb Task and the Effort Task.

Results

Demographics of the Sample

Demographics of the 227 participants (95 males and 132 females) can be found in Table 1. Race of the sample was predominantly European-American/White (78.6%). The remaining distribution of ethnicity in the sample endorsed as: 9.6% Hispanic/Latino(a), 4.4% Asian, 4.4% “Other” category, 1.3% African American, and 0.4% American Indian. All 227 individuals met the criteria for inclusion in the study and analysis of the baseline data collected in session one.

The mean BMI for the sample was 26.4 (SEM= 6.4). Table 1 shows that about 49.8% (n = 114) of participants were of normal BMI, 24.9% (n =57) were overweight, and 24% (n = 55) were obese. One participant (0.4%) was underweight. Analyses conducted on differences among BMI status on demographic variables revealed significant differences on age only, in which the obese category had significantly older participants than healthy weight participants $t(90.31)=-3.632)$, $p<.001$. This pattern was also observed with PBF; that is, participants in the upper third of waist circumference were significantly older (M=26.43, SE=1.710) than those in the lower third (M=21.77, SE= 0.473), $t(25.469)=-2.628$, $p<.01$. Additionally, obese participants had significantly higher

PBF and waist circumference than those with a healthy BMI. No significant differences were observed between obese and healthy weight individuals on glucose level, hours since last caloric consumption, or subjective hunger ratings. Further, measures of glucose, self-reported hours since last caloric consumption, and self-reported subjective hunger ratings were unrelated to one another.

Table 1. Means (SEM) for Demographic Variables Across BMI.

	Healthy BMI (<25)		Overweight BMI (25-29.9)		Obese BMI (30+)		
	n	M(SEM)	N	M(SEM)	n	M(SEM)	p-value
PBF	102	23.14(0.65)	48	28.29(1.25)	46	37.14(1.24)	0.03*
WC (in)	102	79.19(0.73)	48	91.88(1.16)	49	112.07(1.75)	<0.01*
Gluc. (mg/dL)	99	86.63(1.11)	46	88.26(1.64)	49	91.10(1.83)	NS
Sub. Hunger (0-100)	102	60.42(2.25)	48	59.54(3.02)	49	53.71(3.32)	NS
Hrs Last Meal	102	11.63(0.55)	48	9.55(0.81)	49	10.84(0.78)	NS
Hrs Last Snack	102	9.15(0.51)	48	7.12(0.69)	49	7.32(0.63)	NS
Age	102	22.47(0.67)	45	24.21	49	26.43 (1.12)	<0.01
Female		79		30	27	--	NS
Smoke		4			5	--	NS

Note, PBF= percent body fat, WC= waist circumference, BMI = body mass index.

Body Weight Status Correlates

Pearson *r* correlations were conducted to assess the relations among the predictor variables of BMI, PBF, and waist circumference (see Table 2). All predictor variables of weight status significantly correlated with one another. BMI and PBF had the highest correlation with over 81% of the variance accounted for.

Table 2.Correlation Matrix of Predictor Variables

	BMI	**PBF**	**Wt C (cm)**
BMI	1	0.903**	0.692**
PBF	0.903**	1	0.649**
Wt C (cm)	0.692**	0.649**	1

**Correlation is significant at the 0.01 level (two-tailed).

Food Preference Taste Test

Table 3 shows caloric consumption and total calories consumed in the Food Preference Taste Test. No relations were found between total calories consumed and BMI (p=0.982), lower and upper waist circumference (p=0.914), and lower and upper PBF (p=0.686). Additionally, no differences were observed between specific food items and predictors of weight status. A One-Way Analysis of Variance was conducted between PBF, gender, and total calories consumed; No effect was observed for gender across PBF, $F(16,116) = 1.643$, $p = 0.13$. However, when analyses were conducted for men and women separately, males in the lower third (6.4% to 20.5%) of PBF (M=77.74, SD=7.54) consumed more calories than those in the upper third (34.6%- 48.7%) of PBF (M=52.37, SD=3.28), $t(105)=2.859$, p=.005. There were no differences in women (p=.967)

Table 3. Means (SEM) of Calories Consumed across BMI.

	Total	BMI >25	BMI (30+)	*p-value*
Goldfish	9.82 (0.82)	11.21(1.49)	7.98(1.05)	NS
Doritos	19.58 (1.39)	19.67(2.04)	20.78(3.33)	NS
Lay's Potato Chips	13.48 (0.70)	13.56 (0.90)	13.62(1.60)	NS
M&Ms	11.69 (0.73)	12.33 (1.23)	12.47(1.38)	NS
Skittles	12.44 (0.79)	13.18(1.28)	13.14(1.75)	NS
Total Calories	**66.26 (3.24)**	**69.56(5.38)**	**65.24(6.03)**	**NS**

Table 4 demonstrates the percent of participants that preferred the various food types. Cool Ranch Doritos were the most preferred food item, $\chi^2(4)=2.522$, $p=0.043$ and Goldfish were the least preferred food item, χ^2 $(4)=7.742$, $p<0.01$ by the sample of participants. No statistical differences between weight status and preference of food items were found.

Table 4. Preference Ratings for Food Items

Food Item	Preferred Food (%)	Least Preferred Food (%)
Goldfish	4.4%	49.8%
Cool Ranch Doritos	35.8%	5.2%
Lays Potato Chips	27.1%	7.4%
M&Ms	7.4%	9.6%
Skittles	24.5%	27.1%

One finding worthy of mention is that 52% of participants (n = 120) consumed the caloric amount presented on the sample plate or less, and did not make additional contact with food located in the adjacent bowls. There were no differences in obese vs. healthy weight individuals in terms of sampling additional food, $p=0.670$. In addition, no significant differences were found between lower versus higher PBF for women, $p=0.248$, or between lower versus higher PBF for males, $p=0.063$. Waist circumference did not predict additional consumption either, $p=0.172$.

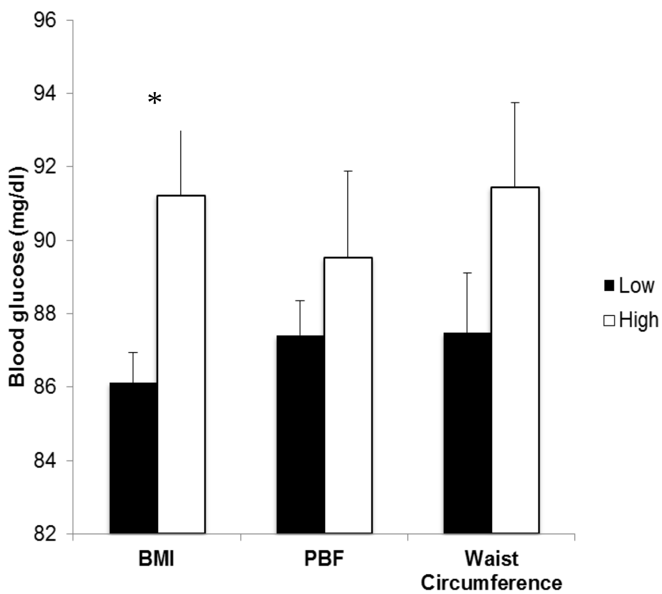
Demand Tasks

Of the 227 total participants, 199 successfully completed the demand tasks in the second session (87.7% of the overall sample), and were included in the analyses.

Effort (stair) task. On average, healthy weight individuals climbed 73.41 (SEM = 14.62) stairs; obese individuals climbed only 53.55 (SEM = 9.55). Obese individuals climbed the stairs at a rate of 0.129 (SEM = 0.01) stairs per sec; healthy weight individuals' rates were 1.74 (SEM = 1.54) stairs per sec. Neither of these were statistically different, however, as independent samples t-tests for low vs. high BMI, PBF, or waist circumference showed no differences (all p's > 0.20). When males and females were analyzed separately for all measures of obesity status, no differences were found.

However, when the second glucose test was given (at the beginning of Session 2) a significant relation was observed for BMI and glucose level, in which obese participants had significantly higher glucose levels than those of normal BMI, $t(64.52)=-2.82$, $p=0.005$ (see Figure 1). No statistically significant relations, however, were observed between PBF and waist circumference and glucose.

Figure 1. Session two glucose level as a function of weight predictors (BMI, Waist Circumference, PBF). High BMI participants had significantly higher glucose levels than low-BMI participants.



Low-Magnitude Food Purchasing Task. Of the 199 participants, 197 (98.9%) were included in the linear demand analyses; One hundred ninety-two participants (96.5%) were included in the exponential demand analyses.

Figure 2 shows demand curves for self-reported food portions as a function of price in dollars. A two-way repeated measures analysis showed that as price increased, self-reported food portions decreased significantly, $F(17) = 18.909$, $p < 0.01$, $\eta^2=0.124$. No main effect was found for BMI, $p=0.29$, or interaction, $p=0.51$. There was no main effect for waist circumference, $p=0.75$, or interaction $p = 0.10$.

Figure 2. Mean number of self-reported food portions purchased (top) and responses (bottom) as a function of price (low magnitude) of the Food Purchasing Task. Low waist circumference = diamonds; high waist circumference = squares. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (low waist = solid and high waist = dotted).

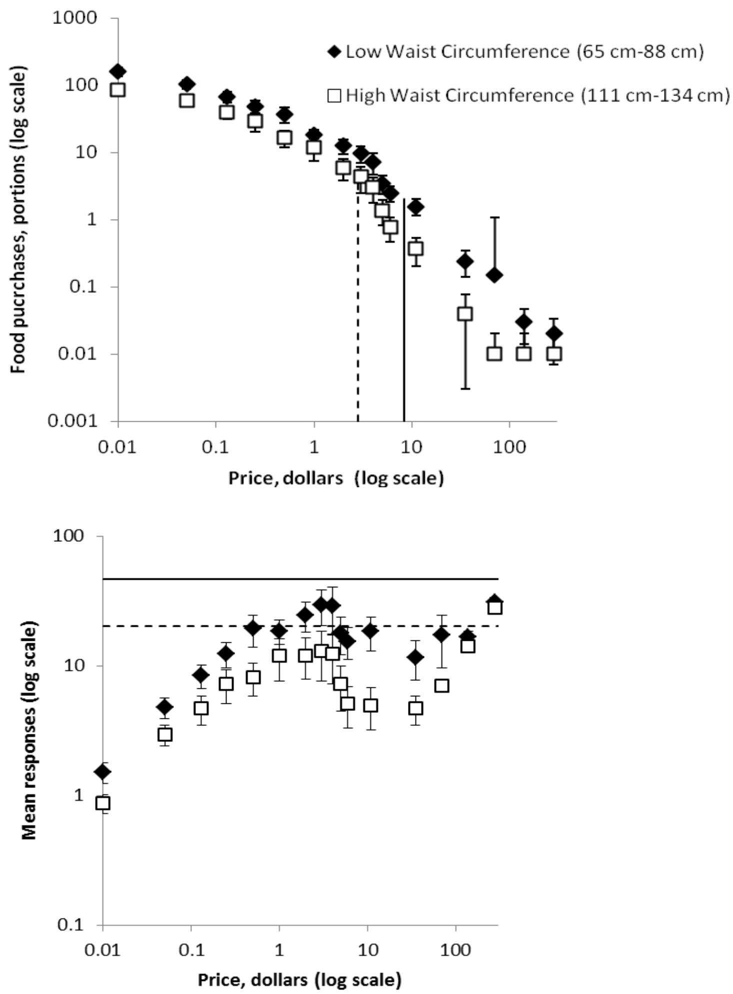


Table 5 shows free parameter values for the linear demand analysis. Those with a lower waist circumference had higher *L*-parameter values than those with higher waist circumference, $t(133.49)=2.468$, $p=0.02$. No significant differences were found for linear elastic demand parameters P_{max}, O_{max}, *a*, and *b*. The exponential analysis showed significant differences were found with the α and *Q0* values (see lower half of Table 5 for statistics). Individuals with high waist circumference demonstrated lower values than those with lower waist circumference for both variables. This pattern held for linear elastic demand and exponential demand when BMI was analyzed, but differences were not observed when PBF was analyzed (see Appendices L through P for figures and tables with corresponding linear and exponential values).

Table 5. Mean (SEM) of free parameter values for linear elastic (top) and exponential demand (bottom) for lower waist circumference vs upper waist circumference on the low-magnitude Food Purchasing Task.

	Lower Waist (65 to 88 cm)	Higher Waist (111 to 134 cm)	*t*(df)	p-value
Linear				
L	159.14(25.77)	86.44(14.26)	2.468(133.50)	0.05*
a	0.02(0.00)	0.03(0.00)	0.688(135)	NS
b	0.80(0.02)	0.82(0.024)	0.499(135)	NS
P_{max}	8.25(3.15)	2.80(1.28)	0.852(135)	NS
r^2	0.79(0.01)	0.78(0.02)	0.238(135)	NS
O_{max}	24.35(6.44)	20.10(6.33)	1.150(135)	NS
Exponential				
Q0	112.76(13.63)	77.00(13.88)	1.981(83.55)	0.05*
α	0.04(0.01)	0.03(0.01)	0.908 (87.69)	0.04*
k	4	4	---	---
r^2	0.87(0.02)	0.90(0.02)	-0.928(132)	NS

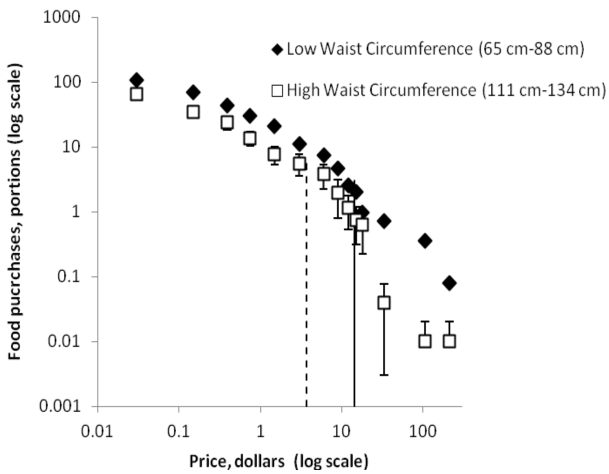
The lower panel of Figure 2 shows responses (self-reported bites of food) as a function of price. A repeated measures analysis showed a main effect for price on responses, in which responses decreased as a function of increasing price and then decreased after a maximum value (O_{max}), $F(17) = 2.913$, $p < 0.01$, $\eta^2 = 0.21$. However, there were no significant differences between lower and upper waist circumferences, $p = 0.235$, or an interaction. This pattern also held for BMI classification and PBF; no main effects of BMI or PBF were observed and no interactions between these weight predictors and reported responses were found.

Because of differences in aspects of weight in males and females (e.g., percent body fat), separate analyses for male and female participants were conducted for each of the obesity status measures. No gender-related differences were found for either the linear or exponential demand analyses.

High-Magnitude Food Purchasing Task. Of the 199 participants, 191 (95.9%) participants demonstrated fits above 0.3 and were included in the linear elastic demand analyses; 188 (94.4%) were included in the exponential demand analyses.

Figure 3 shows demand curves for low- and high-waist circumference individuals for the high-value demand task. A two-way repeated measures analysis showed that as price increased, self-reported purchasing for food decreased, $F(17) = 11.262$, $p < 0.01$, $\eta^2 = 0.078$. There were no main effects of waist circumference and no interaction (p's above 0.18). Similarly, no main effects or interactions were found when PBF and BMI were analyzed.

Figure 3. Mean number of food portions purchased (top) and responses (bottom) on high-magnitude prices of the Food Purchasing Task. Low and High waist circumference are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low waist circumference by solid and High waist circumference by dotted).



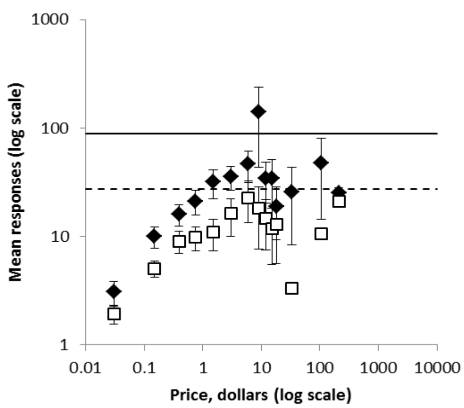


Table 6 displays parameter estimates for linear elastic and exponential demand analyses for lower and upper waist circumference. No significant relations were found on free parameter estimates on the high-value Food Purchasing Task. This pattern held for BMI and PBF for both linear elastic demand and exponential demand analyses (see Appendices Q through U for figures and tables with corresponding linear and exponential values).

Table 6. Mean (SEM) of free parameter values for linear elastic (top) and exponential demand (bottom) for lower waist circumference vs upper waist circumference on the high-magnitude Food Purchasing Task.

	Lower Waist (65 to 88 cm)	Higher Waist (111 to 134 cm)	*t*(df)	p-value
Linear				
L	105.83 (22.63)	63.56 (11.88)	0.915(135)	NS
a	0.01 (0.00)	0.03 (0.00)	.563(135)	NS
b	0.41 (0.02)	0.39 (0.03)	.232(135)	NS
P_{max}	14.18 (4.84)	3.68 (0.95)	1.07(135)	NS
O_{max}	88.00 (31.04)	27.25 (10.51)	.964(135)	NS
r^2	0.70(0.018)	0.64(0.05)	1.397(135)	NS
Exponential				
Q0	77.86 (9.03)	76.65 (89.80)	0.06(129)	NS
α	0.03 (0.00)	0.03 (0.05)	0.31(129)	NS
k	2.1	2.1	---	---
r^2	0.88(0.02)	0.87(0.04)	0.107(129)	NS

The lower panel of Figure 3 shows responses as a function of monetary price. A two-way repeated measures analysis showed a main effect of price, $F(17)=6.174$, $p = 0.03$, $\eta^2=0.297$, in which response output decreased as price increased. However, no significant effects of waist circumference or an interaction were observed. Moreover, when PBF and BMI were analyzed, no main effects of weight status or interactions were observed.

Analyses were conducted that compared data from the Low vs. High Food

Purchasing Tasks. Using data from all participants, Figure 4 compared demand curves generated from the low and high Food Purchasing Tasks. Analysis of free parameters values from the linear and exponential analysis revealed significant differences between the measures for free parameters *L* and *Q0*; however, no differences were revealed between P_{max}, O_{max}, α, b and a-parameters (see Table 7).

Figure 4. The number of food portions purchased (top) and responses (bottom) on the Low (diamonds) and High (squares) magnitude Food Purchasing Tasks. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low by solid and High by dotted).

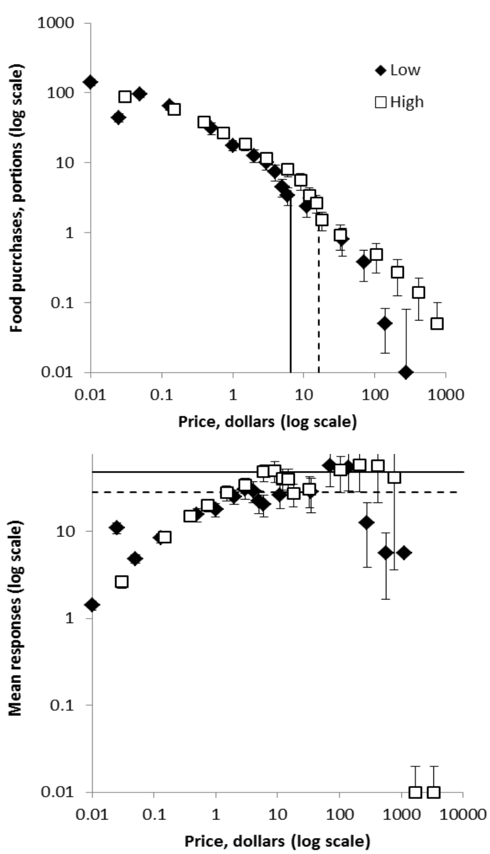


Table 7. Free parameters of linear and exponential demand for the low- and high-magnitude Food Purchasing Tasks.

	Low-Value Mean(SEM)	High-Value Mean(SEM)	*t*(df)	*p*-value
Linear				
L	140.99(16.04)	87.36(13.09)	3.073(198)	<0.01*
a	0.04(0.01)	0.03(0.01)	0.746(198)	NS
b	0.86(0.09)	0.77(0.08)	0.945(198)	NS
P_{max}	5.77(1.70)	14.91(4.97)	-1.896(198)	NS
O_{max}	62.77(15.40)	123.59(43.3)	-1.587(198)	NS
r^2	0.78(0.01)	0.69(0.01)	8.974(198)	0.01*
Exponential				
Q0	112.23(10.85)	67.48(5.91)	4.877(198)	<0.01*
α	0.03(0.01)	0.03(0.00)	0.768(198)	NS
k	4	2.1	---	---
r^2	0.86(0.01)	0.86(0.02)	-0.138(198)	NS

Comparisons of fits for the low-magnitude and high-magnitude versions were assessed for both linear and exponential demand models; significant differences were found between the low-magnitude version and high-magnitude version in which the model fit the low-magnitude version better than the high-magnitude version. There were no differences in fit for the exponential model. Moreover, when low magnitude values were regressed against high magnitude values, there was a significant relation between the two, $F(1,198)=14.436$, $p<0.01$, $y = 10.51 + 0.763(x)$, $R^2 = 0.068$.

The lower panel of Figure 4 depicts self-reported responses as a function of increasing price between the low-magnitude and high-magnitude Food Purchasing Tasks. A significant relationship was found between low magnitude and high magnitude values, $F(1,198)=61.334$, $p<0.01$, $37.645 + 1.369x$, $R^2 = 0.237$.

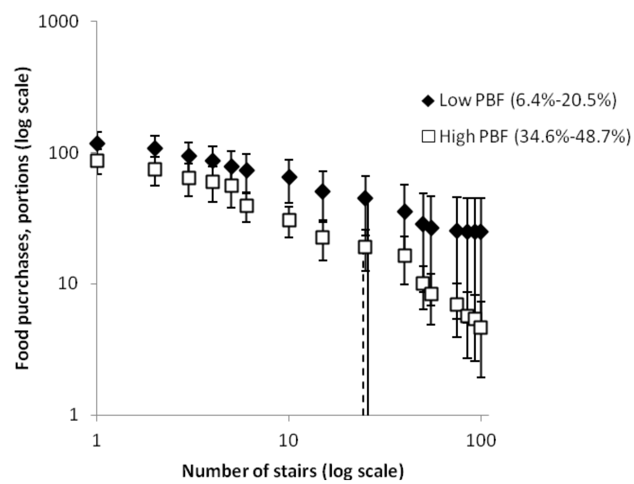
Low-Effort Food Climb Task. For the low-effort Food Climb Task 186 participants (93.47%) were included in analyses. Additionally, 178 participants (89.4%) were used for the exponential equation and were included in analyses.

The top of Figure 5 shows self-reported food portions as a function of price (stairs to climb) with individuals with high and low PBF. A two-way repeated measures ANOVA showed that as number of stairs increased, self-reported food purchases decreased, $F(15)=26.303$, $p < 0.01$, $\eta^2=0.23$. No main effects of PBF or interactions were observed. This pattern held when waist circumference and BMI were analyzed.

Behavioral economic analyses for the linear elastic demand and exponential demand models found no differences between high and low PBF, (see Table 8), BMI, or waist circumference (see Appendices V and Y, respectively). Analyses on gender differences also revealed no significant differences.

The lower panel of Figure 5 shows responses as a function of increasing stairs. A two-way repeated measures analysis revealed a main effect of price, $F(15)=4.249$, $p=0.024$, $\eta^2=0.03$. No main effects of PBF or an interaction were found. Further, this pattern was observed when waist circumference and BMI were analyzed (See Appendices X through AA for figures and tables of linear elastic demand and exponential demand parameters).

Figure 5. The number of food portions purchased (top) and responses (bottom) on low-effort stair prices of the Food Climb Task. Low PBF (6.4%-20.5%) and High PBF (34.6%-48.7%) participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF = solid; High PBF = dotted).



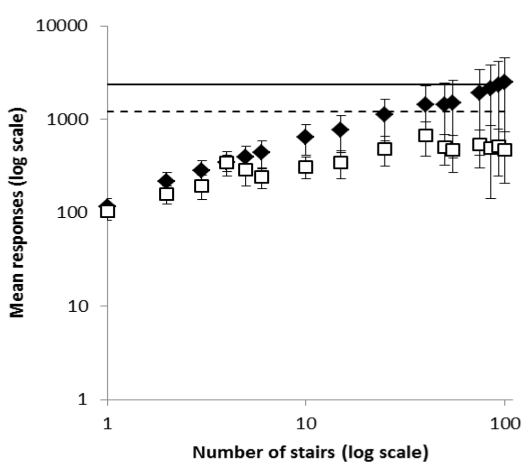


Table 8. Mean (SEM) of free parameter values for linear elastic (top) and exponential demand (bottom) for lower PBF vs upper PBF on the low-effort Food Climb Task.

Linear	Lower PBF (6.4% to 21.0%)	Upper PBF (37.6% to 53.4%)	*t*(df)	p-value
L	82.29(21.00)	63.85(12.26)	0.648(87)	NS
a	0.01(0.00)	0.56(0.55)	1.278(87)	NS
b	0.71(0.08)	0.81(0.10)	0.818(87)	NS
P_{max}	12.76(7.79)	27.79(22.40)	-0.746(87)	NS
O_{max}	135.81(68.87)	268.86(223.03)	-0.680(87)	NS
r^2	0.84 (0.03)	0.86 (0.04)	-0.421(87)	NS
Exponential				
Q0	149.98(29.81)	115.82(20.90)	0.826(87)	NS
α	1.00×10^{-3}(0.00)	1.00×10^{-3} (0.00)	0.057(87)	NS
k	3.2	3.2	---	---
r^2	0.82(0.03)	0.84(0.05)	-0.353(87)	NS

High-Effort Food Climb Task. Of the 199 participants,190 participants (95.47%) were used in the linear model. One-hundred eighty-three (91.95%) participants were used in the exponential demand analysis,

Figure 6 shows demand curves for self-reported food portions as a function of stairs to climb for those with low and high PBF. As stairs increased, food purchases decreased significantly, $F(15)=13.449$, $p < 0.01$, $\eta^2=0.134$. There was no main effect of PBF($p=0.373$) or an interaction ($p = 0.95$). When the linear and exponential demand equations were fit to the data, there were no significant differences in any of the free parameters (see Table 9). Similar patterns were observed when BMI and waist circumference were used as predictors (see Appendices Z and BB for figures and Appendices AA and CC for tables, respectively). When separate analyses for males and females were conducted, no differences were observed.

Figure 6. The number of food portions purchased (top) and responses (bottom) on high-effort stair prices of the Food Climb Task for low PBF (diamonds) and High PBF (squares), respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF by solid and High PBF by dotted).

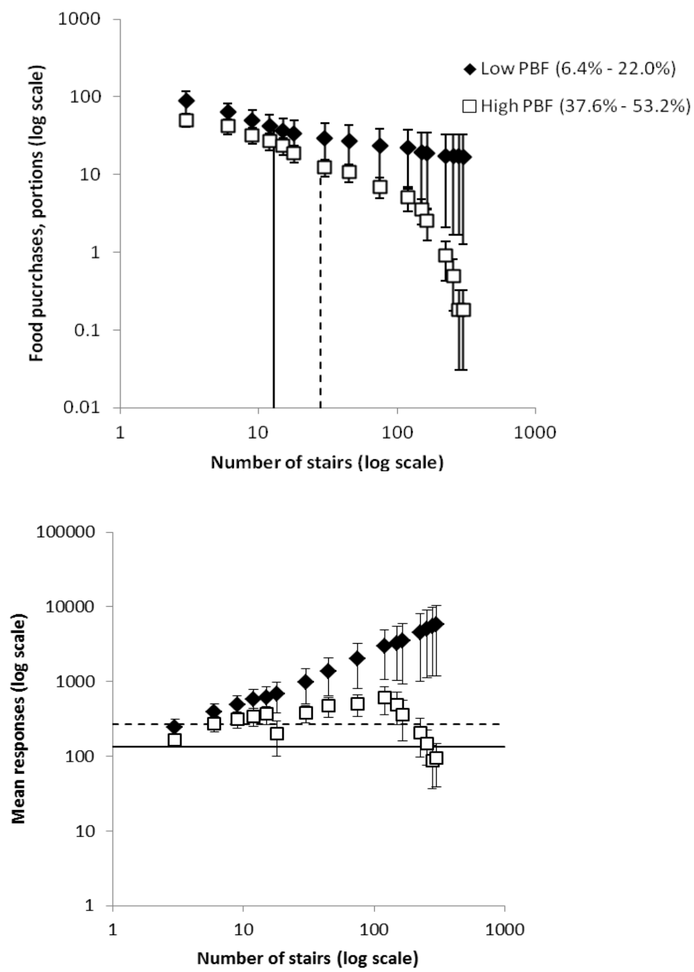


Table 9. Mean (SEM) of free parameters for linear elastic (top) and exponential demand (bottom) for lower PBF vs upper PBF on the high-effort Food Climb Task.

	Lower PBF (6.4% to 21.0%)	Upper PBF (37.6% to 53.4%)	*t*(df)	p-value
Linear				
L	82.29(21.00)	63.85(12.26)	0.648(87)	NS
a	0.01(0.00)	0.01(0.00)	-1.339(87)	NS
b	0.83(0.07)	0.76(0.09)	-0.611(87)	NS
P_{max}	12.76(7.79)	27.79(22.40)	-0.746(87)	NS
O_{max}	135.81(68.87)	268.86(223.03)	-0.680(87)	NS
r^2	0.82(0.03)	0.83(0.03)	-0.400(87)	NS
Exponential				
Q0	103.46(35.72)	56.12(9.01)	1.022(85)	NS
α	1.00×10^{-3} (0.00)	1.00×10^{-3} (0.00)	-0.163(85)	NS
k	2.2	2.2	---	---
r^2	0.87(0.02)	0.85(0.04)	0.326(85)	NS

The lower panel of Figure 6 depicts response output as a function of price. A main effect was observed, $F(15)=3.411$, $p<0.01$, $\eta^2=0.025$, in which responses initially increased and then decreased with price. There was no main effect of PBF, $p = 0.40$, or interaction between PBF and response output, $p=0.77$. Similarly, when BMI and waist circumference were analyzed, no main effects or interactions were observed.

Demand curves for the low- and high-effort Stair Climb tasks were compared.

The left panel of Figure 7 shows bites of food purchased as a function of increasing stairs, whereas the right panel of Figure 7 shows response output as a function of increasing stairs. Using data from all participants, free parameters values from the linear and exponential analysis revealed significant differences between free parameter values of P_{max}, O_{max}, *L,* and *Q0*; however, no differences were revealed between *α*, *b* and *a* parameter values (see Table 10). Moreover, when low magnitude values were regressed against high magnitude values, there was a significant relation between the two, $F(1,198)=171.581$, $p<0.01$, $y = 13.924 + 0.254x$, $R^2=0.464$. Response output was also analyzed between low and high versions of the Food Climb Tasks; a significant relationship was found, $F(1,198)=1849.56$, $p<0.01$, $y = 605.7 + 0.309x$, $R^2=0.903$.

Figure 7. The number of food portions purchased (left) and responses (right) on the Food Climb Task. Low –effort Food Climb Task and high-effort Food Climb Task for all participants are represented as diamonds and squares, respectively. P_{max} (left) and O_{max} (right) values are represented by vertical and horizontal lines, respectively (Low by solid and High by dotted).

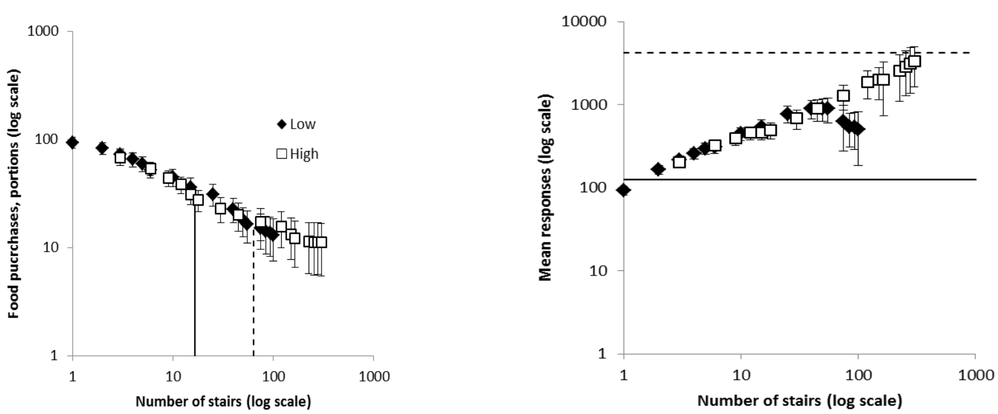


Table 10. Free parameters of linear and exponential demand for the low- and high-magnitude Food Climb Tasks.

	Low-Effort Mean(SEM)	High-Effort Mean(SEM)	*t*(df)	*p*-value
Linear				
L	92.48(10.77)	67.61(10.46)	4.276(198)	<0.01*
a	0.03(0.00)	0.02(0.00)	-0.542(198)	NS
b	0.46(0.08)	0.37(0.07)	-0.634(198)	NS
P_{max}	30.22(2.23)	62.23(5.99)	-7.140(198)	<0.01*
O_{max}	1910.97(549.30)	4221.38(1688.43)	-1.960(198)	0.05*
r^2	0.85(0.02)	0.83(0.02)	1.361(198)	NS
Exponential				
Q0	113.16(11.96)	89.48(11.95)	2.478(198)	0.01*
α	1.00×10^{-3} (0.00)	1.00×10^{-3} (0.00)	-0.205(198)	NS
k	3.2	2.2	---	---
r^2	0.79(0.02)	0.83(0.02)	-1.891(198)	NS

Relations among measures of demand. Pearson *r* correlations were conducted to test the strength of relations among all variables. The degree to which strong relations were observed tended to group into three areas: variables related to food consumption at a low cost, variables related to monetary based elasticity, and effort-based elasticity. Because so many variables were compared, these relations are presented in three tables that correspond to these areas.

Table 11 shows correlations among variables related to food consumption at a low cost. All measures correlated significantly with one another. Low and high intensity values for *Q0* were strongly correlated, as were low and high intensity values for *L*. Moreover, *Q0* and *L* parameters correlated strongly with one another across the low and high magnitudes of both the Food Purchasing and Food Climb Tasks. Finally, values on the Food Climb Task correlated well with those on the Food Purchasing Task. No significant relations were observed between total calories consumed in the FPTT and other values of intensity.

Table 11. Correlations of variables associated with consumption at low prices: kcals consumed on the FPTT and *L* and *Q0* values for all demand measures.

	FPTT (total kcals)	Low FPT *Q0*	High FPT *Q0*	Low FCT *Q0*	High FCT *Q0*	Low FPT *L*	High FPT *L*	Low FCT *L*	High FCT *L*
FPTT (total kcals)	1	0.068	0.009	0.062	-0.021	0.081	0.064	0.026	-0.019
Low FPT *Q0*	0.068	1	0.534**	0.433**	0.247**	0.739**	0.238**	0.409**	0.228**
High FPT *Q0*	0.009	0.534**	1	0.573**	0.433**	0.486**	0.361**	0.524**	0.429**
Low FCT *Q0*	0.062	0.433**	0.573**	1	0.680**	0.352**	0.294**	0.932**	0.714**
High FCT *Q0*	-0.021	0.247**	0.433**	0.680**	1	0.251**	0.130	0.812**	0.963**
Low FPT *L*	0.081	0.739**	0.486**	0.352**	0.251**	1	0.296**	0.363**	0.254**
High FPT *L*	0.064	0.238**	0.361**	0.294**	0.130	0.296**	1	0.266**	0.157*
Low FCT *L*	0.026	0.409**	0.524**	0.932**	0.812**	0.363**	0.266**	1	0.850**
High FCT *L*	-0.019	0.228**	0.429**	0.714**	0.963**	0.254**	0.157*	0.850**	1

Note, FPT = Food Purchasing Task; FCT = Food Climb Task
**Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level

Table 12 shows correlations of monetary measures of elasticity (P_{max} and *α*-values) for the low- and high-magnitude Food Purchasing Tasks. Significant relations were observed for *α*-values across both monetary demand tasks. Further, a significant relation was also observed for P_{max} values across both monetary demand tasks. No relations were observed for parameters of elasticity for the exponential and linear elastic models across the low- and high-magnitude versions of the Food Purchasing Task. No relations were found between other linear elastic demand parameters (*L, a, b)* and the total calories consumed, so these are not listed in the table.

Table 12. Correlations of variables associated with monetary elasticity: P_{max} and *α* for low- and high-magnitude Food Purchasing Tasks.

	Low FPT *α*	Low FPT P_{max}	High FPT *α*	High FPT P_{max}
Low FPT *α*	1	-0.080	0.689**	-0.095
Low FPT P_{max}	-0.080	1	-0.107	0.261**
High FPT *α*	0.689**	-0.107	1	-0.105
High FPT P_{max}	-0.095	0.261**	-0.105	1

Note, FPT = Food Purchasing Task; FCT = Food Climb Task
**Correlation is significant at the 0.01 level

Table 13 shows correlations of variables related to effort-related elasticity for the Effort (stair climb) Task and the low- and high-effort Food Climb Tasks. A relationship was observed between the P_{max} value on the high-effort Food

Climb Task and the total stairs traversed. The strongest correlation was found for P_{max} values between the low- and high-effort Food Climb Tasks. No relations were found between other linear elastic demand parameters (*L, a, b)* and the total stairs traversed, so these are not listed in the table. For the exponential model, no significant relations were found total stairs traversed and the exponential parameter α . As with the linear elastic model, the exponential model demonstrated significant correlations between the low- and high-effort Food Climb Task.

Table 13. Correlations of variables associated with effort-based elasticity: total stairs traversed, P_{max} and α values for the low- and high-effort Food Climb Tasks.

	Stairs Traversed	Low FCT P_{max}	Low FCT α	High FCT P_{max}	High FCT α
Stairs Traversed	1	0.037	-0.048	0.204**	-0.091
Low FCT P_{max}	0.037	1	-0.216**	0.681**	-0.345**
Low FCT α	-0.048	-0.216**	1	-0.181*	0.560**
High FCT P_{max}	0.204**	0.681**	-0.181*	1	-0.260**
High FCTα	-0.091	-0.345**	0.560**	-0.260**	1

Note: FPT = Food Purchasing Task; FCT = Food Climb Task
**Correlation is significant at the 0.01 level
*Correlation is significant at the 0.05 level

A few additional significant correlations existed among measures between tables should be mentioned. These include: the relation between stairs climbed and total calories consumed in the FPTT (r = 0.195), P_{max} values of the low-effort FCT and high-magnitude FPT (r = 0.197), α values for low-magnitude FPT and high-effort FCT (r = 0.257), and *α* values for the high-effort FCT and high-magnitude FPT (r = 0.39).

Discussion

The current study sought to establish three measures of demand for food in humans and determine the extent to which three measures of weight status (BMI, PBF, and waist circumference) predicted differences in aspects of demand. We used three tasks that measured demand. First, we used the Food Purchasing Task (Epstein, Dearing, & Roba, 2010) that asked participants to self-report food consumption as a function of monetary price. In addition to this original version, we adapted the prices to create a second version, the high-magnitude Food Purchasing Task. Second, we adapted this measure to replace money with effort and used two versions (low and high magnitude) of the Food Climb Task--something that has not been done in the literature before. Finally, we used a behavioral task that required individuals to make choices between a real, small amount of favorite preferred food with no effort or a larger amount with an effort component (climbing stairs).

Demand Tasks

Consistent across all demand tasks, consumption was found to decrease as a function of increasing prices (money and stairs) in a predictable fashion. In general, responses (self-reported bites of food) also increased to a maximal value, then decreased in a predictable fashion with increasing prices. These patterns in consumption and response output are consistent with prior literature on behavioral economics (Bickel, et al., 2000; Christensen, et al., 2008; Hursh, 1984; Hursh 2000; Madden, 2000; Rasmussen et al , 2010, 2012). In some instances, deviations from this pattern occurred with healthy-weight individuals on the Food Climb task, in which the descending limb was not observed at higher prices. The descending limb of an output function is important, as it reflects the maximal behavioral output, or an exhaust in spending for the reinforcer. Given this, obese individuals demonstrated maximal spending, while healthy-weight participants demonstrated willingness to “pay more” in the form of effort for food.

The linear and exponential models were also good descriptions of the data for both versions of the Food Purchasing Task and the Food Climb Task, with r-squared values ranging from the upper 0.60 to lower 0.90 range. The exponential demand models across low- and high-magnitude versions of demand tasks and predictors of weight status had higher r-squared values than the linear, though this difference was not significant. In addition, the linear elastic demand described the low-magnitude version of the Food Purchasing Task better than the high-magnitude version. This finding was not observed for the exponential model, which had equally strong fits for both magnitudes of tasks.

This is the first study, to our knowledge, to develop and test an effort-based questionnaire to estimate demand for food. Thus, specific attention must be paid towards discussion of fit to the linear elastic and exponential demand models to the low- and high-magnitude versions of the Food Climb Task. The linear elastic model demonstrated a slightly better fit for the low-effort Food Climb Task (r-squared was 0.85) than the exponential model (r-squared = 0.79). However, both models provided strong descriptions of the high-effort Food Climb Task data for all responders. When the sample of participants was stratified into groups based on predictors of weight, the linear elastic and exponential models demonstrated good fit for the data (fit values ranging from 0.77 to 0.89 for the low-effort Food Climb Task and a range of 0.78 to 0.87 for the high-effort Food Climb Task). For the low-effort Food Climb Task, the exponential model was a better fit than the linear elastic model when analyses were conducted based on BMI; however, the linear elastic model provided a better description of the data when analyzed by waist circumference and PBF. The converse was shown for the high-effort Food Climb Task, in which the exponential model demonstrated a better fit for the data across all weight predictors than the linear elastic model. The exponential model was consistently found to have better fits across the low- and high-magnitude Food Purchasing Tasks when analyzed across weight predictors. Overall, then, the exponential model appeared to provide better estimates of participants demand for food when compared to the linear elastic model.

Positive relations were found among measures of elasticity and essential value for the demand tasks. First, significant positive correlations were found for all demand measures and the values of *L* and *Q0*, with the exception of the relation between the high-magnitude Food Purchasing Task *L*-values and the high-effort Food Climb Task *Q0* values. These implications for these relations are twofold: 1) Participants are consistent in reported consumption when prices for a reinforcer are minimal, and 2) Both linear elastic and exponential demand models provide strong estimates of parameters for intensity for food across all demand tasks.

Second, relations between measures of elasticity for the linear elastic and exponential models of the monetary-based demand tasks were found. Positive relations were observed between the low and high magnitude P_{max} values and the low and high magnitude *α* values Food Purchasing Tasks; thus, participants demonstrated related points of unit elasticity. Third, estimates of elasticity for the effort-based behavioral task and effort-based demand tasks demonstrated significant negative relations between the parameter models on the low- and high-effort Food Climb Tasks. The directionality of this relation is not unexpected, as larger *α* values and smaller P_{max} values represent greater elasticity. Thus, participants' values for food was found to be consistent across both magnitudes of the Food Climb Tasks. No relations were observed between the number of stairs traversed and estimates of elasticity with the exception of P_{max} for the high-effort Food Climb Task.

Finally, correlations were conducted among the measures and parameter estimates of elasticity for both the exponential and linear elastic models. In sum, significant relations were observed between the P_{max} values for the low- and high-magnitude Food Purchasing Tasks and the P_{max} values for the low- and high-effort Food Climb Tasks. Thus, participants were consistent in their reports of purchasing for food across money and effort-based tasks, respectively. For both money and effort, participants demonstrated related points of unit elasticity, or the point at which consumption of food declined as a function of the increases in price. Further, relations were also found among P_{max} for the high-magnitude

Food Purchasing Task and both versions of the Food Climb Task. Though these relations were found, the low-magnitude Food Purchasing Task did not relate to P_{max} values from the Food Climb Tasks. Additionally, the *α* values for the low-effort Food Climb Task did not relate strongly to those of the low-magnitude Food Purchasing Task. Taken together, it appears as though consistency is found in the value for food across participants when compared within the same "price" scale. Stated differently, measures of elasticity within monetary prices are more consistent, and measures of elasticity within effort-based prices are more consistent. However, when correlating *across* forms of prices, there is greater variability in the measurement of demand for food.

Obesity and Demand. Significant differences between obese and healthy weight individuals were found for the *L*-parameters value in the linear analysis and in the *Q0* values for the exponential demand analysis for both the low- and high magnitude Food Purchasing Tasks. Specifically, those with higher waist circumference and high BMI had lower values than those with lower waist circumference and BMI in both analyses. This suggests when monetary price is low, those who are obese will consume less than healthy weight controls. These results were not consistent, though, with other findings in the literature (Epstein, Dearing, & Roba, 2010;Rasmussen, Reilly, & Hillman,2010). For example, Rasmussen and colleagues observed that obese rats earned more food than lean rats, and had significantly higher *L* and *Q0* values when response requirements were low for food. As such, the expectation would be to see obese participants of our sample consuming a greater amount than the healthy-weight participants, specifically at lower prices.

In addition, the present study showed that those with higher waist circumference had lower *α* values than those with lower waist circumference in the low-magnitude Food Purchasing Task. This suggests that when low-magnitude money is the price, demand is less elastic for obese individuals. However, we did not observe differences in linear measures of elasticity (*a* and *b* parameters or P_{max} values) in either of the Food Purchasing Tasks, so we are less confident in this difference. Moreover, other measures of body mass were not consistently related to this finding. This is consistent with Rasmussen et. al. (2010), in that differences in elasticity were not found in obese and lean Zucker rats. No significant differences for obesity status were found on the Food Climb Tasks, so the obesity-related effects appear to be specific to monetary price.

Effort-Based Tasks. The Food Climb Task was developed as an effort-based version of the Food Purchasing Task in order to evaluate the extent to which consumption is impacted by increasing effort requirements. It was hypothesized that behavior of participants of high weight status would have less demand for food, or be more impacted by increasing effort requirements, than those of low weight status. No significant differences were observed in any aspect of the low-effort or high-effort Food Climb Task across waist circumference, BMI, or PBF. In addition, no differences in weight status were found in the Food Climb Tasks. Therefore, across three effort-based tasks, which were significantly correlated, obesity-related differences were not found.

A number of explanations can be considered for the inconsistent findings on these effort-based measures. First, findings detected on the measurement may be representative of a true absence of meaningful differences between individuals of high and low weight status, in which weight status does not predict value for food at an effortful price. While this is one possibility, it is inconsistent with other effort-based tasks in the literature (Epstein, Dearing, & Roba, 2010; Epstein, et al., 2005). However, methodological differences in the present study vs. Epstein et al (2010) exist. For example, participants in prior research earned food after completion of a specified number of computer-based responses instead of the current study's use of physical exercise requirements. Second, the high-magnitude Food Purchasing Task and both versions of the Food Climb Task are novel measurements that have not been previously established within the literature. As such, the measurements themselves could have inherent psychometric flaws, such as poor reliability or validity. However, as we have already stated, orderly and consistent effects were observed with the low and high versions of the Food Climb Task, as well as strong fits of the data with the linear and exponential analyses. In addition, we also observed strong correlations of these measures with one another. Finally, it may be the case that the effort-based tasks of stair-climbing or the Food Climb Task may not be sensitive enough measures to detect meaningful differences. To our knowledge, no other study has used this demand questionnaire, and no comparison exists for the high-magnitude Food Purchasing Task or both forms of the Food Climb Tasks, so it is difficult to evaluate this assertion.

Low- versus High-Magnitude Demand Tasks

Holding unit price constant, comparisons were made between the low- and high-magnitude versions of the Food Purchasing Task and the Food Climb Task. Participants had higher rates of consumption (higher *L* and *Q0*) on the low-magnitude version of the Food Purchasing Task compared to the high-magnitude version, however, there were no differences in measures of elasticity. This suggests that low prices weighed more heavily on behavior when the low-magnitude version was used compared to the high-magnitude version. Further, the lack of differences observed for elasticity measures between the low and high versions of the Food Purchasing Task suggests that magnitudes differences in price are not important when assessing for the essential value of a food reinforcer.

For the Food Climb Task, participants showed greater level of consumption when prices were low on the low-effort Food Climb Task than on the high-effort Food Climb Task as measured by *L* and *Q0* values. Food was also more inelastic (higher P_{max} and $O_{\underline{max}}$ values) on the high-effort Food Climb Task than on the low-effort Food Climb Task. These findings suggest that, despite unit price being similar, the magnitude of stairs matters. At lower prices (fewer stairs), the higher magnitude version of the Food Climb Task led to lower consumption than the lower magnitude Food Climb Task. At higher prices, a higher magnitude of stairs impacted behavior less than the lower magnitude version. This finding is interesting, as magnitude was not a factor in determining unit elasticity with monetary prices, but was found to be important when given an effortful price.

Food Preference Taste Test

Research using the Food Preference Taste Test has previously shown differences in consumption between obese and healthy-weight human participants (Epstein, Leddy, Temple, & Faith, 2007; Epstein, Dearing, & Roba, 2010), with obese individuals eating more. The current study did not replicate this finding, despite controlling for caloric deprivation, or time since last consumption between the two groups, smoking, and other variables. Moreover, waist circumference also did not predict differences in consumption of total calories. Significant differences were found for males, but not females, when using PBF as a predictor. Males of a lower PBF consumed more overall calories than those of a higher PBF, which was in the opposing direction of our hypothesis.

The lack of replication of this finding may be due to several methodological differences in our implementation of the FPTT. One, in the original studies (Epstein, Dearing, & Roba, 2010; Epstein, Temple, Neaderhiser, Salis, Erbe, & Leddy, 2007), data on weight and other biometric measurements were collected after participation in sampling of the food items. In the current study, collection of biometric information and administration of all questionnaires was done before the FPTT as a screening for inclusion in the study. In hindsight, it is possible that collection of data on physical measurements of weight and waist circumference before the presentation of palatable “junk food” items may have increased sensitivity to the participants’ physical size or appraisals of themselves, which may have reduced consumption. Two, another difference in our task was the specific palatable food items used. In the other studies, six food items were used instead of the five. Research on consumption has demonstrated that increasing the number of food items presented in the same sitting increases the amount consumed by individuals when compared to presentation of fewer food options (Wansink, 2004).

Finally, another difference in our implementation of the Food Preference Taste Test is worthy of mention, and that is the use of a sample plate. Over half of the sample (52.9%) consumed what was on the sample plate and did not consume any additional food. Moreover, obesity status did not predict whether a person ate beyond what was given on the sample plate. Previous research did not use a sample plate, but rather presented only large quantities in individual bowls. It is possible that the sample plate may have served as an unintentional stop cue. A number of studies have shown that stop cues–even subtle ones such as changes in food color, the degree to which a bowl empties, plate size, and candy wrappers –can inhibit additional eating (Geier, Wansink, and Rozin, 2012). Further research should address these issues when implementing the FPTT.

Limitations

In addition to the limitations mentioned with the Food Preference Taste Test, there are other potential limitations to this study. One concerns the use of college students. While this sample was convenient, there are several potential differences between a college population and the general population that may have impacted our research. One, college students may have fewer financial resources than the general population. For our study, participants endorsed an average income of $20,000 annually, which is roughly 30% lower than the estimated average for the state of Idaho, which is approximately $28,051 (United

Stated Census Bureau, 2012). Therefore, their data may not generalize to the greater population.

Additionally, the effort-based stair climbing task used in this research was initially developed to mirror that of similar effort-based choice tasks in animal research (Salamone & Correa, 2009), but may lack ecological validity. Though similar to other research, in that there were two choices: one for a small amount of food with no effort, or a larger amount of food with greater effort, other research (Epstein, et al., 2010; Salamone & Correa, 2009; Wansink, 2004) has used physical barriers or other behavioral effort-based requirements for the effort component. Future research could examine if physical barriers (e.g., climbing a wall, opening a door, opening difficult lids or wrappers) may be a more sensitive measure to reveal differences in lean and obese individuals.

Limitations within the demand tasks may also exist. One possible limitation in our study is the nature of the economy. Collier and colleagues (1992) discussed the impact of an open versus closed economy on the efficacy of a reinforcer, identifying that the elasticity of an outcome is greater in a closed economy (when access to the reward happens only in the experiment) compared to an open economy (in which access to the reward can also take place outside the experiment). Because we could not completely reduce the intake of food outside of the laboratory, the demand curves generated took place in an open economy. This also may have limited the possibility of finding differences between lean and obese participants. Interestingly, though, differences in the demand curves for sucrose of lean and obese Zucker rats, which also took place in an open economy led to similar elasticity in lean and obese Zuckers—namely, that level of consumption at low prices was different between the two groups, but elasticity did not differ (Rasmussen et al., 2010; 2012). More research is needed to understand the degree to which economy plays a role on establishing demand in obesity-related questions.

Despite these limitations, the data from the current study show that food procurement is sensitive to price, whether it is monetary or effort-based, and that obesity status can predict some aspects of food attainment. In particular, consumption is most likely to differ between obese and healthy weight individuals when monetary price for food is low. Moreover, this study provided a new means for measuring demand—the Food Climb Task, which reported orderly and consistent self-reported consumption of food based on effort. The data from this task followed what behavioral economic studies would suggest-- namely, that consumption and responding for food decrease in a predictable manner with increasing prices and that the linear and exponential models adequately characterize demand.

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Appendix A

Subject Code______

Demographics & Lifestyle Questionnaire

PLEASE CIRCLE RESPONSE OR FILL IN THE BLANK WHERE INDICATED. Remember, your answers are anonymous and confidential.

1. What is your gender?
    a. Male
    b. Female

2. What is your age? _______

3. What is your ethnicity?
    a. White/ Caucasian
    b. Black/ African-American
    c. Hispanic/ Latino
    d. Asian
    e. Native-American
    f. Other

4. What is your religious affiliation? ______________

5. Approximately what is your annual family income?
    a. Less than 10,000
    b. 10,000-20,000
    c. 20,000-30,000
    d. 30,000-40,000
    e. 40,000-50,000
    f. 50,000-60,000
    g. 60,000-70,000
    h. 70,000+

6. Do you smoke?
    a. Yes (Continue to Question 7)
    b. No (Skip to Question 13)

7. How many cigarettes do you smoke per day?
    a. 10 or less
    b. 11 – 20
    c. 21 – 30
    d. 31 or more

8. How soon after you wake up do you smoke your first cigarette?
    a. 0 – 5 minutes
    b. 30 minutes
    c. 31 – 60 minutes
    d. After 60 minutes

9. Do you find it difficult to refrain from smoking in places where smoking is not allowed (e.g., hospitals, government offices, cinemas, libraries, etc.?)
    a. Yes
    b. No

10. Do you smoke more during the first hours after waking than during the rest of the day?
    a. Yes
    b. No

11. Which cigarette would you be the most unwilling to give up?
    a. First in the morning
    b. Any of the others

12. Do you smoke even when you are very ill?
    a. Yes
    b. No

13. How would you classify your exercise routine for a typical day?
    a. None
    b. Very light
    c. Light
    d. Moderate
    e. Vigorous

14. What types of exercise do you typically engage in?

____

____

____

15. How long do you engage in this/these exercise/s (per day)?

____

16. What is your best estimate for how many one-cup servings of grains (bread, cereal, pasta, rice, etc.) you eat per day?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

17. What is your best estimate for how many one-cup servings of fruits you eat per day (a piece of fruit is equal to a one-cup serving)?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

18. What is your best estimate of how many one-cup servings of vegetables you eat per day?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

19. What is your best estimate of how many one-cup servings of dairy products (milk, yogurt, cheese, etc.) you eat per day?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

20. What is your best estimate of how many one-cup servings of protein (meat, fish, eggs, nuts, etc.) you eat per day?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

21. What is your best estimate of how many servings of fats, oils, and sweets you eat per day?
    a. 1 or fewer
    b. 2-3
    c. 4-5
    d. 6 or more

22. Do you think you may have an eating disorder?
    a. Yes
    b. No

23. If you answered yes to questions 22, what eating disorder do you think you might have?

___ Anorexia Nervosa
___ Bulimia Nervosa
___ Binge Disorder
___ Other (please specify): _________________

24. Have you been diagnosed with an eating disorder within the past two years?
   a. Yes
   b. No

25. If you answered yes to question 24, please indicate which disorder you have been diagnosed:

___ Anorexia Nervosa
___ Bulimia Nervosa
___ Binge Disorder
___ Other (please specify): _________________

26. How would you characterize the time it takes for you to complete a meal?
   a. 0-5 minutes
   b. 5-10 minutes
   c. 10-15 minutes
   d. 15-20 minutes
   e. 20-25 minutes
   f. 25-30 minutes
   g. 30-35 minutes
   h. Don’t know

Appendix B

Subject Number ______________

Subjective Hunger Questionnaire

1. How long ago was your last full meal? ____________
2. How long has it been since you had anything at all to eat (e.g., a snack)?

Using the scale below, how hungry do you feel right now?

0	25	50	75	100
Not Hungry At All				Very Hungry

Appendix C

Subject Code_______

EDE-Q

Instructions: The following questions are concerned with the ***past 4 weeks(28 days) only.*** Please read each question carefully. Please answer all of the questions. Thank you.

Questions 1-12: Please circle the appropriate number. Please remember that the questions only refer to the past 4 weeks (28 days).

On how many of the past 28 days…

1. Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

3. Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

4. Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

5. Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

6. Have you had a definite desire to have a totally flat stomach?

0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

7. Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

9. Have you had a definite fear of losing control over eating?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

On how many of the past 28 days…
10. Have you had a definite fear that you might gain weight?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

11. Have you felt fat?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

12. Have you had a strong desire to lose weight?
0 1-5 6-12 13-15 16-22 23-27
28 (Everyday)
days days days days days days
days

Questions 13-18: Please fill in the appropriate number of days. Remember that the questions only refer to the past 4 weeks (28 days).

Over the past 4 weeks (28 days)…

13. How many times have you eaten what other people would regard as an unusually large amount of food (given the circumstances)?

____

14. On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)? ____________________

15. On how many days have such episodes of overeating occurred (i.e., you have eaten an unusually large amount of food and have had a sense of loss of control at the time)?__________

16. How many times have you made yourself sick (vomit) as a means of controlling your shape or weight? _________

17. How many times have you taken laxatives as a means of controlling your shape or weight? _________

18. How many times have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories?

______

Questions 19-21: Please circle the appropriate number. Please not that for these questions the term "binge eating" means eating what others of your age and gender would regard as an unusually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

19. Over the past 28 days, on how many days have you eaten in secret (i.e., furtively)? Ignore episodes of binge eating

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

20. On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight? Ignore episodes of being eating

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

21. Over the past 28 days, how concerned have you been about other people seeing you eat? Ignore episodes of binge eating

0 days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	28 (Everyday) days

Questions 22-28: Please circle the appropriate number. Remember that the questions only refer to the past 4 weeks (28 days).

Over the past 28 days…

22. Has your weight (number on the scale) influenced how you think about (judge) yourself as a person?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

23. Has your shape influenced how you think about (judge) yourself as a person?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

24. How much would it have upset you if you have been asked to weight yourself once a week (no more, or less, often) for the next 4 weeks?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

25. How dissatisfied have you been with your weight (number on the scale)?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

26. How dissatisfied have you been with your shape?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath/shower)?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

28. How uncomfortable have you felt about others seeing your body (for example, in communal changing rooms, when swimming, or wearing tight clothes)?

Not at all Slightly Moderately Markedly
0 1 2 3 4 5 6

Appendix D

Subject Code __________

Food Preference Taste Test

Please complete each of the following ratings:

Food Item 1:___________________________

This item was ***sweet***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***bitter***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***salty***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This is was ***tangy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***chewy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***crunchy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

On a scale of 1-10, how much ***did you like this item?***
(1 = did not like the item, 5 = neutral, 10 = loved the item)

1 2 3 4 5 6 7 8 9 10

Please complete each of the following ratings:

Food Item 2:___________________________

This item was ***sweet***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***bitter***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***salty***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This is was ***tangy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***chewy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***crunchy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

On a scale of 1-10, how much ***did you like this item?***
(1 = did not like the item, 5 = neutral, 10 = loved the item)

1 2 3 4 5 6 7 8 9 10

Please complete each of the following ratings:

Food Item 3:___________________________

This item was ***sweet***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***bitter***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***salty***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This is was ***tangy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***chewy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

This item was ***crunchy***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

On a scale of 1-10, how much ***did you like this item?***
(1 = did not like the item, 5 = neutral, 10 = loved the item)

1 2 3 4 5 6 7 8 9 10

Please complete each of the following ratings:

Food Item 4:____________________________

<u>This item was ***sweet***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***bitter***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***salty***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This is was ***tangy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***chewy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***crunchy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>On a scale of 1-10, how much ***did you like this item?***</u>
(1 = did not like the item, 5 = neutral, 10 = loved the item)

1 2 3 4 5 6 7 8 9 10

Please complete each of the following ratings:

Food Item 5:___________________________

<u>This item was ***sweet***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***bitter***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***salty***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This is was ***tangy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***chewy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>This item was ***crunchy***</u>

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

<u>On a scale of 1-10, how much ***did you like this item?***</u>
(1 = did not like the item, 5 = neutral, 10 = loved the item)

1 2 3 4 5 6 7 8 9 10

Rankings
Please complete the following rankings by placing the NAME of the food next to the description:

Favorite: ______________________________

Second Favorite: _______________________

Neutral: _______________________________

Dislike: _______________________________

Least Favored: _________________________

Appendix E

Subject Code __________

Food Purchasing Task A

Imagine a TYPICAL DAY during which you eat snack foods. The following questions ask **how many servings of the snack food in front of you** would consume if they cost various amounts of money.

Assume a serving is equivalent to the amount in front of you.

The available snack food is _______________ (preferred snack food).

Assume you have the same income/savings that you have now and NO ACCESS to any snack food other than the snack food offered at these prices. In addition, assume that you would consume the snack food that you request on that day; that is, you cannot save or stockpile snack food for a later date. Please respond to the questions honestly.

1. How many servings of ___________ (preferred snack food) would you consume if they were **$0.01** each?

2. How many servings of ___________ (preferred snack food) would you consume if they were **$0.05** each?

3. How many servings of ___________ (preferred snack food) would you consume if they were **$0.13** each?

4. How many servings of ___________ (preferred snack food) would you consume if they were **$0.25** each?

5. How many servings of ___________ (preferred snack food) would you consume if they were **$0.50** each?

6. How many servings of ___________ (preferred snack food) would you consume if they were **$1** each?

7. How many servings of ___________ (preferred snack food) would you consume if they were **$2** each?

8. How many servings of ___________ (preferred snack food) would you consume if they were **$3** each?

9. How many servings of ___________ (preferred snack food) would you

consume if they were **$4** each?

10. How many servings of ___________ (preferred snack food) would you consume if they were **$5** each?

11. How many servings of ___________ (preferred snack food) would you consume if they were **$6** each?

12. How many servings of ___________ (preferred snack food) would you consume if they were **$11** each?

13. How many servings of ___________ (preferred snack food) would you consume if they were **$35** each?

14. How many servings of ___________ (preferred snack food) would you consume if they were **$70** each?

15. How many servings of ___________ (preferred snack food) would you consume if they were **$140** each?

16. How many servings of ___________ (preferred snack food) would you consume if they were **$280** each?

17. How many servings of ___________ (preferred snack food) would you consume if they were **$560** each?

18. How many servings of ___________ (preferred snack food) would you consume if they were **$1120** each?

Appendix F

Subject Code __________

Food Purchasing Task B

Imagine a TYPICAL DAY during which you eat snack foods. The following questions ask **how many servings of the snack food in front of you** would consume if they cost various amounts of money.

Assume a serving is equivalent to the amount in front of you.

The available snack food is _______________ (preferred snack food).

Assume you have the same income/savings that you have now and NO ACCESS to any snack food other than the snack food offered at these prices. In addition, assume that you would consume the snack food that you request on that day; that is, you cannot save or stockpile snack food for a later date. Please respond to the questions honestly.

1. How many servings of ___________ (preferred snack food) would you consume if they were **$0.03** each?

2. How many servings of ___________ (preferred snack food) would you consume if they were **$0.15** each?

3. How many servings of ___________ (preferred snack food) would you consume if they were **$0.39** each?

4. How many servings of ___________ (preferred snack food) would you consume if they were **$0.75** each?

5. How many servings of ___________ (preferred snack food) would you consume if they were **$1.50** each?

6. How many servings of ___________ (preferred snack food) would you consume if they were **$3** each?

7. How many servings of ___________ (preferred snack food) would you consume if they were**$6** each?

8. How many servings of ___________ (preferred snack food) would you consume if they were **$9** each?

9. How many servings of ___________ (preferred snack food) would you

consume if they were **$12** each?

10. How many servings of ___________ (preferred snack food) would you consume if they were **$15** each?

11. How many servings of ___________ (preferred snack food) would you consume if they were **$18** each?

12. How many servings of ___________ (preferred snack food) would you consume if they were **$33** each?

13. How many servings of ___________ (preferred snack food) would you consume if they were **$105** each?

14. How many servings of ___________ (preferred snack food) would you consume if they were **$210** each?

15. How many servings of ___________ (preferred snack food) would you consume if they were **$420** each?

16. How many servings of ___________ (preferred snack food) would you consume if they were **$760** each?

17. How many servings of ___________ (preferred snack food) would you consume if they were **$1680** each?

18. How many servings of ___________ (preferred snack food) would you consume if they were **$3360** each?

Appendix G

Subject Code ______________

Food Climb Task A

Imagine a TYPICAL DAY during which you eat snack foods. The following questions ask **how many servings of the snack food in front of you** would consume if they cost various amounts of money.

Assume a serving is equivalent to the amount in front of you.

The available snack food is _______________ (preferred snack food).

Assume you have the same income/savings that you have now and NO ACCESS to any snack food other than the snack food offered at these prices. In addition, assume that you would consume the snack food that you request on that day; that is, you cannot save or stockpile snack food for a later date. Please respond to the questions honestly.

1. How many servings of ___________ (preferred snack food) would you consume if you had to climb **1 stair**?

2. How many servings of ___________ (preferred snack food) would you consume if you had to climb **2 stairs**?

3. How many servings of ___________ (preferred snack food) would you consume if you had to climb **3 stairs**?

4. How many servings of ___________ (preferred snack food) would you consume if you had to climb **4 stairs**?

5. How many servings of ___________ (preferred snack food) would you consume if you had to climb **5 stairs**?

6. How many servings of ___________ (preferred snack food) would you consume if you had to climb **6 stairs**?

7. How many servings of ___________ (preferred snack food) would you consume if you had to climb **10 stairs**?

8. How many servings of ___________ (preferred snack food) would you consume if you had to climb **15 stairs**?

9. How many servings of ___________ (preferred snack food) would you

consume if you had to climb **25 stairs**?

10. How many servings of ____________ (preferred snack food) would you consume if you had to climb **40 stairs**?

11. How many servings of ____________ (preferred snack food) would you consume if you had to climb **50 stairs**?

12. How many servings of ____________ (preferred snack food) would you consume if you had to climb **55 stairs**?

13. How many servings of ____________ (preferred snack food) would you consume if you had to climb **75 stairs**?

14. How many servings of ____________ (preferred snack food) would you consume if you had to climb **85 stairs**?

15. How many servings of ____________ (preferred snack food) would you consume if you had to climb **93 stairs**?

16. How many servings of ____________ (preferred snack food) would you consume if you had to climb **100 stairs**?

Appendix H

Subject Code ______________

Food Climb Task B

Imagine a TYPICAL DAY during which you eat snack foods. The following questions ask **how many servings of the snack food in front of you** would consume if they cost various amounts of money.

Assume a serving is equivalent to the amount in front of you.

The available snack food is _______________ (preferred snack food).

Assume you have the same income/savings that you have now and NO ACCESS to any snack food other than the snack food offered at these prices. In addition, assume that you would consume the snack food that you request on that day; that is, you cannot save or stockpile snack food for a later date. Please respond to the questions honestly.

1. How many servings of ___________ (preferred snack food) would you consume if you had to climb **3 stairs**?

2. How many servings of ___________ (preferred snack food) would you consume if you had to climb **6 stairs**?

3. How many servings of ___________ (preferred snack food) would you consume if you had to climb **9 stairs**?

4. How many servings of ___________ (preferred snack food) would you consume if you had to climb **12 stairs**?

5. How many servings of ___________ (preferred snack food) would you consume if you had to climb **15 stairs**?

6. How many servings of ___________ (preferred snack food) would you consume if you had to climb **18 stairs**?

7. How many servings of ___________ (preferred snack food) would you consume if you had to climb **30 stairs**?

8. How many servings of ___________ (preferred snack food) would you consume if you had to climb **45 stairs**?

9. How many servings of ___________ (preferred snack food) would you consume if you had to climb **75 stairs**?

10. How many servings of ____________ (preferred snack food) would you consume if you had to climb **120 stairs**?

11. How many servings of ____________ (preferred snack food) would you consume if you had to climb **150 stairs**?

12. How many servings of ____________ (preferred snack food) would you consume if you had to climb **165 stairs**?

13. How many servings of ____________ (preferred snack food) would you consume if you had to climb **225 stairs**?

14. How many servings of ____________ (preferred snack food) would you consume if you had to climb **255 stairs**?

15. How many servings of ____________ (preferred snack food) would you consume if you had to climb **279 stairs**?

16. How many servings of ____________ (preferred snack food) would you consume if you had to climb **300 stairs**?

Appendix I

Subject Code ___________

Feedback Questionnaire: Session 1

Please answer these few questions about your experience in this research.

Using the scale below, please indicate how comfortable you felt completing the various parts of this study.

1	2	3	4	5
very uncomfortable				very comfortable

1. Completing the questionnaires ______
2. Completing the Food Preference Taste Test ______
3. Being weighed and measured ______
4. Having blood sugar tested ______
5. Having waist circumference measured ______

5. Would you participate in another study like this in the future? (please circle)
Yes (1) No (0)

If no, then why not? ____________________________________

Appendix J

Subject Code _________

Feedback Questionnaire: Session 2

Please answer these few questions about your experience in this research.

1. How difficult did you find the stair-climbing activity?

1	2	3	4	5
very difficult				**very easy**

2. How much did you enjoy the selected food reward?

1	2	3	4	5
Did NOT enjoy At all				**Enjoyed Completely**

3. How much do you agree with this statement: The food reward motivated me to climb the stairs

1	2	3	4	5
Not at all motivated me				**Completely motivated me**

4. Would you participate in another study like this in the future? (please circle)
Yes (1) **No (0)**

If no, then why not? ___________________________________

Appendix K

Idaho State University
Human Subjects Committee
Informed Consent Form for Non-Medical Research
CONSENT TO PARTICIPATE IN RESEARCH

Effects of Effort on Choice for Food in Humans

You are asked to volunteer for a research study conducted by Jennifer C. Stoll, M.S. and Erin B Rasmussen, Ph.D. (208-282-5651), from the Department of Psychology at Idaho State University. You have been asked to participate in this research because you are a student at Idaho State University and are at least 18 years old. Your participation in this research is voluntary. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

1. PURPOSE OF THE STUDY

The purpose is to examine food choices by individuals and evaluate techniques that may affect choices for food. The goal of this research is to better understand choices in regards to food in adults.

2. PROCEDURES

This study has two different components. The initial component involves completing a series of questionnaires and consuming various palatable foods. The second component is composed a follow-up study in which you will be able to make choices among food options.

For this study, you will be asked to sign this consent form and complete a series of brief self-report measures. You will be asked about subject matter that pertains to life-style, such as health and exercise habits. You will also be weighed and your height and body fat concentration will be measured. You will not need to remove your clothes for any part of the study. You will then be asked to complete a series of questions on the taste of a variety of presented foods. For the follow-up study session, you will be asked to make choices about different options of food available to you at different levels of effort. This effort component requires a moderate level of physical exertion. In order to adequately measure your body mass, however, we ask that you do not drink any liquid for 2 hours prior to coming to the experiment. If you do drink water within 2 hours, we ask that you report it to us. We also ask that you do not consume food for up to 3 hours prior to participation. If you do eat any food within 3 hours, we ask that you report it to us.

Participation in this study will involve approximately 1 hour of participation in session 1 and 1.5 hours of participation in session 2.

3. POTENTIAL RISKS AND DISCOMFORTS

You may experience some very slight emotional discomfort from answering questions about lifestyle and health.

4. ANTICIPATED BENEFITS TO SUBJECT

There are no tangible benefits to you for participating in this study.

5. ANTICIPATED BENEFITS TO SOCIETY
Results of this research will be used to increase our understanding of food-related choices.

6. ALTERNATIVES TO PARTICIPATION
An alternative is to not participate in the study.

7. PAYMENT FOR PARTICIPATION
You will receive one (1) credit of extra credit research for each 30-minute block (or part thereof) of time you spend participating in this research. We anticipate that you will receive 3-4 credits for this study.

8. FINANCIAL OBLIGATIONS
There are no financial obligations to you in the study.

9. EMERGENCY CARE AND COMPENSATION FOR INJURY
Idaho State University does not provide any other form of compensation for injury. No other compensation is available.

10. PRIVACY AND CONFIDENTIALITY
To protect your privacy, the questionnaires you complete will contain a subject code and not your name. Your name and subject code will be located on a master list available only to the researcher. Your contact information and this consent form will be stored separately from the other information you provide us. No information about you, or provided by you during the research, will be disclosed to others without your written permission, except (a) if necessary to protect your rights or welfare (for example, if you are injured), or (b) if required by law.

When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. Any paper containing your name will be stored in a locked cabinet in the Principle Investigator's laboratory separate from data collected during the study.

11. PARTICIPATION AND WITHDRAWAL
Your participation in this study is VOLUNTARY. If you choose not to participate in the study, this will not affect your current or future medical care or any benefits to which you are entitled. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time. You should call the investigator in charge of this study if you decide to do this.

12. WITHDRAWAL OF PARTICIPATION BY THE INVESTIGATOR
The investigators and/or the sponsor may stop your participation in this study at any time if circumstances arise which warrant doing so. The investigator, Jennifer C. Stoll, M.S., will make the decision and let you know if it is not possible for you to continue. The decision may be made either to protect your health and welfare, or because it is part of the research plan. You may also be forced to withdraw if you do not follow the investigator's instructions.

If you must drop out because the investigator asks you to (rather than because you have decided on your own to withdraw), for any reason other than not complying with the investigator's instructions, you will still receive your research credit.

13. IDENTIFICATION OF INVESTIGATORS
In the event of a research related injury or if you experience an adverse reaction, please immediately contact the investigator listed below. If you have any questions about the research or your participation in the study, please feel free to contact Jennifer C. Stoll, M.S., or Erin. B Rasmussen, Ph.D., Garrison Hall, Campus Box 8112, Idaho State University, Pocatello, ID 83209-8112; (208) 282-5651

12. RIGHTS OF RESEARCH SUBJECTS
You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have any questions regarding your rights as a research subject, you may contact the Idaho State University Institutional Review Board for Human Research at (208) 282-2714.

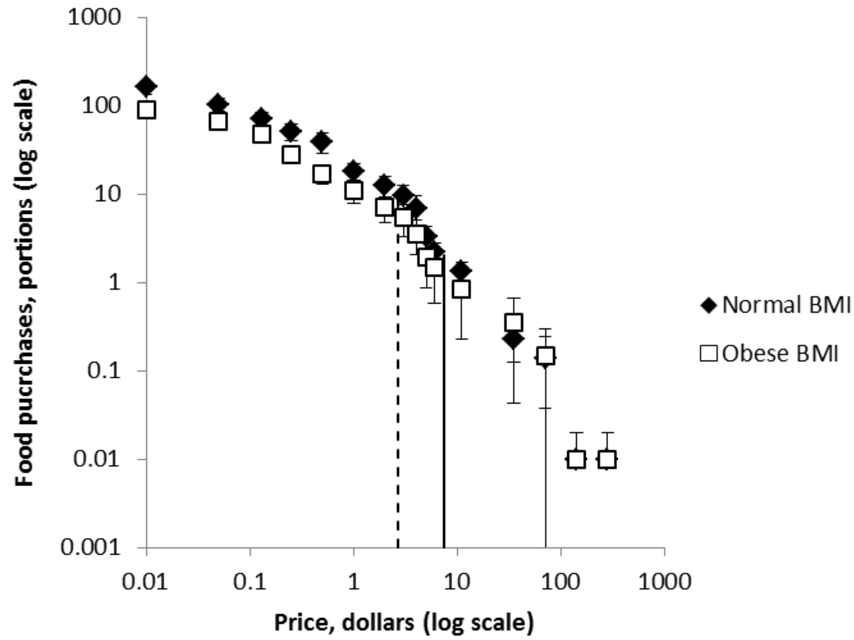
____

Name

______________________________ ______________

Signature Date

Appendix L



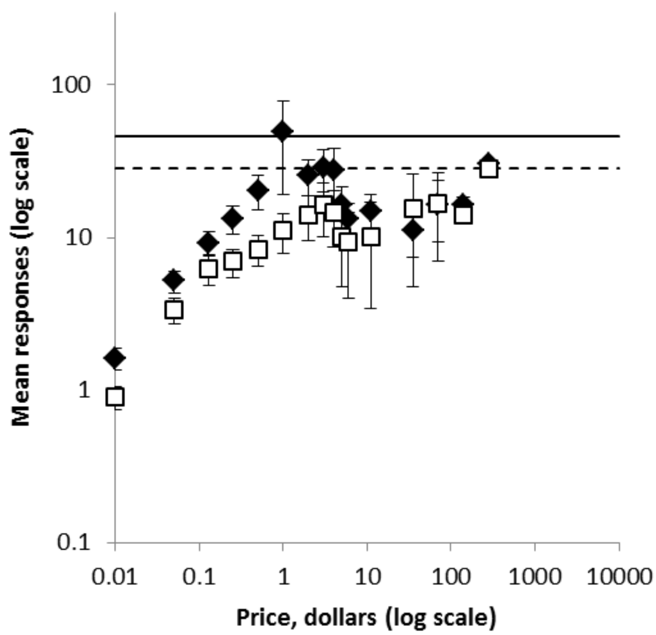


Figure 8. The number of food portions purchased (top) and responses (bottom) on low-magnitude prices of the Food Purchasing Task. Normal and Obese participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Normal BMI by solid and Obese BMI by dotted).

Appendix M

Table 14. Free parameters for linear elastic (top) and exponential demand (bottom) for Normal vs. Obese BMI on the low-magnitude Food Purchasing Task.

	Normal BMI M(SEM)	Obese BMI M(SEM)	*t*(df)	p-value
Linear				
L	161.70 (27.70)	89.47 (15.15)	2.29(142.27)	0.038*
a	0.03 (0.00)	0.03 (0.00)	.951(148)	NS
b	0.81 (0.02)	0.77 (0.026)	.647(148)	NS
P_{max}	7.46 (3.16)	2.68 (0.99)	1.040(148)	NS
O_{max}	23.06 (6.51)	28.49 (11.366)	.917(148)	NS
r^2	0.79(0.01)	0.77(0.02)	0.809(148)	NS
Exponential				
Q0	117.03 (14.66)	76.69 (12.64)	2.066(135.63)	0.039*
α	0.03 (0.01)	0.05 (0.01)	-1.695(67.57)	0.05*
k	4	4	---	---
r^2	0.88(0.02)	0.86(0.03)	0.719(148)	NS

Appendix N

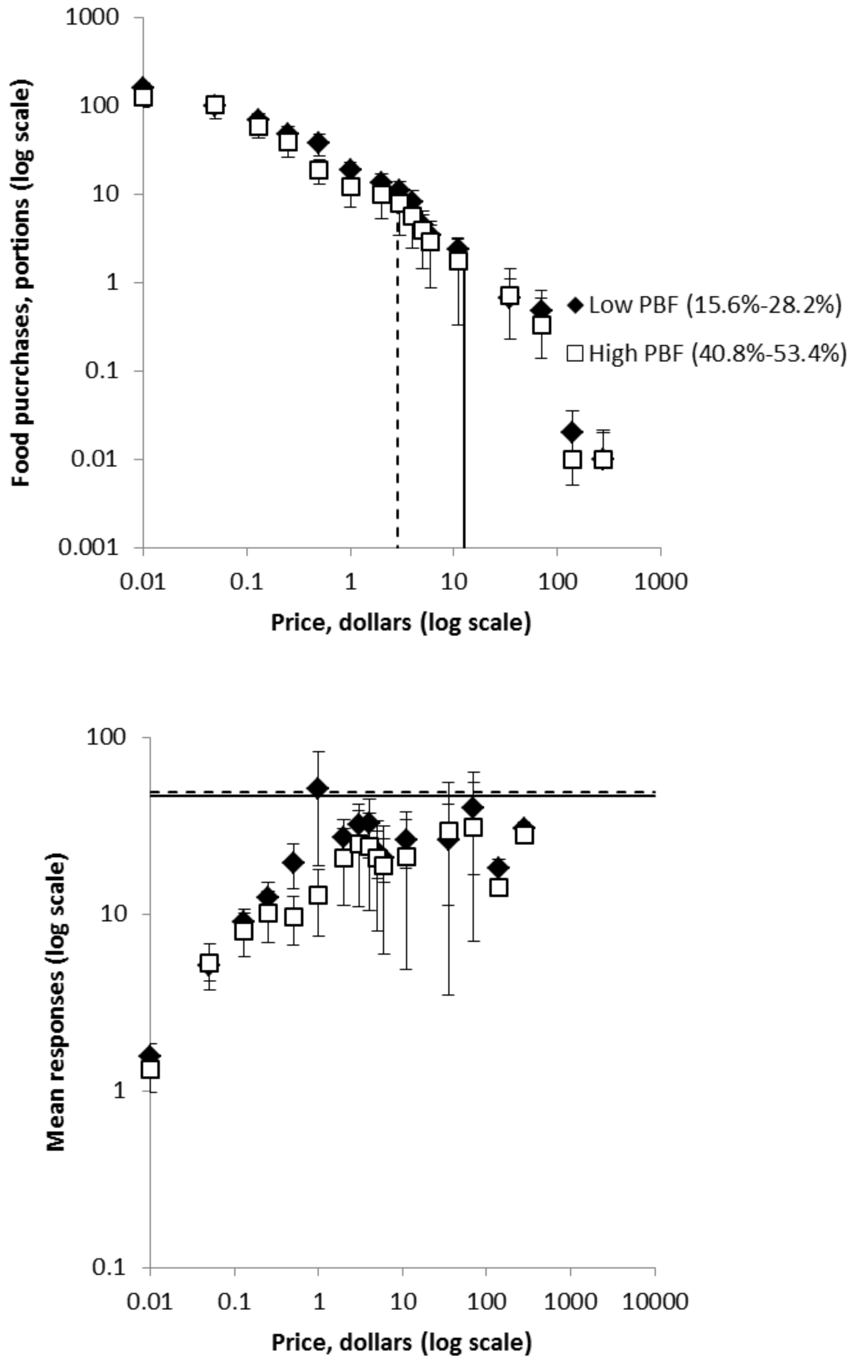


Figure 9. The number of food portions purchased (top) and responses (bottom) on low-magnitude prices of the Food Purchasing Task. Low PBF (15.6%-28.2%) and High PBF (40.8%-53.4%) for female participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF by solid and High PBF by dotted).

Appendix O

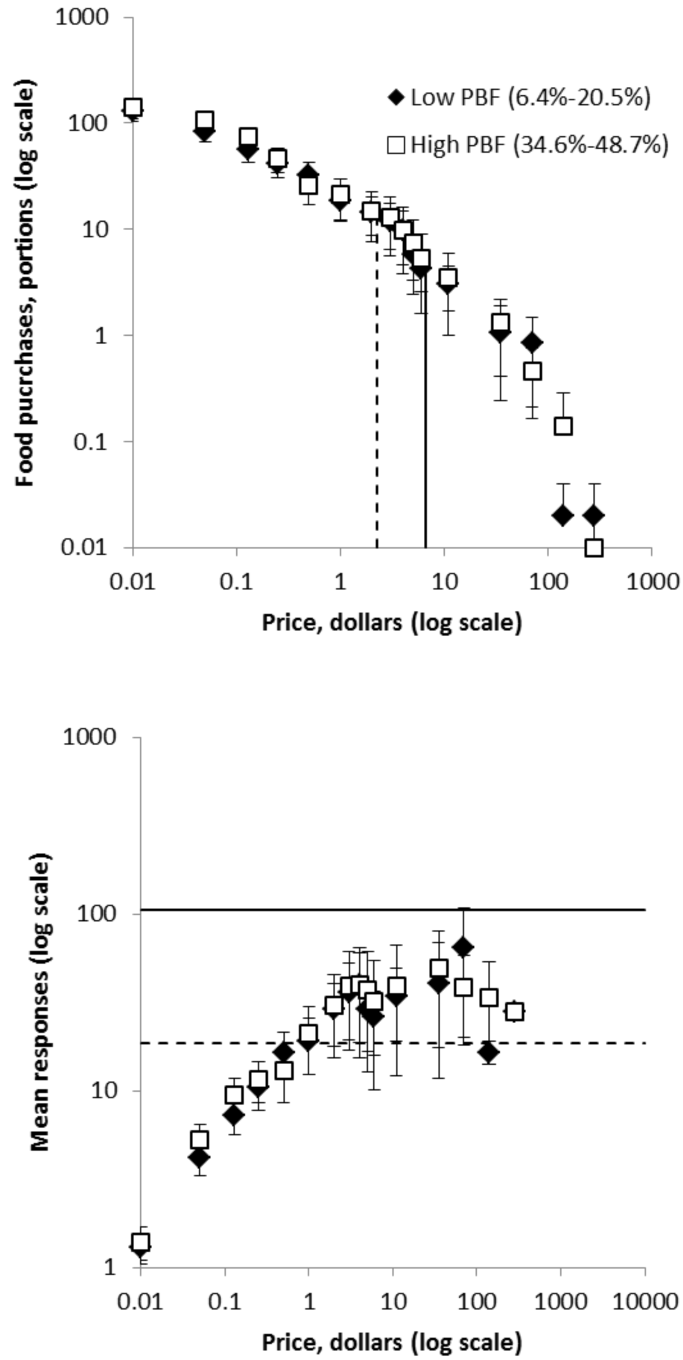


Figure 10. The number of food portions purchased (top) and responses (bottom) on low-magnitude prices of the Food Purchasing Task. Low PBF (6.4%-20.5%) and High PBF (34.6%-48.7%) for male participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF by solid and High PBF by dotted).

Appendix P

Table 15. Free parameters for linear elastic (top) and exponential demand (bottom) for lower PBF vs upper PBF on the low-magnitude Food Purchasing Task.

	Lower PBF M(SEM) (6.4% to 21.0%)	Upper PBF M(SEM) (37.6% to 53.4%)	*t*(df)	p-value
Linear				
L	82.29(21.00)	63.85(12.26)	0.648(87)	NS
a	0.01(0.00)	0.56(0.55)	1.278(87)	NS
b	0.71(0.08)	0.81(0.10)	0.818(87)	NS
P_{max}	12.76(7.79)	27.79(22.40)	-0.746(87)	NS
O_{max}	135.81(68.87)	268.86(223.03)	-0.680(87)	NS
r^2	0.84(0.03)	0.86(0.04)	-0.421(87)	NS
Exponential				
Q0	91.31(14.71)	146.84(37.01)	-1.151(87)	NS
α	1.00×10^{-3}(0.00)	1.00×10^{-3} (0.00)	0.057(87)	NS
k	3.2	3.2	---	---
r^2	0.82(0.03)	0.84(0.05)	-0.353(87)	NS

Appendix Q

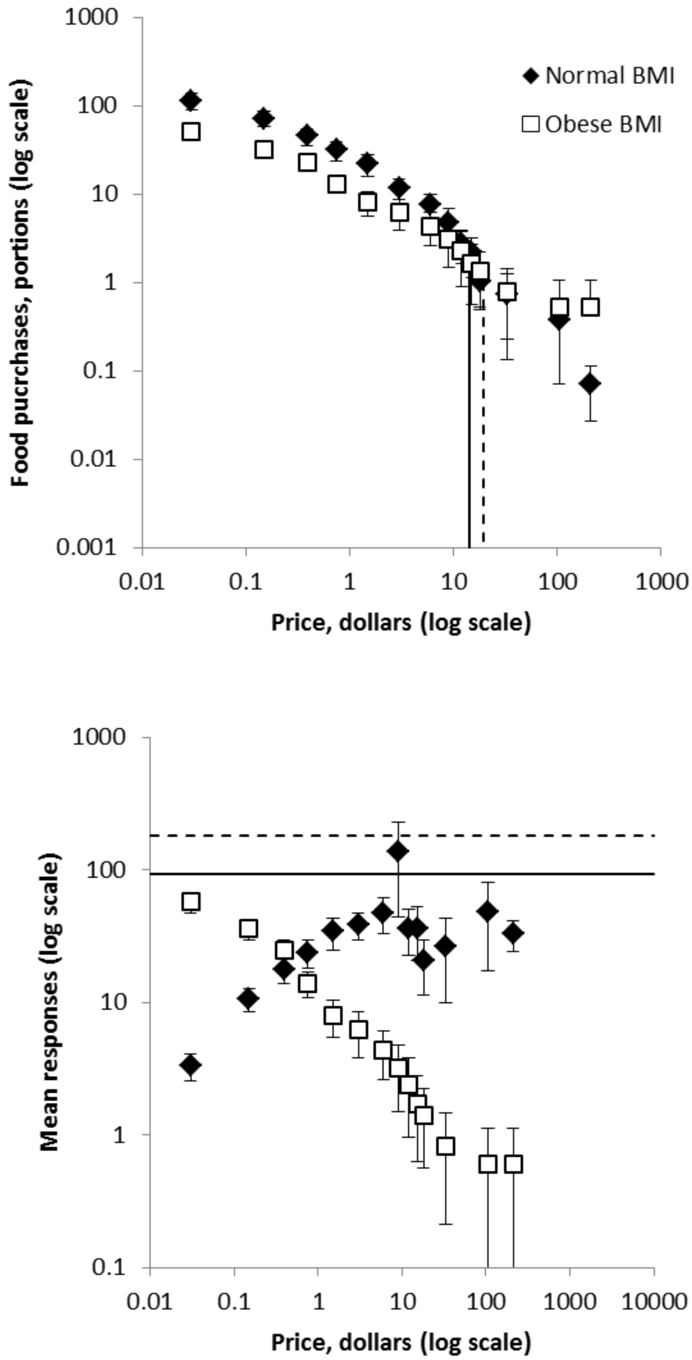


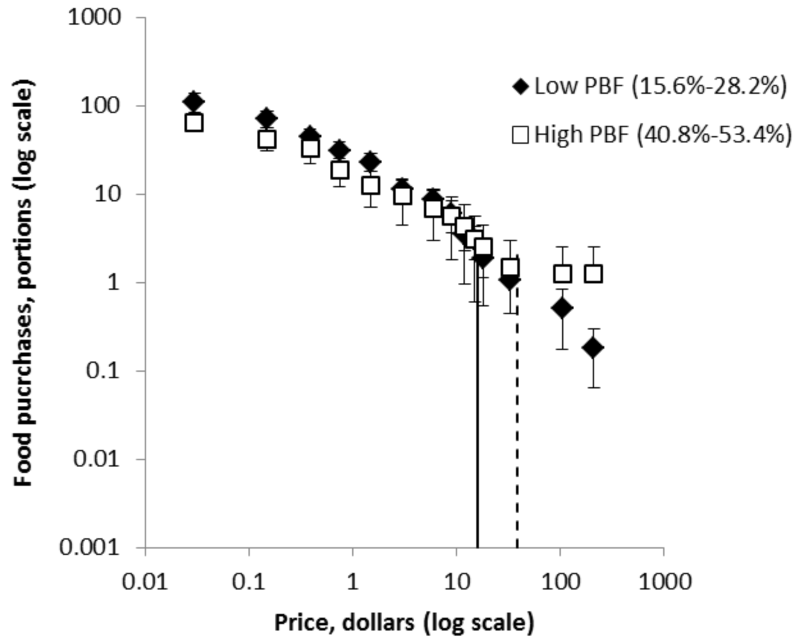
Figure 11. The number of food portions purchased (top) and responses (bottom) on high-magnitude prices of the Food Purchasing Task. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Normal BMI by solid and Obese BMI by dotted).

Appendix R

Table 16. Free parameters for linear elastic (top) and exponential demand (bottom) for Normal vs. Obese BMI on the high-magnitude Food Purchasing Task.

	Normal BMI M(SEM)	Obese BMI M(SEM)	*t*(df)	p-value
Linear				
L	110.20 (24.50)	56.96 (10.13)	2.00(129.224)	0.05*
a	0.00 (0.00)	0.00 (0.00)	.242(148)	NS
b	0.42 (0.02)	0.36 (0.024)	.478(148)	NS
P_{max}	14.24 (5.19)	19.43 (15.46)	-0.397(148)	NS
O_{max}	92.58 (33.72)	180.95 (154.73)	-0.750(148)	NS
r^2	0.71(0.02)	0.68(0.03)	0.80(148)	NS
Exponential				
Q0	81.45 (9.80)	55.35 (10.91)	1.780(111.94)	NS
α	0.03 (0.01)	0.04 (0.01)	-0.867(139)	NS
k	2.1	2.1	---	---
r^2	0.88(0.02)	0.84(0.03)	0.947(148)	NS

Appendix S



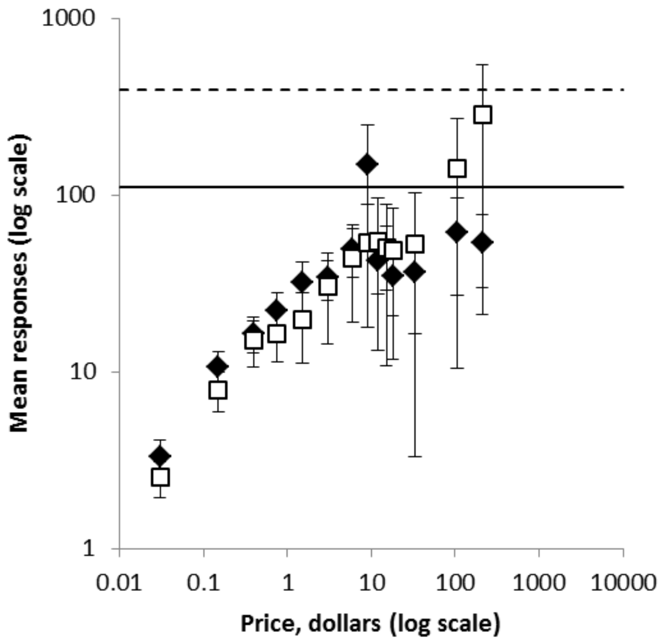


Figure 12. The number of food portions purchased (top) and responses (bottom) on high-magnitude prices of the Food Purchasing Task. Low PBF (15.6%-28.2%) and High PBF (40.8%-53.4%) for female participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF by solid and High PBF by dotted).

Appendix T

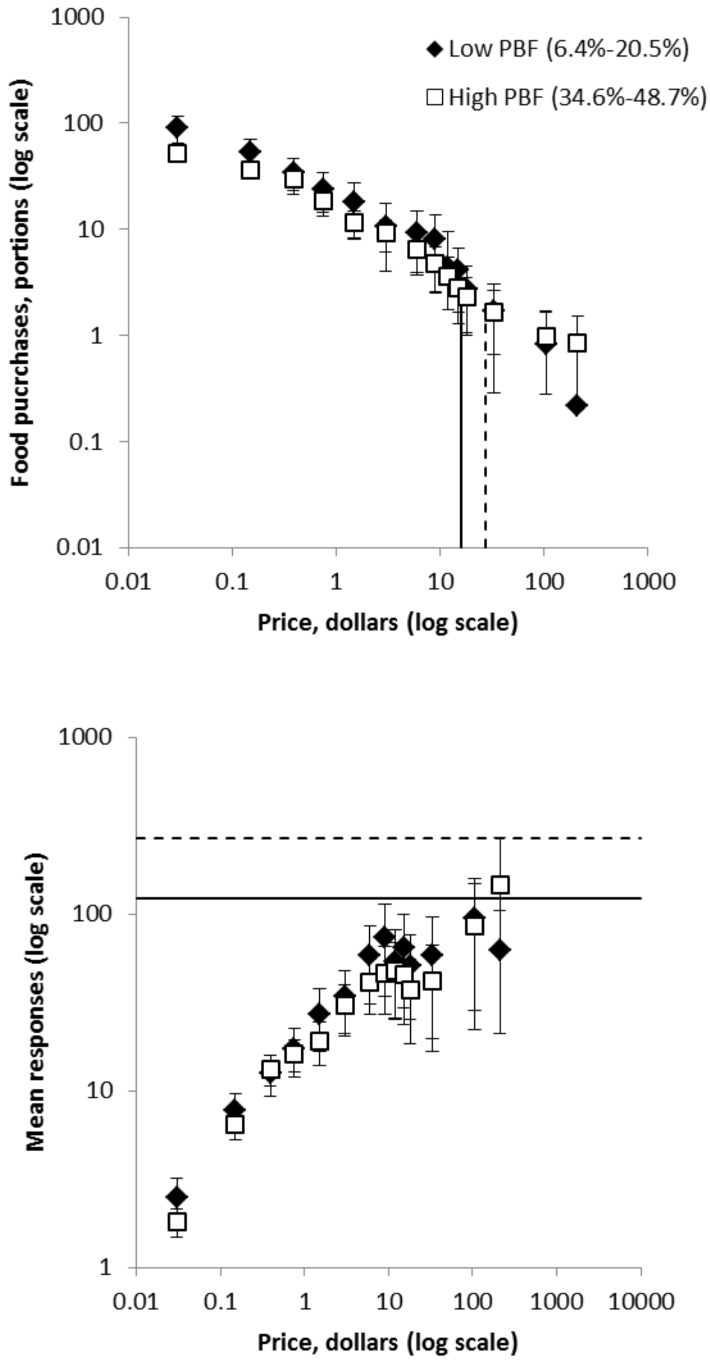


Figure 13. The number of food portions purchased (top) and responses (bottom) on high-magnitude prices of the Food Purchasing Task. Low PBF (6.4%-20.5%) and High PBF (34.6%-48.7%) for male participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low PBF by solid and High PBF by dotted).

Appendix U

Table 17. Free parameters for linear elastic (top) and exponential demand (bottom) for lower PBF vs upper PBF on the high-magnitude Food Purchasing Task.

	Lower PBF Mean(SEM) (6.4% to 21.0%)	Upper PBF Mean(SEM) (37.6% to 53.4%)	*t*(df)	p-value
Linear				
L	82.29(21.00)	63.85(12.26)	0.648(87)	NS
a	0.01(0.00)	0.56(0.55)	1.278(87)	NS
b	0.71(0.08)	0.81(0.10)	0.818(87)	NS
P_{max}	12.76(7.79)	27.79(22.40)	-0.746(87)	NS
O_{max}	135.81(68.87)	268.86(223.03)	-0.680(87)	NS
r^2	0.84(0.03)	0.86(0.04)	-0.421(87)	NS
Exponential				
Q0	7.508(9.02)	51.31(9.51)	1.632(87)	NS
α	0.03(0.01)	0.04(0.01)	-0.629(87)	NS
k	2.1	2.1	---	---
r^2	0.88(0.02)	0.84(0.03)	0.947(87)	NS

Appendix V

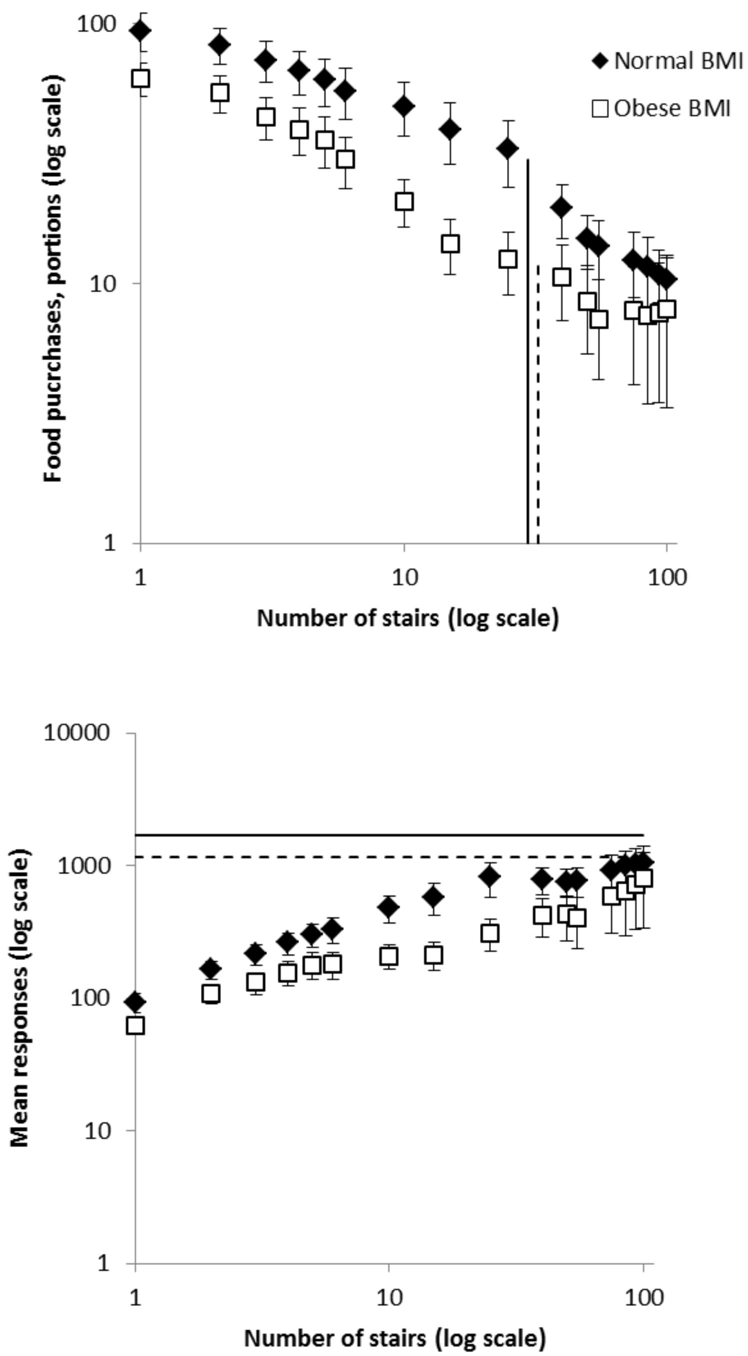


Figure 14. The number of food portions purchased (top) and responses (bottom) on low-effort stair prices of the Food Climb Task. Normal and Obese participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Normal BMI by solid and Obese BMI by dotted).

Appendix W

Table 18. Free parameters for linear elastic (top) and exponential demand (bottom) for Normal vs. Obese BMI on the low-effort Food Climb Task.

	Normal BMI M(SEM)	Obese BMI M(SEM)	*t*(df)	p-value
Linear				
L	88.64 (15.16)	72.55 (12.46)	0.686(148)	NS
a	0.03 (0.07)	0.39 (0.08)	1.057(148)	NS
b	0.66 (0.06)	0.77 (0.39)	1.435(148)	NS
P_{max}	29.57 (3.27)	32.37 (4.62)	-0.473(148)	NS
O_{max}	1700.60 (400.27)	1153.51 (461.90)	0.830 (148)	NS
r^2	0.81(0.03)	0.77(0.05)	0.953(148)	NS
Exponential				
Q0	121.84(19.83)	79.755(11.76)	1.403(132)	NS
α	0.01(0.00)	2.00×10^{-3} (0.00)	-0.949(132)	NS
k	3.2	3.2	---	---
r^2	0.85(0.02)	0.86(0.03)	-0.164(132)	NS

Appendix X

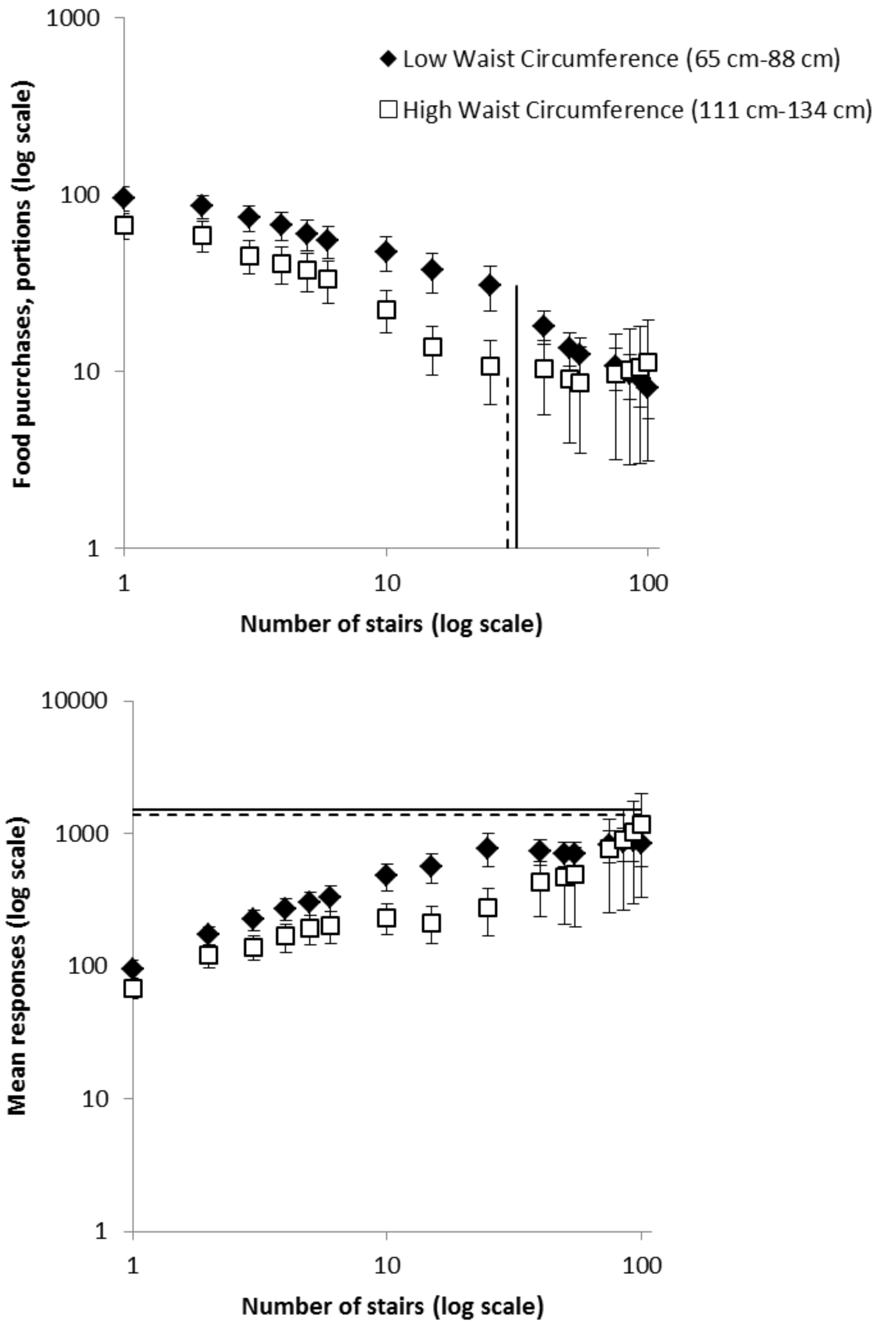


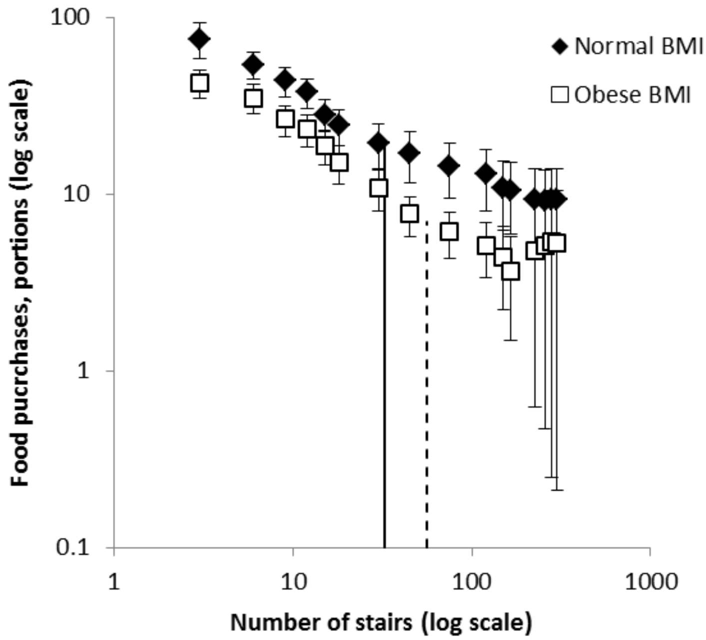
Figure 15. The number of food portions purchased (top) and responses (bottom) on low-effort stair prices of the Food Climb Task. Low waist circumference (65 cm-88cm) and High waist circumference (111 cm-134 cm) for participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low waist circumference by solid and High waist circumference by dotted).

Appendix Y

Table 19. Free parameters for linear elastic (top) and exponential demand (bottom) for lower waist circumference vs upper waist circumference on the low-effort Food Climb Task.

	Lower Waist M(SEM) (65 to 88 cm)	Higher Waist M(SEM) (111 to 134 cm)	*t*(df)	p-value
Linear				
L	90.46(14.71)	67.78(11.05)	0.750(135)	NS
a	0.04(0.002)	0.08(0.07)	1.008(135)	NS
b	0.64(0.06)	0.87(0.10)	1.770(135)	NS
P_{max}	31.40(3.16)	29.19(5.81)	0.316(135)	NS
O_{max}	1503.62(330.25)	1375.19(803.93)	0.166(135)	NS
r^2	0.86(0.02)	0.89(0.04)	-0.687(148)	NS
Exponential				
Q0	125.15(19.41)	81.23(15.47)	0.973(124)	NS
α	1.00×10^{-3} (0.00)	1.00×10^{-3} (0.00)	-0.821(124)	NS
k	3.2	3.2	---	---
r^2	0.82(0.03)	0.84(0.05)	-0.353(132)	NS

Appendix Z



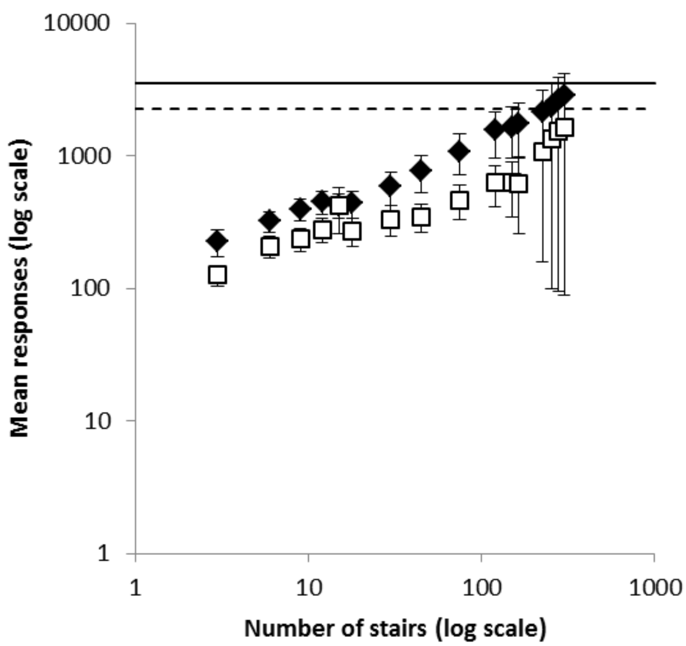


Figure 16. The number of food portions purchased (top) and responses (bottom) on high-value stair prices of the Food Climb Task. Normal and Obese participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Normal BMI by solid and Obese BMI by dotted).

Appendix AA

Table 20. Free parameters for linear elastic (top) and exponential demand (bottom) for Normal vs. Obese BMI on the high-effort Food Climb Task.

	Normal BMI M(SEM)	Obese BMI M(SEM)	*t*(df)	p-value
Linear				
L	60.33(9.39)	45.18(7.74)	1.042(148)	NS
a	0.01(0.01)	0.02(0.00)	0.802(148)	NS
b	0.83(0.06)	0.77(0.84)	0.540(148)	NS
P_{max}	62.47(8.96)	56.33(10.62)	0.413(148)	NS
O_{max}	3533.67(1380.74)	2257.16(1526.95)	0.567(148)	NS
r^2	0.82(0.02)	0.86(0.02)	-1.278(148)	NS
Exponential				
Q0	100.06(20.81)	57.56(9.24)	1.381(146)	NS
α	1.00×10^{-3} (0.00)	1.00×10^{-3} (0.00)	-0.372(146)	NS
k	2.2	2.2	---	---
r^2	0.84(0.02)	0.77(0.04)	1.766(132)	NS

Appendix BB

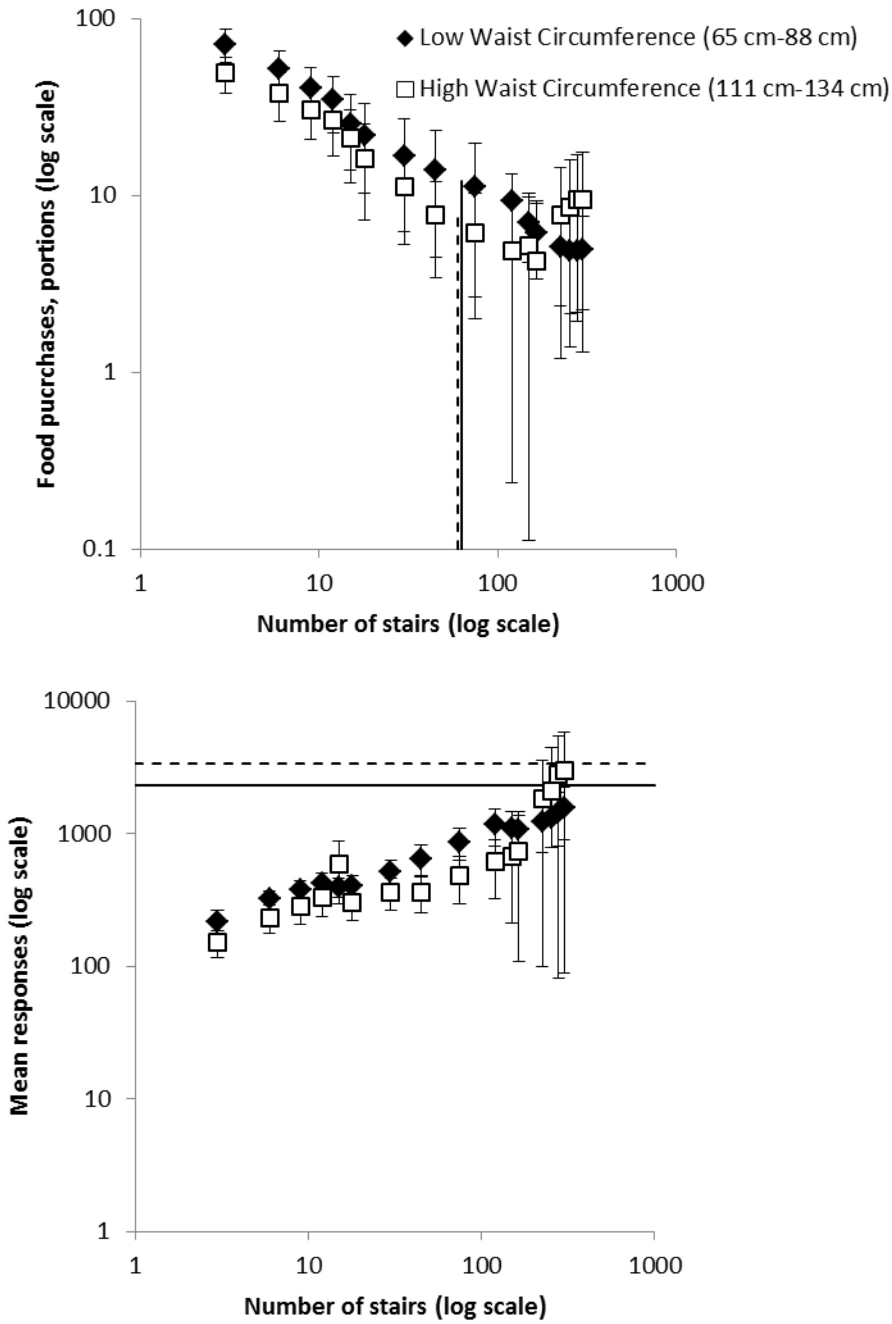


Figure 17. The number of food portions purchased (top) and responses (bottom) on high-effort stair prices of the Food Climb Task. Low waist circumference (65 cm-88cm) and High waist circumference (111 cm-134 cm) for participants are represented as diamonds and squares, respectively. P_{max} (top) and O_{max} (bottom) values are represented by vertical and horizontal lines, respectively (Low waist circumference by solid and High waist circumference by dotted).

Appendix CC

Table 21. Free parameters for linear elastic (top) and exponential demand (bottom) for lower waist circumference vs upper waist circumference on the high-effort Food Climb Task.

	Lower Waist M(SEM) (65 to 88 cm)	Higher Waist M(SEM) (111 to 134 cm)	*t*(df)	p-value
Linear				
L	57.64(8.45)	49.81(15.47)	0.973(135)	NS
a	0.01(0.00)	0.00(0.001)	-0.519(135)	NS
b	0.80(0.06)	0.84(0.11)	0.282(135)	NS
P_{max}	63.20(8.37)	60.00(14.38)	0.174(135)	NS
O_{max}	2326.85(685.23)	3398.22(2760.56)	-0.553(135)	NS
r^2	0.79(0.01)	0.78(0.02)	0.238(135)	NS
Exponential				
Q0	95.39(19.08)	65.17(12.85)	0.772(135)	NS
α	1.00×10^{-3} (0.00)	1.00×10^{-3} (0.00)	-0.783(135)	NS
k	2.2	2.2	---	---
r^2	0.84(0.02)	0.87(0.08)	-0.822(135)	NS