THE EFFECTS OF CUMULATIVE CONSUMPTION FEEDBACK ON DEMAND FOR MONEY AS A COMMODITY

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Behavioral economic theory describes a relation between response requirement and magnitude of reinforcement, and combines these variables into one independent variable (unit price) affecting operant behavior. This study investigated the relative effects of cumulative feedback on consumption for money as a commodity. Subjects were exposed to ranges of unit prices with or without a cumulative feedback bar on the computer screen indicating monetary earnings. For all participants in this study, consumption of money was a decreasing function of unit prices and the results from the present study are consistent with the behavioral economic prediction that increasing the unit price of a commodity will decrease consumption of that commodity. Analyses of demand curves, elasticity coefficients and response rates suggested differences between Feedback and No Feedback groups, although these were small and not statistically significant. The small differences observed were consistent with a behavior strengthening effect of feedback.

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CHAPTER 1

INTRODUCTION

Behavioral economics is a specialized area of experimental interest within the field of the experimental analysis of behavior. Hursh (1984) has defined behavioral economics as the application of microeconomics' classification, terminology, research methods and analysis within the theoretical framework of behavior analysis. Recent work within the field of behavioral economics has provided useful conceptualizations for analyzing both human and non-human behavior (Hursh, 1984). A basic element of behavioral economic theory is the study of the relationship between how much of a commodity an individual will consume (contact) at a specific price (DeGrandpre, Bickel, Hughes & Higgins, 1992). Behavioral economics relates to the theory and application of behavior analysis in that the study of behavior similarly recognizes individual behavior in terms of consequences and contingencies contacted (i.e., the relationship between the behavior of the individual or "consumer" and the reinforcer or commodity.)

Recent behavioral economic research has focused on the study of choice (DeGrandpre, et al.1992; DeGrandpre, Bickel, Higgins & Hughes, 1994; Hursh, 1993). Behavioral economics attempts to predict an individual's choice of a commodity based on the cost to obtain that commodity (DeGrandpre et al., 1994; Hursh, 1980). The theory assumes that a behavioral experiment functions as a dynamic economic system

and that economic properties of that system can determine an individual's choice of reinforcing commodities (Hursh, 1980). That is, behavioral economics predicts the individual's choice of a reinforcer by considering a given response requirement, reinforcer magnitude and the presence of other reinforcers (Bickel, Green, & Vuchinich, 1995).

A primary independent variable within the study of behavioral economics is unit price (UP). The UP quantifies an interaction between the response requirement and reinforcer magnitude in terms of a cost-benefit ratio, allowing a consolidation of several variables into one independent variable (DeGrandpre, Bickel, Hughes, Layng, & Badger, 1993). Hursh (1991) defined the UP in terms of the cost-benefit ratio in the following equation:

$$\text{Unit Price} = \frac{\text{Response per reinforcer x Effort}}{\text{Magnitude of reinforcement}}$$

For example, to obtain a UP5, a schedule would require 5 responses to obtain 1 reinforcer. Theoretically, different compositions of each UP will generate similar consumption levels (DeGrandpre et al., 1992). The basis of this assumption is important because it suggests that reinforcer value and response requirement manipulation can be functionally equivalent within certain parameters (Bickel, DeGrandpre, Hughes, & Higgins, 1991). This finding has recently been disputed by Madden, Bickel and Jacobs (2000) using cigarette puffs as a commodity, however, and should be examined further to ascertain the effects of differing compositions of the UP.

Applications of the UP to the experimental analysis of behavior have shown that interactions between reinforcer magnitude and schedule requirement determine the level

of consumption (Hursh, 1988; Bickel, 1990; DeGrandpre et al., 1994). Consumption is the primary dependent measure of behavior within the field of behavioral economics (Hursh, 1980). Consumption refers to the number of reinforcers contacted and has been defined by Bickel, DeGrandpre, Higgins, and Hughes (1990) with the following equation:

Consumption = Number of response requirement completions x reinforcer magnitude

The levels of consumption at a given unit price are described as demand. The demand curve is the most basic data analysis tool within these studies (Bickel, DeGrandpre, & Higgins, 1995). The theory of demand describes the amount of a commodity consumed as a function of the price of that commodity and is typically shown in log-log coordinates to represent proportional change (Hursh, 1984). Typically, as the UP increases a corresponding decrease in consumption results. For example, Bickel et al. (1991) analyzed the effects of increasing the response requirement (and thus the unit price) for cigarette puffs for human subjects who were smokers. Results indicated that levels of consumption remained stable at low unit prices and rapidly decreased at higher UP values. In economic theory, decreasing consumption as a function of increasing unit prices is labeled the “Law of Demand” (Hursh, 1980).

The extent to which consumption changes as a function of increasing price is referred to as *elasticity of demand* (Hursh, 1978, 1980, 1984; DeGrandpre et al., 1993; Bickel, et al., 1995). If consumption for a commodity changes very little, or not at all, as price increases dramatically, the demand for that commodity is said to be inelastic

(Hursh, 1978, 1980, 1984). Conversely, if consumption for a commodity decreases rapidly with small price increases, the demand for that commodity is said to be elastic.

It is important to note that elasticity is not an inherent property of the commodity or reinforcer (DeGrandpre et al., 1994). Elasticity of demand for a commodity can be affected by the availability of other commodities; thus, a given commodity cannot be said to be elastic or inelastic. The concept of elasticity simply describes the mathematical measure of the slope or the rate of change in consumption as a function of price (Hursh, 1978, 1980, 1987, 1991). The measure that determines if consumption or demand is elastic or inelastic is determined by a quantification of own-price elasticity measure defined by Samuelson and Nordhaus (1985) as the following equation:

$$E_D = \frac{\Delta Q}{(Q1+Q2)/2} \div \frac{-\Delta P}{(P1+P2)/2}$$

The ΔQ is the change in the quantity consumed, Q1 and Q2 are the quantity consumed under price 1 and 2 respectively, $-\Delta P$ is the change in price and P1 and P2 are the two respective prices. If the resulting coefficient is less than 1.0 the demand for that commodity is said to be inelastic between those prices (Bickel et al., 1992). Other coefficients of elasticity are also used (see DeGrandpre, et al., 1994 for a discussion of an alternative equation proposed by Allison, 1983) but they are not appreciably different from that proposed by Samuelson and Nordhaus (1985).

The types of reinforcers analyzed in economic research have varied since Kagel and Winkler (1972) first proposed the application of behavioral economics to the experimental analysis of behavior. Many studies of demand for essential commodities have utilized the basic principles of elasticity and unit price with non-human subjects (Kagel & Battalio, 1980). For example, Hursh (1978) analyzed consumption of food and water commodities at specific ratio (variable-ratio and fixed-ratio) schedule requirements. The results suggested that demand for both commodities was inelastic at relatively high prices. This is consistent with microeconomic theory in that certain commodities (such as luxuries) may tend to generate more elastic demand at lower prices and others that are essential commodities for survival will produce inelastic demand at relatively higher prices (Samuelson & Nordhaus, 1985).

In a study by Foltin (1994), the effect of the magnitude of food pellets on demand was examined using the UP analysis. Results suggested, as predicted by demand law, that higher UP values produced lower work output rates and lower consumption levels even when the magnitude of the reinforcement (grams of food) was increased. However, demand remained inelastic at all prices for food. In another experiment by Green and Rachlin (1991), consumption of electrical brain stimulation (EBS) by rats was compared to their consumption of water. The results showed that demand for the essential commodity, water, remained inelastic while demand for a non-essential commodity, EBS, became elastic at these prices. According to Hursh (1994), the basic law of demand would have predicted these results in that the nature of the commodity (e.g., luxury or necessity) is a variable that alters elasticity of demand for a commodity.

More recently, the study of reinforcers within the framework of behavioral economics has focused on non-essential commodities such as addictive drugs. The research extensions to drug self-administration have demonstrated that the economic concepts of demand, unit price, and elasticity pertain to drug reinforcement as well as commodities such as food and water (Bickel et al., 1991; Bickel et al., 1995; Carroll, Carmona & May, 1991; DeGrandpre et al., 1995; Green & Kagel, 1996). As with the analysis of essential commodities, most of the research has focused on non-humans and has typically investigated choices between two separate reinforcers. For example, some earlier studies analyzed economic relations between self-administration of heroin and food in baboons, ethanol and PCP in rhesus monkeys, food and cocaine in rhesus monkeys, and saccharine and PCP in rhesus monkeys (Carroll, 1987; Carroll, et al., 1991; Griffiths, Wurster & Brady, 1981; Woolverton, English & Weed, 1997).

It has been argued that further studies should investigate the economic effects of human drug self-administration due its ability to provide both a conceptual analysis of socially significant behaviors and implications for treatment, yet research with human subjects has been limited (Bickel et al., 1995; Hursh, 1993; DeGrandpre et al., 1994). For example, Bickel et al. (1995) reviewed the drug self-administration research from 1966 to 1992 and showed that the majority of studies were conducted with non-human subjects. Each of the studies that had used human subjects attempted to assess the effects of two concurrently available commodities such as nicotine, coffee, alcohol and marijuana (Bickel, et al 1995). Of these, only one study included an analysis of a non-drug reinforcer: money (DeGrandpre et al., 1994). DeGrandpre et al. (1994) investigated the

effects of concurrently available cigarettes and money to assess the economic effects of each. Results showed that demand for money was more elastic than demand for cigarettes. DeGrandpre et al. (1994) stated that, prior to this study, consumption of money as a commodity had not been investigated.

Viken (1999) investigated consumption of money alone with different compositions of the UP. Results suggested that consumption of money with humans adheres to the law of demand in that consumption decreased as UP increased. Furthermore, an analysis of elasticity of consumption showed that consumption became elastic at relatively high prices. That is, consumption became elastic for 3 subjects between UP4 and UP6, UP5 and UP7 and UP16 and UP 18 respectively. In a follow up study by Reyes (2000) investigating the effects of instructions describing the unit price in effect, results suggested that some methodological aspects of the Viken (1999) study might have contributed to the relative high degree of inelasticity observed. Reyes (2000) modified some aspects of the experimental procedures and found that consumption became elastic at lower values (between UP3 and UP5) for two out of three subjects. These results suggested that instructions or other procedural aspects (such as how the session was terminated) might have a significant impact on both work output and consumption levels.

The Viken (1999) and Reyes (2000) studies differed ways. However, because no controlled comparison was made, it is not known which of these procedural differences might be responsible for differences in demand or elasticity of money. For example, Viken (1999) included a passive escape response that required subjects to wait for 3

minutes before the session would terminate whereas Reyes (2000) included an active escape key with which subjects could choose to terminate the session at any point. Viken (1999) also included a cumulative feedback bar that was present throughout all sessions displaying total amount of money earned; Reyes (2000) had excluded this in his study. This type of informative feedback bar had been previously used in both behavioral economic and other studies investigating money as a reinforcer (DeGrandpre et al. 1994; Matthews, Shimoff, Catania & Sagvolden, 1977; Shimoff, Matthews & Catania, 1986) yet the independent effects of these types of feedback mechanisms have not been investigated in the behavioral economic literature. The use and effectiveness of feedback in applications of behavior analysis suggest that it might be worthwhile to study these feedback mechanisms in basic behavioral economic research.

Organizational behavior management (OBM) performance change programs commonly involve the use of a feedback component as a part of an applied intervention strategy (Daniels, 1989). Daniels (1989) has contended that feedback can effectively change and/or maintain performance within certain parameters. Performance feedback has been defined as information communicated back to the individual regarding some important aspect of past performance (Prue & Fairbanks, 1981). Further, performance feedback is most effective when the feedback is specific, based directly on performance that the performer has control over, and when it functions as an antecedent to reinforcement (Daniels, 1989).

According to Balcazar, Hopkins, and Suarez (1986) and Nolan, Jarema and Austin (1999), over 70% of OBM research utilizes some form of performance feedback.

Such studies have reported success including increasing employee individual performance utilizing performance feedback (Balcazar, Hopkins & Suarez, 1986). Allison, Silverstein and Falente (1992) utilized "objective" feedback in the form of cumulative graphs displaying current and past performance. Allison et al. (1992) state that this type of objective performance feedback is effective in improving (increasing responding) employee performance in general when paired with some type of incentive system. Newby and Robinson (1983) describe the use of public feedback postings and contingent rewards to reduce cash inaccuracies, increase punctuality and increase the daily checkout proficiency of clerical employees in a retail setting. Results suggested that the use of individual feedback alone and with rewards substantially increased performance and efficiency in all targeted areas.

Research within the field of OBM is somewhat consistent in that the results have shown that informative feedback, when combined with some tangible incentive, is effective in increasing productivity in clerical jobs, administration performance, industry and human service settings (Andrasik, 1989; Wilk & Redmon, 1998; Merwin, Thomason & Samford, 1989). However, the definition of feedback varies considerably across instances of feedback implementation and it is usually combined with tangible rewards and other variables such as goal setting and/or social consequences (Houmanfar & Hayes, 1998). The various effects of differing types of feedback in the OBM literature suggests a need to analyze the effects of different feedback mechanisms on performance (Nordstrom, Lorenzi & Hall, 1991).

The effects of performance feedback within the experimental field of behavioral economics have not been analyzed at all. It is unclear what impact feedback may or may not have on consumption. That is, will elasticity of demand increase or decrease when informative feedback about cumulative consumption is employed? Economic studies employing a feedback component have included a cumulative feedback bar or counter when analyzing money as a commodity (DeGrandpre et al., 1994; Viken, 1999). Other economic studies (e.g., Reyes, 2000) have not utilized consumption feedback during the session; however, other procedural differences made it impossible to isolate the effects of this kind of variable. The purpose of this study was to examine the effects of a cumulative feedback component on consumption of money as a commodity. Two groups of subjects were exposed to identical sequences of changing unit prices, but one group received on-screen feedback about levels of consumption while the other group did not.

CHAPTER 2

METHOD

Participants

Six undergraduate students from the University of North Texas volunteered to participate in this study. Four participants were female and two participants were male ranging between 18 to 26 years of age. Participants were recruited from introductory classes in behavior analysis, newspaper advertisements and posted flyers around the university campus. Participants were selected based on their ability to complete a prescreening questionnaire to determine whether any visual or motor impairments were present and the ability to perform multiplication problems at a minimum rate of 12 per minute on a 2-minute timed test. Participants had the opportunity to earn from $0.00 to $6.00 in $.05 increments in each session. The participants received a bonus of $25.00 for completion of the experiment.

Apparatus

The experiment took place in two small laboratory rooms at the University of North Texas. Each room was equipped with a computer programmed with or without the feedback component. One experimental group was assigned to one room and the other group to the other room. The laboratories both contained a desk with a computer, monitor, keyboard, mouse and a chair. Each room was also equipped with a one-way mirror with blinds. Participants were seated alone in the experimental room and were prohibited from bringing outside materials into the room during sessions.

The apparatus used throughout this study was one of two IBM-compatible computers with a Pentium-based 200 MHz processor, monitor, keyboard, and mouse. The Visual Basic computer program presented multiplication problems ranging from 1 x 1 to 10 x 10 one at a time on the monitor screen. The numbers appeared in 150pt Comic Sans Serif font on a gray screen with a square space at the middle bottom where answers were to be typed on the numeric keypad or numbers at the top of the keyboard. All keys remained operable but only correct answers to the multiplication problems resulted in monetary compensation. When a correct answer was entered the next problem appeared. If an incorrect answer was entered, the text color of the numbers presented changed from black to red and the numbers remained on the screen until the correct answer was provided. The maximum number of math problems presented was determined by the current unit price. When each schedule requirement was completed, a sound clip of a human voice stating “5 cents” was presented. At any time during the session, subjects could press the “Q” button on the keyboard to end the session.

For the feedback group only, an additional feature of the computer program was employed. Subjects assigned to the feedback group were exposed to a blue income bar at the top of the screen measuring .5 inches in height and stretching from the top left to the top right of the screen, denoting earnings from 0 to 600 cents. When each response requirement was completed, the sound clip denoting the 5-cent earning was presented with a concurrent move of the bar from left to right in a 5-cent increment.

Procedure

The independent variable in this experiment was the presence or absence of the informative feedback income bar. Subjects were randomly assigned to one of two groups: Feedback or No Feedback. In the Feedback condition, subjects were exposed to the income bar throughout the entire experiment. Subjects assigned to the No Feedback condition were exposed to all general procedures and apparatus configurations without the income bar present.

The main dependent variables included the total consumption of money at each UP and the total work output at each UP. Consumption levels refer to how much of the given commodity (money in cents) the participant earned during a session. The work output variable refers to how many problems were solved during the session. In addition, response rates and session duration data were collected.

Prescreening. At the initial meeting with the experimenter, participants were seated alone in a room with an experimenter and the following statements were read aloud:

> "The experiment you are about to participate in involves solving multiplication problems ranging from 1 X 1 to 10 X 10. Only one session will be conducted per day, and the total number of sessions will be around 15. You will earn a $25.00 bonus when you complete all of the sessions. Sessions must be scheduled for a time that will not conflict with other activities. For example, sessions should not be scheduled directly before a meeting or class time."

Participants were then asked to complete a multiplication sheet containing all problems used within the experiment. After this was completed, participants were presented with a similar form that contained the same problems (presented in a different format) for completion on a 2-minute timed test. The participant was selected if he/she completed the multiplication problems at a minimum rate of 12 per minute. The participant then completed a questionnaire that assessed their ability to look at a computer for a prolonged period of time, type on a keyboard with little to no dexterity problems, and the extent to which they could participate without any schedule conflicts. An informed consent form was then completed.

Training. A training session followed the prescreening meeting. During this session, the participants practiced ending the session by earning the maximum amount possible and by terminating the session by pressing the "Q" button. Prior to the participants' arrival to the scheduled session, the experimenter set the maximum earning value at $.25 and the UP value was set at 1. After each of the participants completed prescreening, they were seated in the experimental room in front of the computer, and the experimenter read the general instructions. This was followed by these additional training instructions:

> "The purpose of this session is to familiarize you with the experiment. In this session you will earn 25 cents. Normally, you will be able to earn up to $6.00. When you earn the 25 cents the session will terminate. At this point, exit the room and find the experimenter. Please begin when I exit the room."

When this session was completed, the participant was asked to exit the room while the session was reset. After the participant entered the room again the following instructions were read aloud for this session only:

> "Now I would like you to practice ending the session. When the first problem is presented, terminate the session. You may refer to the instructions if necessary. I will remain in the room during this session"

At the completion of the training session, participants were paid the amount earned, $0.25, and the next session with the experimenter was scheduled.

General Procedure. Participants in each group were exposed to all general procedures either with or without the feedback bar present on the apparatus. Under both conditions, participants solved math problems that were presented on the computer screen, which were later redeemable for money. The number of math problems was determined by the current unit price and the unit prices ranged from UP 1 to UP 10. The amount of money available to each participant was between $0.00 and $6.00 for each session. Unit prices were calculated by dividing the number of correct math problems required by the number of cents delivered (5 cents). One unit price was operative per session and the sequence of UP presentation was in ascending order as follows: UP 1, UP 3, UP 7, UP 5, UP 10. A second exposure to the sequence was programmed for all participants, but one subject (Subject 3 in the No Feedback group) terminated participation in the experiment after the first exposure to the UP sequence. Except for the training session, participants engaged in one session per day.

The participants determined the session length for each session. They were asked to schedule sessions that would not conflict with other scheduled activities in order to not impose any time constraints on each session. The participants were instructed that they could discontinue the session at any time by pressing the letter "Q" on the keyboard. Participants were permitted to take breaks at any point during each session. At the end of each session the computer displayed the amount of money earned and each participant then received payment in cash for that day's earnings.

At the beginning of each session, participants were asked to sit down in front of the computer while the experimenter reviewed the session instructions that were posted on the laboratory wall. The instructions were displayed as follows:

> "In this experiment, you will have the opportunity to earn up to $6.00 every session. The way you can earn money is to work by solving math problems. The purpose of this study is to investigate choice. In each session, you will be able to choose to work as little or as much as you want. You can solve as few or as many math problems as you choose. If you choose to solve math problems, type the answer using the numeric keypad and press the enter key. If the answer is correct, another problem will be presented on the screen. If the answer is incorrect, the problem will turn red, and will remain on the screen until a correct answer is provided. Incorrect responses will NOT count against you in any way. While solving the problems, you may notice a sound periodically informing you of the amount of money you have just earned. The computer will keep a running total of your earnings throughout each session. If you choose not to solve math problems,

at any time after the session begins you may press the “Q” button on the keyboard followed by the enter key and the session will terminate. There is no penalty for pressing the “Q” button at any point throughout the session and you will be paid for the amount of money you have earned up to that point. You may also take short breaks at any point throughout the session to use the bathroom or to get a drink of water. Do not press “Q” if you want to take a break; you may leave a problem presented on the screen until you return. When the session ends, a screen will appear telling you how much money you have earned and you may go inform the experimenter that you have finished. Please remember, there is no right or wrong way to respond. It makes no difference to the experimenter what you choose to do. The number of math problems you choose to solve is entirely up to you.”

Participants were then instructed to begin the session when the experimenter left the room. Any questions related to the experiment were answered reading the relevant section of the given instructions. Participants were paid the amount of money earned at the end of each session. At the end of the experiment, each participant received a $25.00 bonus and was fully debriefed as to the purpose and results of the experiment.

CHAPTER 3

RESULTS

The primary dependent variable in this experiment was consumption of money at different unit prices. Total consumption was analyzed in terms of the demand for the commodity and the work output for such commodity. The demand functions are displayed by plotting consumption against increasing unit price in logarithmic coordinates. The shape of the demand curve, as per economic theory, usually results in an approximate hyperbolic function as unit price increases. The display of work output functions is similar to the demand functions, using logarithmic coordinates with the total amount of responding plotted against increasing unit prices. The shape of this function displays response (work) output changes as unit price increases. Typically, a bitonic function is obtained and the peak corresponds to the point at which demand becomes elastic.

The elasticity of demand between prices (i.e., the resulting slope between prices) was calculated according to the equation described by Samuelson and Nordhaus (1985). Using this formula, demand is considered elastic if the resulting coefficient is greater than or equal to 1.0 and inelastic at any coefficient less than 1.0. As is the case with slope calculations, the magnitude of the resulting coefficient relates to the decrease in the Y value. Therefore, a large elasticity coefficient indicates more elastic demand.

Session duration data were collected to enable the calculation of rate of problems (problems per minute) solved during each session. The session duration data was also analyzed in order to examine any possible "self-imposed" time constraints. If session duration was flat across all unit prices, this suggests that the participant may have been allocating a fixed amount of time to each session. If this were the case, reductions in consumption at high unit prices would be due simply to the inability to complete response requirements within the self-imposed time limit.

In terms of general findings, this study produced two consistent findings. First, all participants showed a decrease in consumption as unit price increased, as shown in the top graphs of Figures 1-6 which display the demand curves for all participants. This indicates that the behavior of the participants conformed to the Law of Demand. Secondly, as shown in the bottom graphs of Figures 1-6, work output functions were bitonic in nature for 4 out of 6 participants. Differences in the points at which the curves became elastic, the magnitudes of the elasticity, the levels of consumption within and between groups, session durations, and the rates of problem solving will be discussed below by group.

No FB Group

Figures 1-3 show the demand and work output functions for the 3 participants in the No FB group for first exposure and second exposure to the sequence of unit prices (S1 and S2). Participant S3 was exposed to only one sequence of unit prices before she withdrew from the experiment. The demand curve for participant S1, displayed in Figure 1, became elastic between UP7 and UP10 with an elasticity coefficient of 2.20. The work

output for this participant showed a bitonic function with the peak in total responding at UP7, corresponding to the point of elasticity. For participant S2, shown in Figure 2, demand became elastic between UP7 and UP10 as well with a coefficient of 2.90, and the work output function displays a similar bitonic function with a corresponding peak work output at UP7. For participant S3, shown in Figure 3, demand became elastic between UP7 and UP10 with a coefficient of 2.50. The work output functions show the peak at UP7.

Table 1 shows the elasticity coefficients between prices for each subject in both groups. For all 3 participants in the No FB group, demand became elastic between UP7 and UP10. The magnitude of elasticity for each participant in the No FB group exceeded 2.00 at the highest unit prices, between UP7 and UP10.

Table 2 displays the consumption levels for all participants. The consumption levels for each of the participants in the No FB group were relatively similar. Consumption at UP1 and UP3 was 600 cents for all subjects in the No FB group for both the first and second (S1 and S2) exposures to these prices. At UP5, participants S1 and S3 both consumed 600 cents on the first exposure. For S2 at UP5, consumption for the first and second pass decreased from the average of 600 cents at UP3 to an average of 405 cents. At the higher prices UP7 and UP10, all participants showed a decrease in consumption.

The session duration data for the participants in the No FB and the FB group are displayed in Figures 7 and Figure 8 respectively. As shown in Figure 7, session duration for participants S1 and S3 increased from UP1 to 5or 7 and decreased at UP10. For

participant S2, session duration peaked at UP7 for the first exposure to the unit price sequence. For the second sequence exposure, the session durations were more stable at UP5, UP7 and UP10. The session duration for this participant never increased over 61 minutes for any session. Participant S2 may have imposed a 1-hour time limit during the second exposure to the prices.

Figure 9 displays the rate of responding for each session and the corresponding UP within each session. The top graph shows problems solved per min (PPM) for the No FB group. For participant S1, the rate of responding increased across sessions 1 to 6 from 40.73 PPM at session 1 to 55.30 PPM at session 6. The rate of problems solved in sessions 7 to 10 remained approximately stable at an average of 55.19 PPM. Participants S2 and S3 showed increases in problems solved per minute within the first 3 sessions. The rate of problem solving for participant S2 increased from sessions 1 to 7, then decreased in rate from 58.96 PPM in session 7 to 37.36 PPM in session 8. Rates decreased further in sessions 9 and 10, when the participant solved 29.82 and 20.41 PPM, respectively. For participant S3, rate of problem solving decreased at session 4 to 41.82 PPM from 56.55 PPM in session 3, and decreased to 5.45 PPM in session 5, after which the participant terminated the experiment.

FB Group

Figures 4-6 show the demand curves and work output functions for the 3 participants in the FB group for first and second exposure to the sequence of unit prices. Each participant in the FB group produced different demand curves with elasticity appearing at different UP values or not at all (see Table 1). The demand curve for

participant S4, displayed in Figure 4, became elastic between UP5 and UP7 and remained elastic between UP7 and UP10 with elasticity coefficients of 1.20 and 1.31 respectively. The work output for this participant showed a bitonic function with the peak in total responding at UP5 corresponding to the point at which demand became elastic. For participant S5, shown in Figure 5, demand became elastic between UP3 and UP5 with an elasticity coefficient of 1.13 but remained inelastic at the higher prices of UP5, UP7 and UP10. The work output function failed to display a bitonic function and resulted in a relatively flat average work output curve. For the participant S6, shown in Figure 6, demand remained inelastic between all prices up to UP10 with elasticity coefficients of 0.00 between UP1 and UP3, UP3 and UP5 and UP5 and UP7 and a coefficient of 0.66 between UP7 and UP10. The work output functions for S6 show the peak at UP10.

For participants S4 and S5, the magnitude of the elasticity coefficient was higher than 1.00 but remained below a coefficient of 2.00 at even the highest unit prices (see Table 1). For the participant in the FB group whose demand did not become elastic at any price (S6), the largest elasticity coefficient was between UP7 and UP10 with a value of 0.66. Table 1 shows that the No FB group produced the highest elasticity coefficients.

The consumption levels for participants in the FB group (as shown in Table 2) varied. Consumption at UP1 was 600 cents for all participants in the FB group for both the first and second exposure. Participants S4 and S5 consumed 600 cents in the first and second exposures to both UP3 and 5. Participant S5's average consumption at UP3 was 432.5 cents. At UP5 the average consumption for S5 was 242.5 cents. At UP7, each participant's consumption levels differed, but each participant consumed the same

amount in the first and second pass through the UP sequence. Participant S4 consumed 400 cents in both passes, S5 consumed 200 cents and S6 consumed 600 cents. At UP10, all participants in the FB group showed a decrease in consumption. For participant S4, consumption decreased at UP 10 to an average of 250 cents. For S5, consumption decreased at UP10 to an average of 165 cents. For S6, consumption decreased from an average of 600 cents at UP7 to 475 cents at UP10. The mean consumption was higher at UP10 for the FB group (m=296.7) than for the No FB group (m=163.3), though this was not statistically different according to an analysis of variance (p=.247).

Figure 10 displays the average consumption for all participants in both the No FB group (top graph) and the FB group (bottom graph). A visual inspection shows the slight difference in average consumption between both groups. In particular, at UP10, 2 out of 3 participants in the FB group show higher average levels of consumption than any of the participants in the No FB group.

The session duration data for the participants in the FB group are displayed in Figure 8. For S4, session duration increased to UP5 where the duration data remain relatively stable never increasing above 60 minutes. This suggests a possible "self-imposed" time constraint for S4. Participant S5 duration data shows first an increasing trend between UP1 and UP3 then decreasing trend for the first exposure between UP5 and 10. The second exposure for participant S5 shows both increasing and decreasing session duration data from UP1 to UP10. Session duration for participant S6 showed increasing session duration from UP1 to UP10 in the first exposure to the UP sequence.

The second exposure to the unit price sequence for participant S6 showed a decrease from the first exposure at all unit prices, with peak session duration at UP7.

Figure 9 displays the rate of responding for each session and the corresponding UP within each session. The bottom graph shows PPM for the FB group. For participant S4, the rate of responding increased between sessions 1 to 5 from 39.29 PPM at session 1 and 53.17 PPM at session 5 and remained stable at an average of 53.53 PPM from sessions 6 to 10. For participant S5, there was no apparent increase in rate of responding from sessions 1 to 5 with an average rate of responding of 38.26 PPM. The rate of responding for S5 increased at session 6 to 53.10 PPM then decreased to 26.76 PPM in session 7. For S5, the rate of responding increased from session 8 with a rate of 38.64 PPM to a rate 70.13 PPM in session 10. The rate of problem solving for participant S6 increased from sessions 1 to 3 from 39.60 in session 1 to 64.21 PPM in session 3. Participant S6's rate of responding in session 4 increased slightly across the remaining sessions with a terminal rate of 69.65 PPM in session 10. In general, subjects in the FB group produced the highest response rates. High response rates were maintained or increased across the experiment for participants in this group, in contrast to the falling rates observed in the No FB group.

CHAPTER 4

DISCUSSION

Behavioral economic theory describes a relation between response requirement and magnitude of reinforcement, and combines these variables into one independent variable (unit price) affecting operant behavior (Hursh, 1984). Economic theories of behavior have made several predictions regarding the outcomes of utilizing unit price as an independent variable and consumption as a dependent variable (Madden et al., 2000). Results from the present study are consistent with the behavioral economic prediction that increasing the unit price of a commodity will decrease consumption of that commodity (Bickel, et al., 1995; DeGrandpre et al., 1993; Hursh, 1978, 1980, 1984; Madden et al., 2000). For all participants in this study, consumption of money was a decreasing function of unit prices. Response output functions were bitonic for 4 of the 6 participants. The fact that demand for money decreases with increasing unit prices is consistent with the "Law of Demand", a phenomenon typically observed with other non-monetary commodities (DeGrandpre & Bickel, 1996). The findings of the present study add to the small but growing set of studies showing that money conforms to some basic principles of consumer demand theory (DeGrandpre et al., 1994; Reyes, 2000; Viken, 1999).

Applied and basic research within the field of OBM has suggested that different types of feedback can improve performance (Daniels, 1984). Those increases in performance have usually been measured as increases in the quantity or rate of desired accomplishments. Feedback has not been examined in an economic framework, so there

is no specific prediction about which economic dimension might be affected by feedback. The variable manipulated in this study was the presence or absence of a cumulative feedback component. Consumption levels and the elasticity of demand were analyzed between groups to assess what impact, if any, the presence of a cumulative feedback bar would have on demand at each unit price. Several slight differences were found between groups suggesting the possibility that the feedback component affected demand.

The major differences between the FB and No FB group were suggested by inspection of the demand curves and the resulting elasticity coefficients. Consumption levels for both groups generally remained high until UP10 was encountered. At UP10, the demand for participants in the No FB group decreased substantially, yielding large elasticity coefficients. Decreases in consumption across prices for participants in the FB group yielded shallower demand curves, with elasticity coefficients slightly greater than 1.0. Average consumption levels for the FB group were higher than those of the No FB group at UP10, though this was not statistically significant.

Response rate data also showed some differences between the groups. Response rates for 2 of 3 participants in the No FB group decreased during their last several sessions, whereas response rates for 2 of 3 participants in the FB group increased during the last several sessions. The highest response rates were produced by participants in the FB group. The differences in demand and response rate between the groups, although small, are consistent with a behavior-strengthening effect of the feedback component.

The small differences between both groups were observed at the highest unit prices. This suggests that even higher prices might have caused the two groups'

performances to diverge further. If the present data trends can be extrapolated, it is possible that consumption levels of the No FB group would have decreased well below that of the FB group at a UP15 or UP20. It is possible that any behavior-strengthening properties of feedback might only become apparent at high unit prices when the motivation to continue to respond is severely challenged.

Between-subject differences in demand were also observed within the FB group whereas between-subject demand in the No FB group was more similar. Participant S5 in the FB group produced an atypical demand curve. Demand for S5 became elastic between UP3 and UP5 and then remained inelastic for the remainder of the experiment. The work output functions for S5 show a slight bitonic function at the lower price structures but remain relatively flat at the higher unit prices. S6 also produced an atypical demand curve in that demand remained inelastic at all prices. These results suggest that the feedback component may function differently for each individual. For example, participant S4 reported during a post-experiment debriefing that the feedback bar helped her "target" what she wanted to earn each session. This may help explain S4's consumption levels, which were always an even dollar amount (i.e., $2.00, $3.00, $4.00 and $6.00) as opposed to consumption that was a dollar amount plus *X* amount of cents, frequently observed with other participants.

The unit price structures used in this experiment were composed of a fixed ratio schedule of reinforcement (i.e., UP=FR value/Magnitude of Reinforcement in cents). Reyes (2000) also used FR-based unit prices in some groups and suggested that subjects can readily calculate earnings and schedule requirements. It is important to note that

while debriefing both groups of participants at the completion of this experiment, they reported that the total number of responses required to earn the 5-cents was easy to calculate. That is, participants reported that they could count the number of responses and the amount of money they had earned. Both groups were exposed to the auditory stimulus indicating 5-cents had been earned upon completion of the response requirement. This could suggest that both groups were essentially functionally equivalent, in that both groups of participants could calculate their earnings as they progressed through the session. The feedback component, then, might have only confirmed the cumulative amount of money earned rather than the participants' estimations of earnings and therefore may provided only a marginal increase in information about their performance. This would suggest that any behavior-strengthening properties of feedback in this preparation were not due to informational elements of the feedback. Rather, it seems more likely that the visual stimulus of a representation of accumulating earnings might have some conditional reinforcing properties beyond that of simply indicating the delivery of a 5-cent consequence (see Shull & Lawrence, 1998).

The slight differences observed both within groups and between groups could be attributed to individual differences rather than to the independent variable. To examine this issue, this experiment should be replicated with a larger number of participants. Individual differences might have been enhanced in this study because it employed and "open economy." In an open economy, total consumption of the commodity is not exclusively the result of the amount of responding within a session due to the availability of the commodity outside a given session (Hursh, 1980, 1984, 1993). Hursh (1980) has

suggested that open economies produce strikingly different demand than do closed economies.

This experiment was conducted in an open economy, in which all participants had access to money outside the experimental session. This characteristic of the experiment could have affected responding (consumption) for all participants differently, given that this variable could not be controlled. Each participant's performance may have been affected by external variables that resulted in different levels of consumption within the experiment. For example, one subject (S6) stated at debriefing that she had lost her job and was saving money for a trip to Mexico. Her demand was the least elastic of all participants. The observed differences between and within both groups could have been affected by uncontrolled variables in the open economy and the effects of the feedback component thus enhanced or diminished.

Economic analyses of feedback effects have not been examined previously in either the behavioral economic literature or the OBM literature. Results of the present study are suggestive, though not conclusive, of an effect of feedback in maintaining demand at high unit-prices. Future studies should examine the effects of a cumulative feedback bar at higher unit prices than those utilized in this experiment. Results showing that feedback of this kind alters consumer demand would have significant implications for behavioral economic experiments utilizing money as the commodity of interest. Such an effect of feedback would also be of interest to researchers in the OBM area, as it would extend the range of effects already observed for a widely used element of performance improvement interventions. The economic analysis of behavior offers a

useful method for studying behavior constrained by costs and beneficial outcomes. This methodology would seem to be especially applicable to the field of OBM, in which all valued accomplishments are understood in light of their costs and benefits (Gilbert, 1978/1996). Future OBM research might benefit considerably by examining variables within the framework of economic analyses.

APPENDIX A

SCREENING QUESTIONNAIRE, MULTIPLICATION SCREENING TEST, DEBRIEFING QUESTIONNAIRE, AND INFORMED CONSENT

Screening Questions for Kathleen's research

Name of Participant: _____

Date of Birth: _____

Name of Experimenter: _____

- **Do you have the ability to look at a computer screen for an extended period of time?**
  Yes_____ **No_____**

- **Can you read small text on a computer screen?**
  Yes_____ **No_____**

- **Do you have any problems using your hands to work a computer keyboard for an extended period of time**
  Yes_____ **No_____**

- **Do you have any inhibitions to work in a room by yourself?**
  Yes_____ **No_____**

- **Do you have an extended understanding of basic research in behavior analysis**
  Yes_____ **No_____**

- **Do you have any commitments following the times that you have signed up for that may conflict with your participation?**
  Yes_____ **No_____**

Participant's signature / Date **Experimenter's signature / Date**

_____ _____

Screening Math Problems

NAME: _____

1x1=	**2x1=**	**3x1=**	**4x1=**	**5x1=**
1x2=	**2x2=**	**3x2=**	**4x2=**	**5x2=**
1x3=	**2x3=**	**3x3=**	**4x3=**	**5x3=**
1x4=	**2x4=**	**3x4=**	**4x4=**	**5x4=**
1x5=	**2x5=**	**3x5=**	**4x5=**	**5x5=**
1x6=	**2x6=**	**3x6=**	**4x6=**	**5x6=**
1x7=	**2x7=**	**3x7=**	**4x7=**	**5x7=**
1x8=	**2x8=**	**3x8=**	**4x8=**	**5x8=**
1x9=	**2x9=**	**3x9=**	**4x9=**	**5x9=**
1x10=	**2x10=**	**3x10=**	**4x10=**	**5x10=**

6x1=	**7x1=**	**8x1=**	**9x1=**	**10x1=**
6x2=	**7x2=**	**8x2=**	**9x2=**	**10x2=**
6x3=	**7x3=**	**8x3=**	**9x3=**	**10x3=**
6x4=	**7x4=**	**8x4=**	**9x4=**	**10x4=**
6x5=	**7x5=**	**8x5=**	**9x5=**	**10x5=**
6x6=	**7x6=**	**8x6=**	**9x6=**	**10x6=**
6x7=	**7x7=**	**8x7=**	**9x7=**	**10x7=**
6x8=	**7x8=**	**8x8=**	**9x8=**	**10x8=**
6x9=	**7x9=**	**8x9=**	**9x9=**	**10x9=**
6x10=	**7x10=**	**8x10=**	**9x10=**	**10x10=**

Screening Math Problems

NAME: _____

5 x 6=	**10 x 8=**	**6 x 7=**
7 x 8=	**7 x 4=**	**7 x 10=**
1 x 3=	**5 x 2=**	**8 x 9=**
3 x 6=	**1 x 8=**	**2 x 2=**
8 x 2=	**3 x 9=**	**8 x 5=**
10 x 5=	**9 x 7=**	**7 x 7=**
6 x 7=	**8 x 3=**	**10 x 3=**
9 x 5=	**6 x 3=**	**1 x 6=**
2 x 2=	**4 x 4=**	**3 x 7=**
4 x 9=	**2 x 10=**	**5 x 1=**
2 x 8=	**9 x 1=**	**4 x 2=**
5 x 7=	**3 x 4=**	**7 x 3=**
2 x 4=	**10 x 2=**	**6 x 6=**
8 x 7=	**8 x 1=**	**1 x 4=**
9 x 10=	**4 x 8=**	**10 x 6=**
10 x 10=	**1 x 2=**	**10 x 6=**
2 x 9=	**8 x 4=**	**4 x 2=**
5 x 5=	**7 x 5=**	**7 x 3=**
8 x 9=	**9 x 8=**	**6 x 6=**
4 x 6=	**6 x 10=**	**1 x 4=**
3 x 3=	**2 x 1=**	**3 x 10=**
4 x 7=	**1 x 5=**	**6 x 8=**
7 x 10=	**5 x 3=**	**5 x 6=**
8 x 6=	**3 x 10=**	**4 x 10=**
9 x 9=	**6 x 5=**	**6 x 6=**
5 x 8=	**10 x 9=**	**1 x 1=**
7 x 6=	**8 x 5=**	**6 x 8=**
3 x 1=	**6 x 1=**	**7 x 9=**
6 x 4=	**4 x 3=**	**3 x 8=**
8 x 8=	**1 x 5=**	**5 x 9=**
10 x 4=	**10 x 7=**	**9 x 2=**
3 x 2=	**6 x 9=**	**10 x 8=**
4 x 5=	**4 x 1=**	**2 x 6=**
9 x 2=	**1 x 10=**	**4 x 7=**
2 x 6=	**3 x 5=**	**7 x 1=**

Debriefing Questions

1. What do you think the purpose of this experiment is?

1. What made you decide how much money you would earn?

1. How important was it for you to earn the money

   - What was the main motivator for you to complete the experiment?

1. Did you at any point want to stop coming to the experiment?

1. Did you ever run out of time or get in a rush for other things while you were participating in the experiment?

   - What did you usually do after you finished the sessions?

1. Were the number of math problems you needed to solve to get the five cents always the same?

Informed Consent Form

My name is Kathleen Bailey, and I am a graduate student at the University of North Texas. I am requesting your consent to participate in a research study. The results from this study will be presented at a conference.

Please read the following consent form carefully before signing.

I understand that taking part in this experiment will last for a minimum of 15 sessions (approximately 2-3 weeks.) Only one session will be conducted each day of participation. I will earn varying amounts of money during sessions for solving math problems on a computer and I will obtain a $25 bonus upon completion of the 15 sessions. After the experiment I will be debriefed and be able to ask questions regarding the experiment. Benefits of participation include the potential for earning money during every session and a $25 bonus for completing the experiment. There are no foreseen risks as a result of participating in this study.

I have been informed that any information obtained in this experiment will be coded by use of arbitrary numbers and the data will be kept locked up without access to anyone but the experimenters. Under these conditions, I agree that any information obtained in the study may be subject for publications and public presentations. Participation in this study is voluntary and I have the right to view data at the conclusion of the experiment and determine to discontinue my participation at any time without penalty, prejudice or loss of benefits.

If I have any questions or problems that arise in connection with the participation in this study, I will contact Kathleen Bailey at (940) 565-3538 (Department of Behavior Analysis) or Dr. Cloyd Hyten at (940) 565-4071 (Department of Behavior Analysis).

Name of participant (please print) _____

_____ _____

Date Signature of Participant

_____ _____

Date Signature of Principal Investigator

APPENDIX B

TABLES

Table 1. Elasticity coefficients for all participants.
Shaded areas indicate elastic demand.

		Unit Price Changes			
		1 - 3	3 - 5	5 - 7	7 - 10
FB	S4	0.00	0.00	1.20	1.31
	S5	0.32	1.13	0.58	0.54
	S6	0.00	0.00	0.00	0.66
NO FB	S1	0.00	0.00	0.62	2.20
	S2	0.00	0.78	0.78	2.90
	S3	0.00	0.00	0.86	2.50

Table 2. Consumption raw data for all subject for 1st pass (C1), 2nd pass (C2) and average (AC).

No FB

		S1	S2	S3
UP1	C1	600	600	600
	C2	600	600	
	AC	600	600	600
UP3	C1	600	600	600
	C2	600	600	
	AC	600	600	600
UP5	C1	600	410	600
	C2	600	400	
	AC	600	405	600
UP7	C1	600	410	450
	C2	375	210	
	AC	487.5	310	450
UP10	C1	325	80	175
	C2	105	120	
	AC	215	100	175

FB

		S4	S5	S6
UP1	C1	600	600	600
	C2	600	600	600
	AC	600	600	600
UP3	C1	600	590	600
	C2	600	275	600
	AC	600	432.5	600
UP5	C1	600	285	600
	C2	600	200	600
	AC	600	242.5	600
UP7	C1	400	200	600
	C2	400	200	600
	AC	400	200	600
UP10	C1	300	125	600
	C2	200	205	350
	AC	250	165	475

Table 3. Work Output raw data for all subject for 1st pass (WO1), 2nd pass (WO2) and average (AWO).

No FB

		S1	**S2**	**S3**
Up1	WO1	600	600	600
	WO2	600	600	
	AWO	600	600	600
UP3	WO1	1800	1800	1800
	WO2	1800	1800	
	AWO	1800	1800	1800
UP5	WO1	3000	2060	3000
	WO2	3000	2024	
	AWO	3000	2042	3000
UP7	WO1	4200	2870	3150
	WO2	2626	1470	
	AWO	3413	2170	3150
UP10	WO1	3251	800	1785
	WO2	1050	1238	
	AWO	2150.5	1019	1785

FB

		S4	**S5**	**S6**
Up1	WO1	600	600	600
	WO2	600	600	600
	AWO	600	600	600
UP3	WO1	1800	1770	1800
	WO2	1800	825	1800
	AWO	1800	1297.5	1800
UP5	WO1	3000	1425	3000
	WO2	3000	1024	3000
	AWO	3000	1224.5	3000
UP7	WO1	2800	1400	4200
	WO2	2800	1400	4200
	AWO	2800	1400	4200
UP10	WO1	3000	1250	6000
	WO2	2000	2050	3500
	AWO	2500	1650	4750

Table 4. Rate Calculations for work output for the No FB group.WO1,WO2, Time, Time1, Rate1 and Rate2 indicate work output, time and rate for first and second pass respectively.

		No FB		
		S1	**S2**	**S3**
UP1	WO1	600	600	600
	Time	14.73	15.88	16.95
	WO2	600	600	
	Time2	10.85	10.05	
	Rate1	40.73	37.78	35.40
	Rate2	55.30	59.70	
UP3	WO1	1800	1800	1800
	Time	39.98	39.88	44.43
	WO2	1800	1800	
	Time2	32.37	30.53	
	Rate1	45.02	45.14	40.51
	Rate2	55.61	58.96	
UP5	WO1	3000	2060	3000
	Time	61	49.43	53.05
	WO2	3000	2024	
	Time2	52.33	54.18	
	Rate1	49.18	41.68	56.55
	Rate2	57.33	37.36	
UP7	WO1	4200	2870	3150
	Time	85.03	56.75	75.32
	WO2	2626	1470	
	Time2	46.4	49.3	
	Rate1	49.39	50.57	41.82
	Rate2	56.59	29.82	
UP10	WO1	3251	800	175
	Time	61.73	16.2	32.12
	WO2	1050	1238	
	Time2	20.5	60.65	
	Rate1	52.66	49.38	5.45
	Rate2	51.22	20.41	

Table 5. Rate Calculations for work output for the No FB group.WO1,WO2, Time, Time1, Rate1 and Rate2 indicate work output, time and rate for first and second pass respectively.

		FB		
		S4	**S5**	**S6**
UP1	WO1	600	600	600
	Time	15.27	16.28	15.15
	WO2	600	600	600
	Time2	11.05	11.3	9.83
	Rate1	39.29	36.86	39.60
	Rate2	54.30	53.10	61.04
UP3	WO1	1800	1770	1800
	Time	40.82	46.5	36.88
	WO2	1800	825	1800
	Time2	33.47	30.83	26.98
	Rate1	44.10	38.06	48.81
	Rate2	53.78	26.76	66.72
UP5	WO1	3000	1425	3000
	Time	58.05	38.58	46.72
	WO2	3000	1025	3000
	Time2	53.95	26.53	43.93
	Rate1	51.68	36.94	64.21
	Rate2	55.61	38.64	68.29
UP7	WO1	2800	1400	4200
	Time	57.12	35.75	75.82
	WO2	2800	1400	4200
	Time2	51.22	28.13	60.28
	Rate1	49.02	39.16	55.39
	Rate2	54.67	49.77	69.67
UP10	WO1	3000	1250	6000
	Time	56.42	31.12	91.73
	WO2	2000	2050	3500
	Time2	36.95	29.23	50.25
	Rate1	53.17	40.17	65.41
	Rate2	54.13	70.13	69.65

APPENDIX C

FIGURES

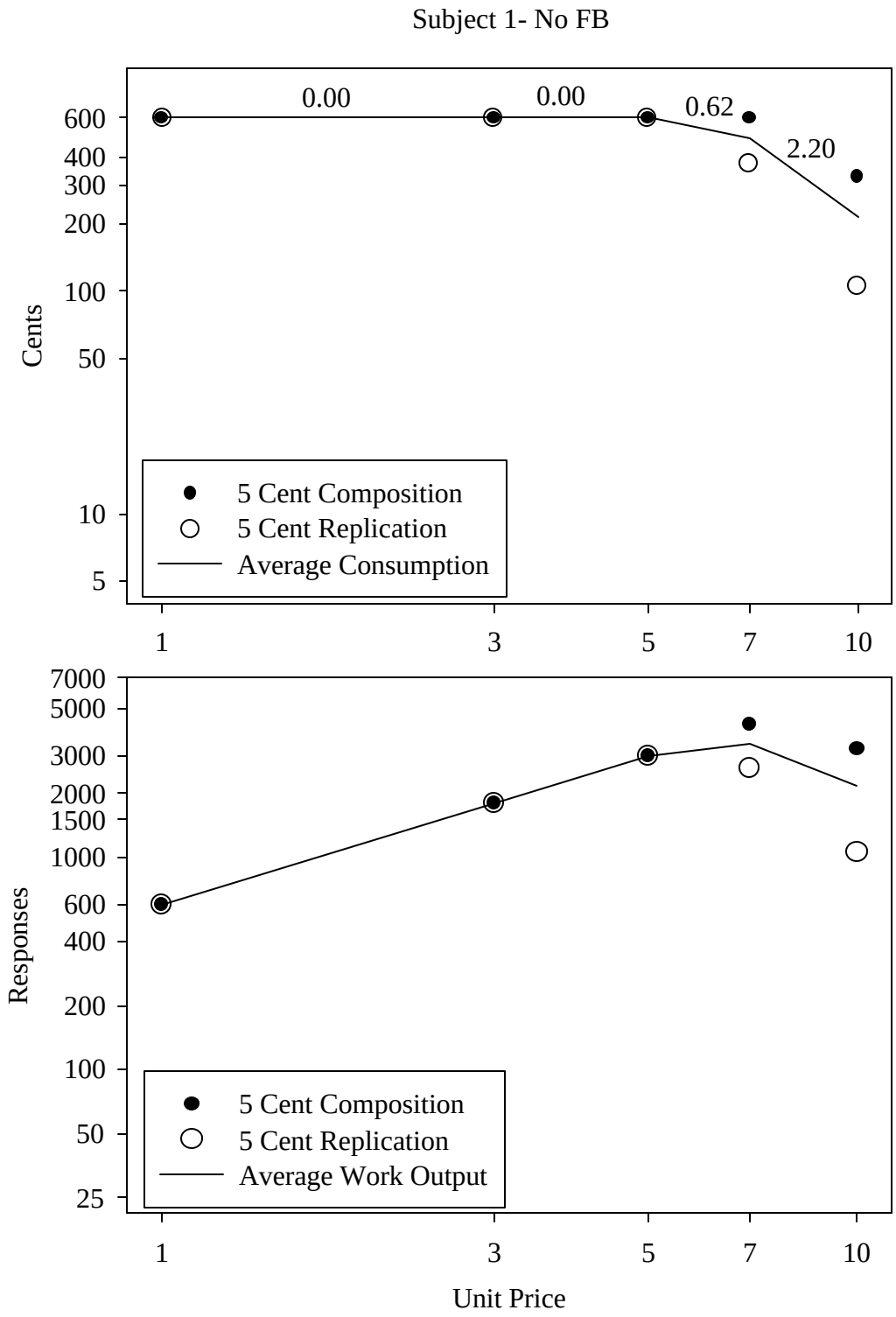

Figure 1. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

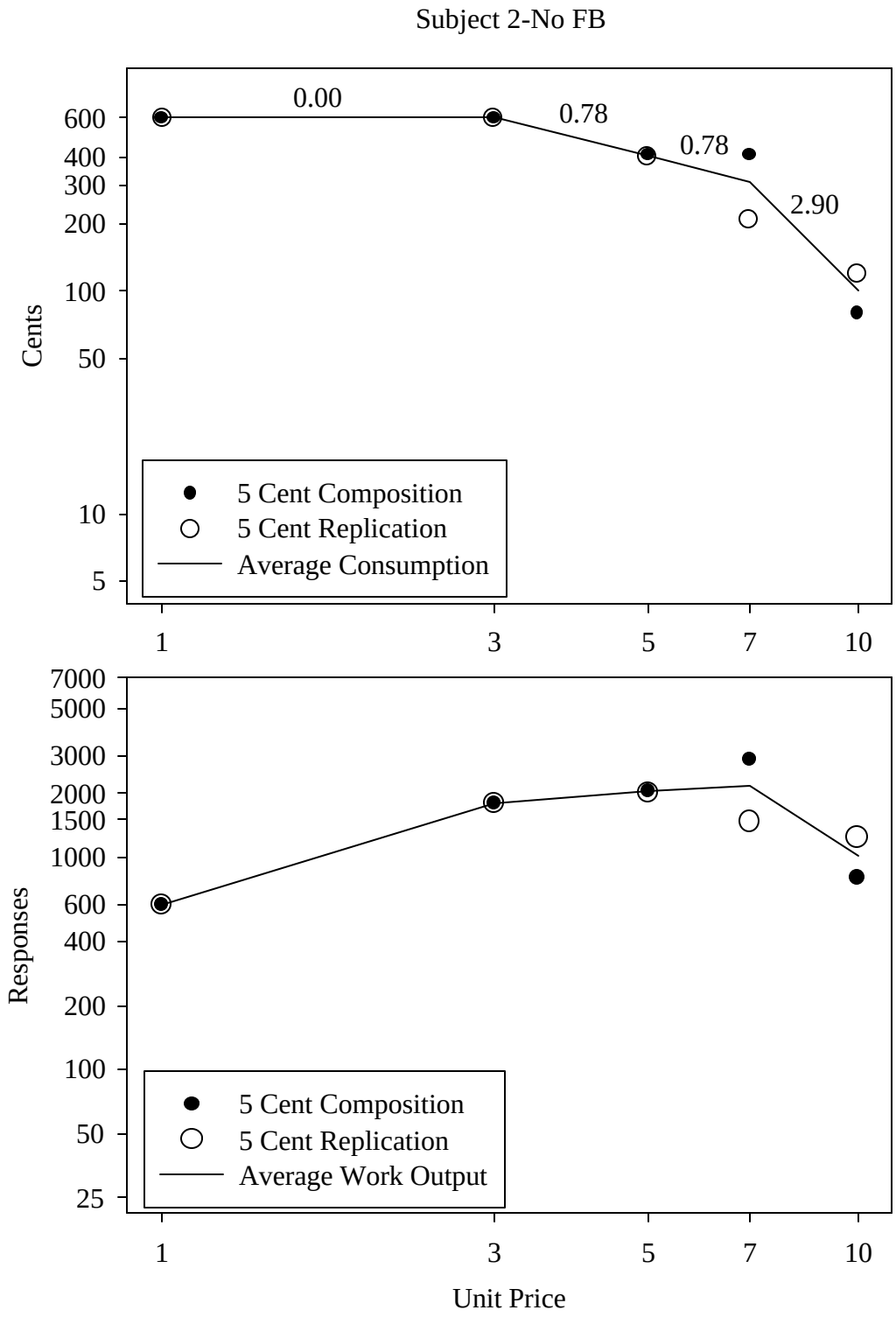

Figure 2. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

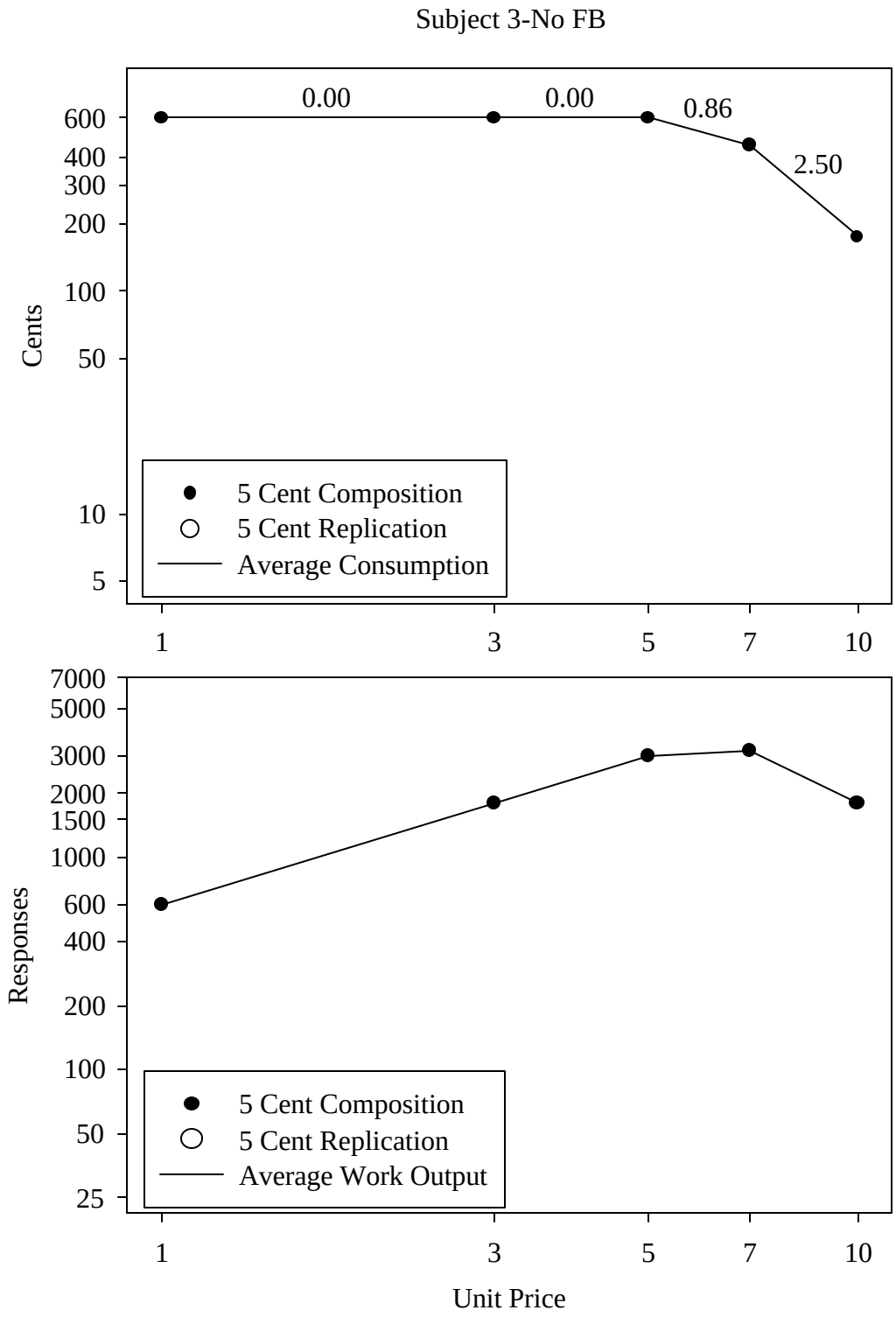

Figure 3. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

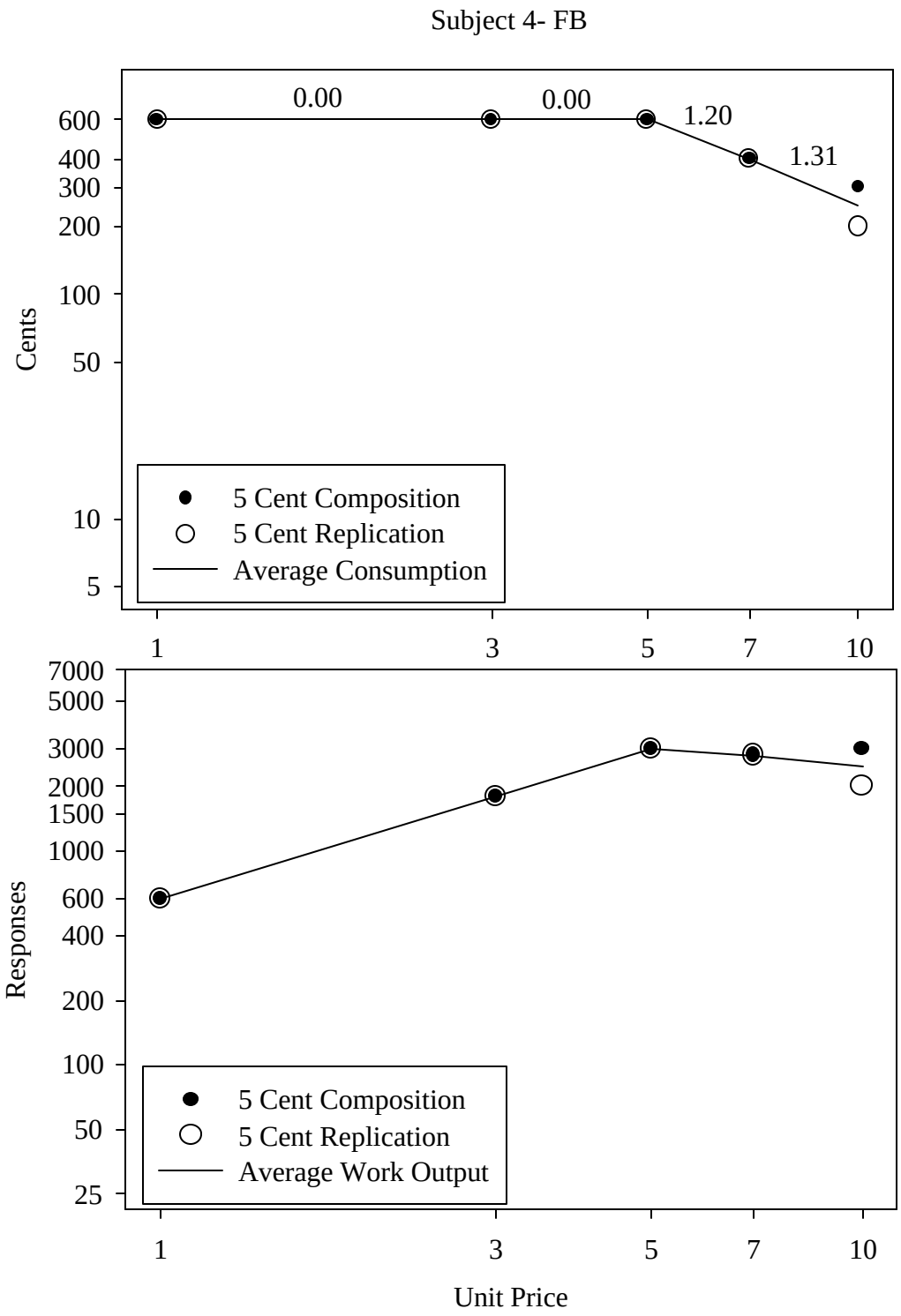

Figure 4. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

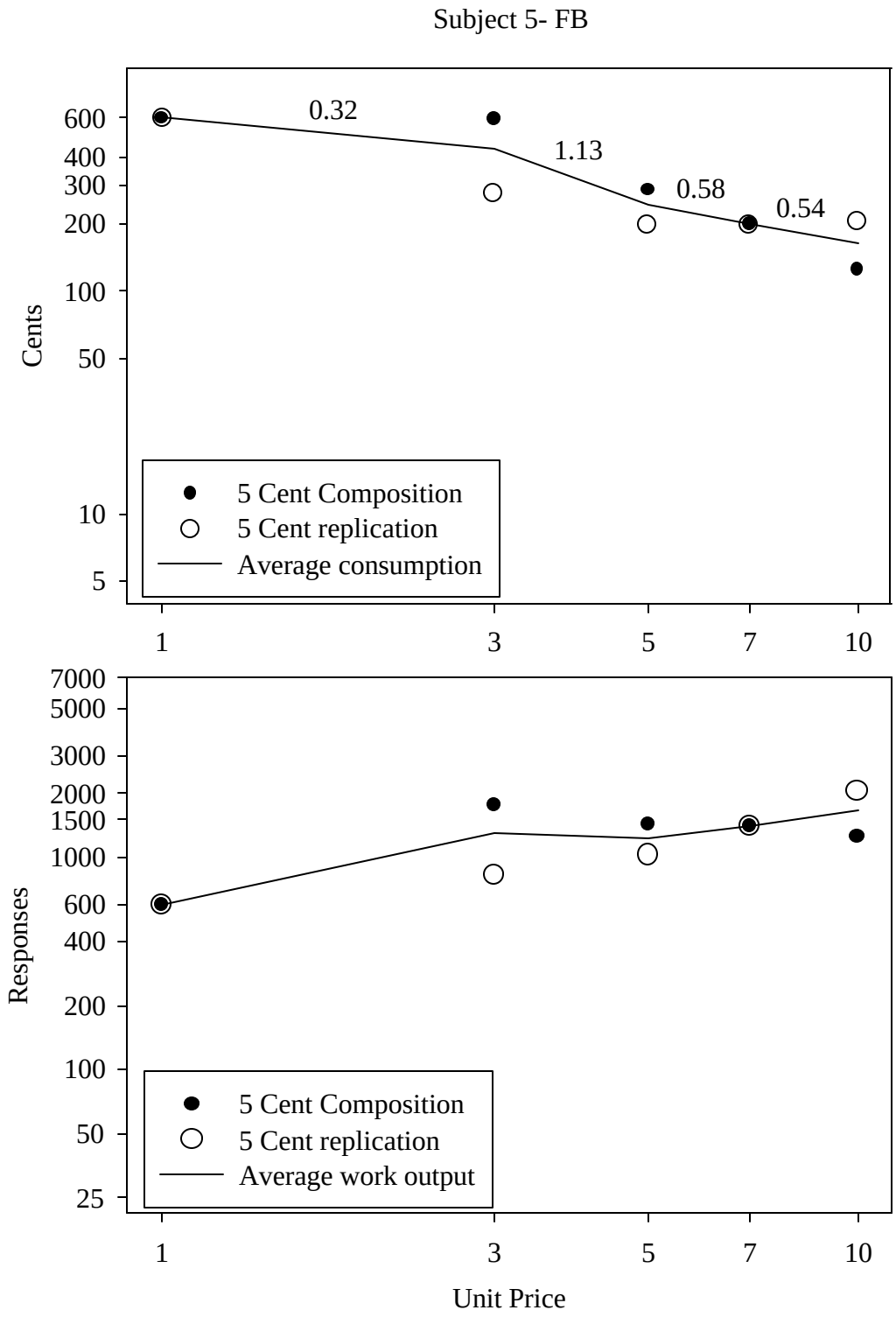

Figure 5. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

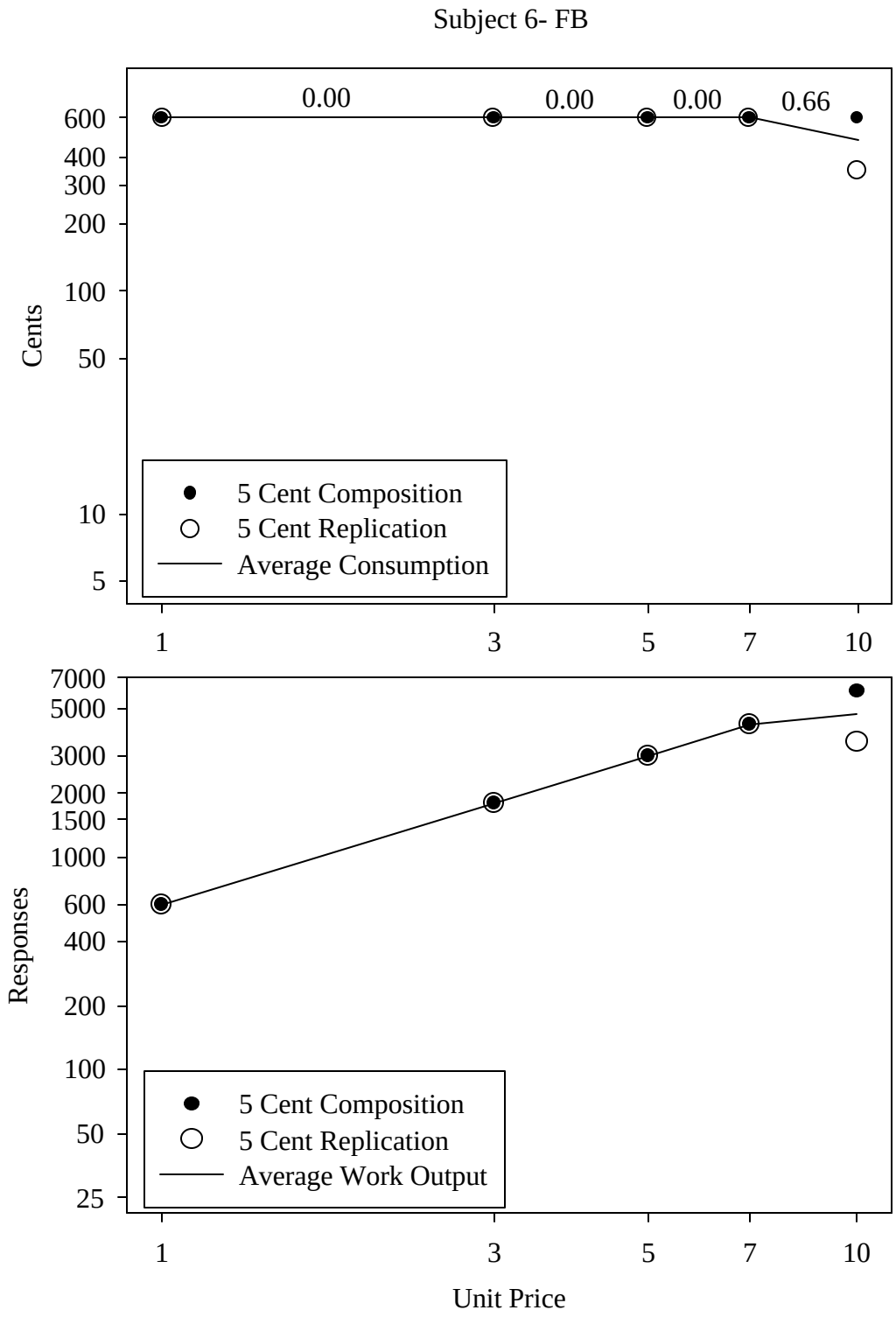

Figure 6. Demand curve (top graph) and work output curve (bottom graph) plotted in log-log units. Lines denote average values of consumption (top graph) and work output (bottom graph). Values on top of the demand curve indicate elasticity coefficients.

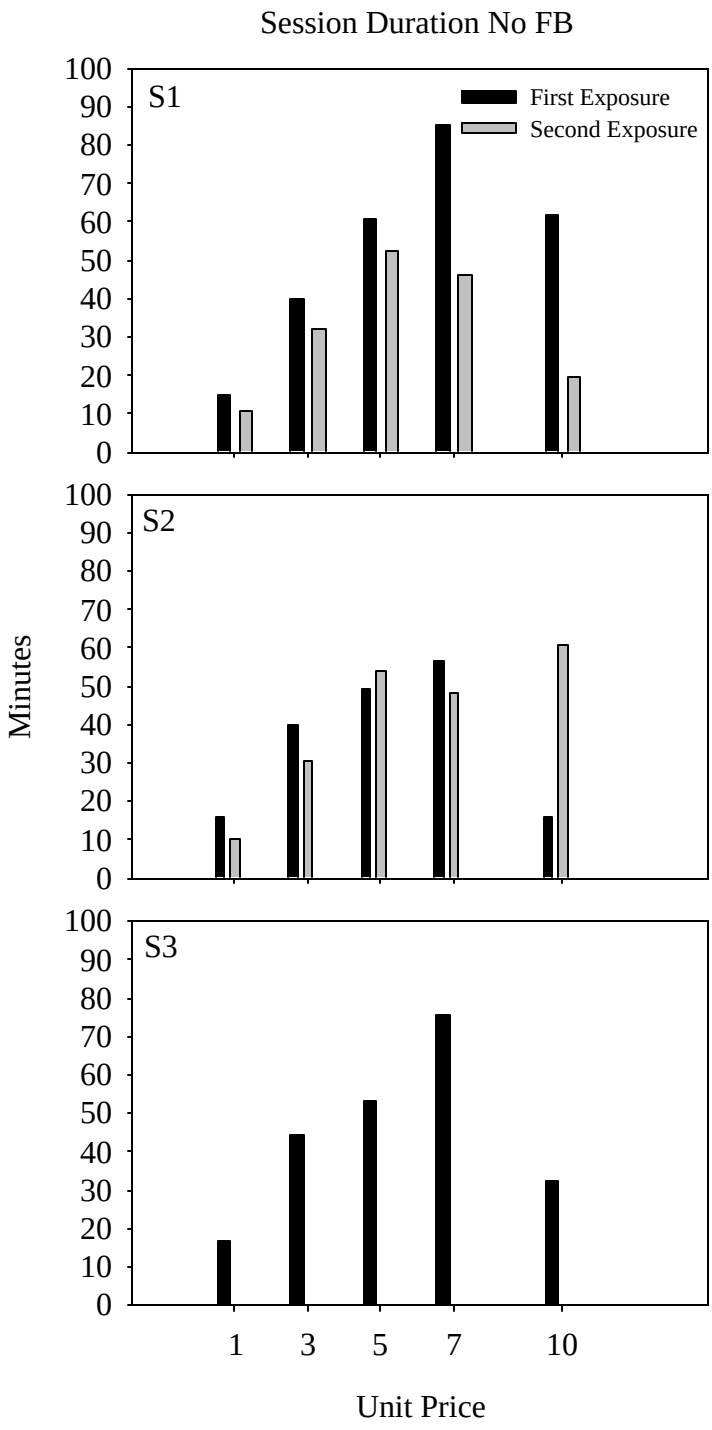

Figure 7. Session durations for first and second exposures to each unit price for all No FB participants

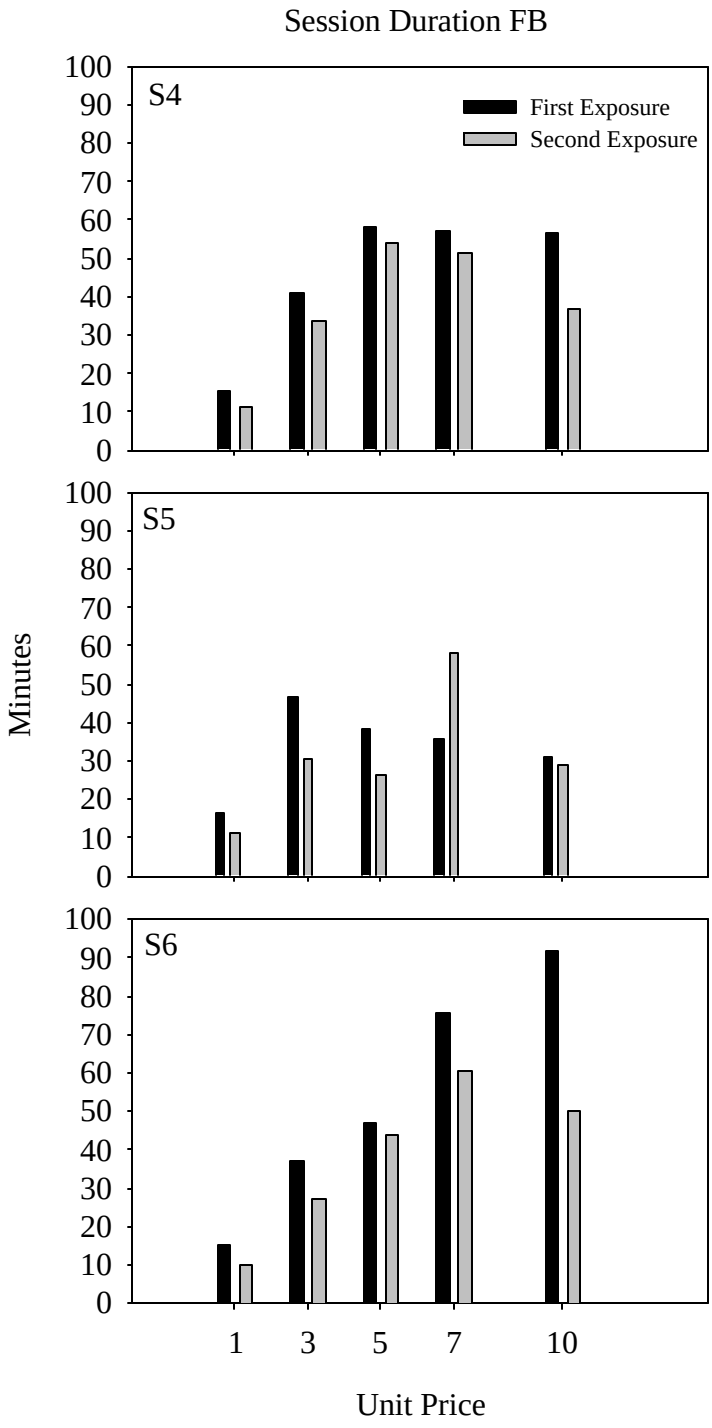

Figure 8. Session durations for first and second exposures to each unit price for all FB participants

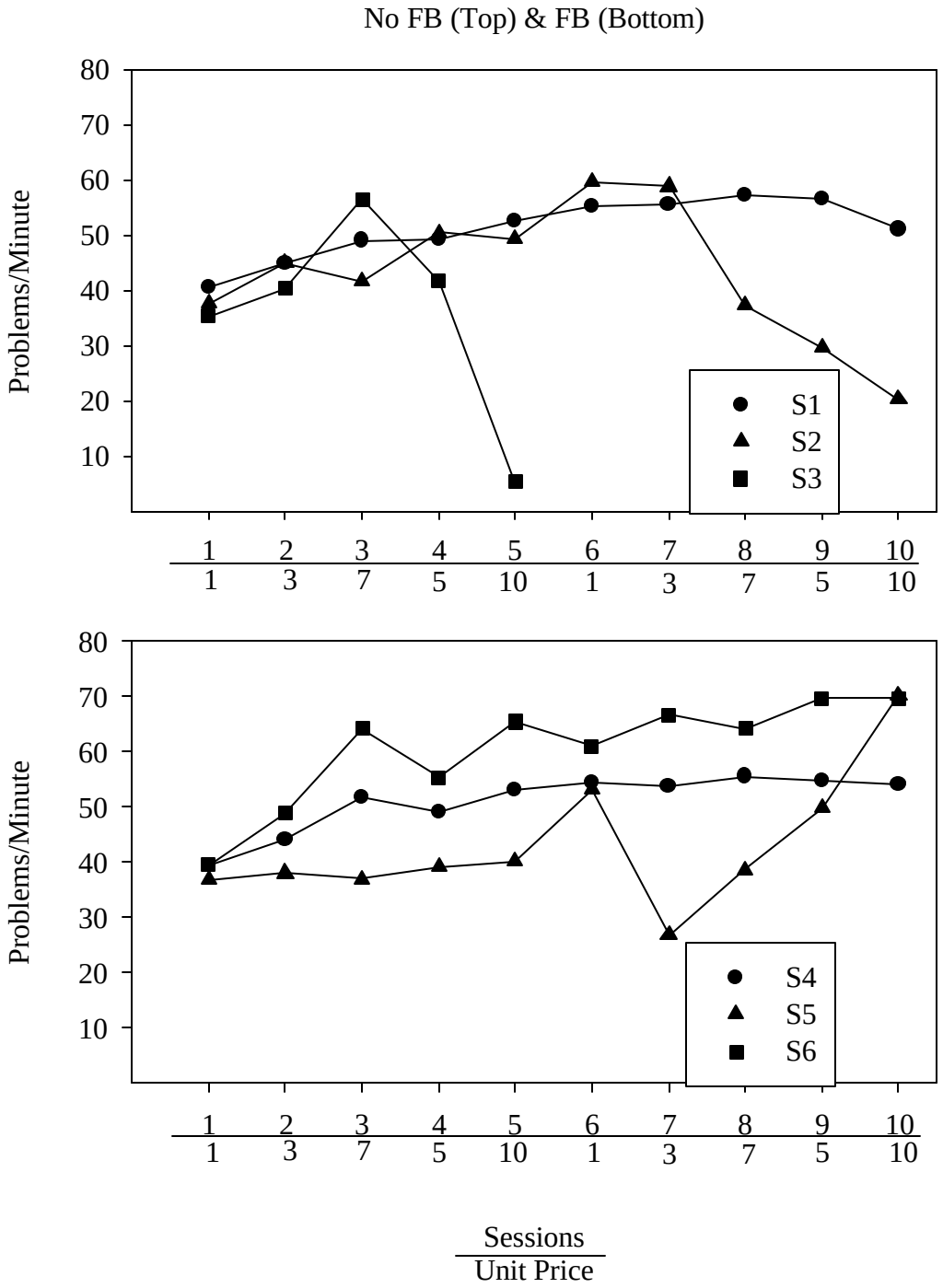

Figure 9. Rate of responding (problems/minute) for each participant in the No FB group (top graph) and FB group (bottom graph) across sessions. Values above the line indicate the session number, values below the line indicate the price in effect for that particular session.

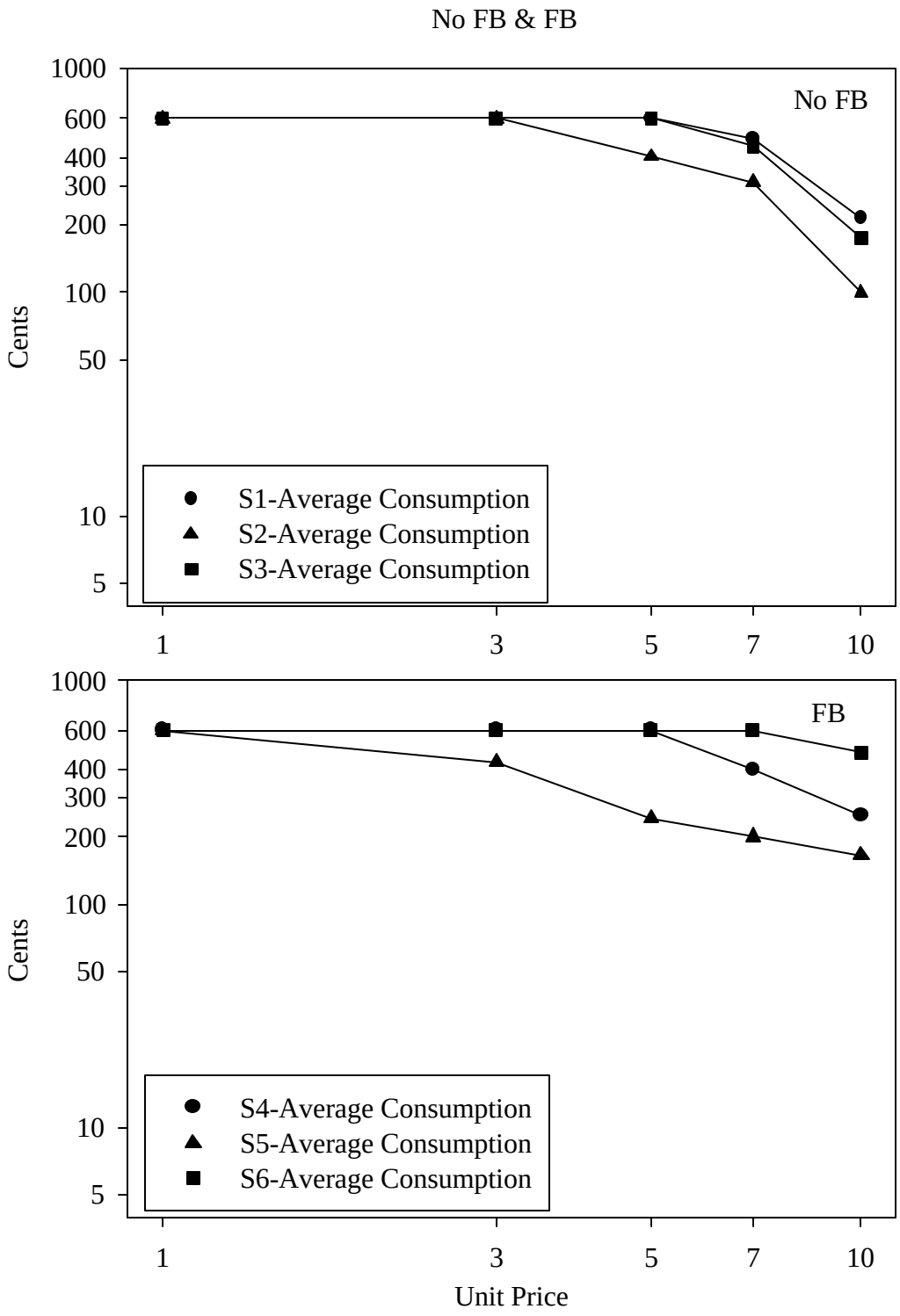

Figure 10. Average consumption for all participants in the No FB group (top graph) and the FB group (bottom graph).

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