1995

Reinforcer Demand Elasticity Under Direct Competition Between Rats

Susan L. Reynolds '95
Illinois Wesleyan University

Running head: Demand Elasticity under Direct Competition

Reinforcer Demand Elasticity Under Direct Competition Between Rats

Susan L. Reynolds
Illinois Wesleyan University

Acknowledgments

The completion of this thesis was not an easy task, and I feel it could not have been finished on time were it not for some very important people. First, I would like to thank my advisor, Dr. James Dougan. His ideas, comments, and hard work helped me every step of the way. He helped me to develop the experiment, assisted in the set-up of the apparatus, and gave critical comments during every stage of the writing process. In addition, he offered his support when times got rough. I also am very indebted to my two assistants, Jennifer Cioni and Jennifer Bredthauer. They both helped shape and run the animals, so it was not necessary for me to spend six hours a day in the lab. So I thank them for their assistance, without which I would probably have lost my mind. Also, much of the experiment would not have been completed if not for the help of Colleen Kennedy. She wrote the program, assisted in setting up the apparatus, watched over my animals when I was unable to, lent a helping hand when I could not deal with the computer, and in general helped me remain calm when things went wrong. Alisha Crawley also deserves a word of thanks for her assistance in the actual writing of this paper. She allowed me access to valuable resources in a calm atmosphere, where I was able to complete the project in peace.

I am very grateful to all my committee members, for I realize the time commitment they make when agreeing to help oversee my project. Specifically, those people are Dr. James Dougan, Dr. Wayne Dornan, Dr. Larry Colter, and Dr. Rob Lusk. Their comments were very helpful, and pushed me to think critically about my research. I would also like to thank Dr. Lon Shapiro and Dr. Wayne Dornan for their careful classroom instruction, for their comments about things to do and things to avoid, and for pushing me to do the best job that I could.

This acknowledgment would not be complete without thanking Jason Colbert. Jason added new challenges to my life and forced me to overcome many obstacles. His influence made the completion of this thesis even more rewarding. Related to that, I would like to thank Dr. Dominic Imburgia, without whose help I would have been mentally and physically incapable of completing any of the research or the final paper. Thanks also to all of my friends for putting up with my mood swings and swearing when bitten by a subject. Thanks to all of the animal colony workers who put in so much effort to ensure that everyone's animals are well cared for and the experimenters' noses kept dry. Last but not least, I thank Ben Chapman for his helpful comments and for being there when I needed him.

Table of Contents

Abstract

Economic theory predicts that cost is an inverse function of the quantity of a commodity. This has also been shown in studies of behavioral economics (Dougan, 1992). According to the law of supply and demand, competition between organisms should drive prices up more rapidly. Previous studies with rats have failed to find an effect of competition; however, the competition was indirect in those studies (Johns, unpublished thesis). In the present experiment, twelve female rats actively competed in pairs for reinforcers on each of four modified fixed interval (FI) schedules: FI 30 s, FI 60 s, FI 120 s, and FI 240 s. A modified operant chamber was used and the animals were separated by a wire barrier. For each schedule, the animals were tested both with and without competition from another rat. Competition involved a pair of animals responding on separate bars where only one would receive reinforcement on a given trial. The non-competition days served as controls. As predicted by the law of supply and demand, the competition resulted in increased cost. The results have a variety of implications for schedule behavior in general and behavioral economics in particular.

Reinforcer Demand Elasticity Under Direct Competition Between Rats

Traditional reinforcement theory views reinforcement as something that causes a response to increase in frequency. Specifically, when a response is immediately followed by a reinforcer, the strength of that response will tend to become greater (Skinner, 1938). More recently, it has been suggested that economic principles could be applied to behavioral experiments (Allison, 1983). Economic approaches differ from traditional reinforcement theory because reinforcers are not viewed as universal strengtheners of behavior. Instead, reinforcers are economic commodities that follow economic principles. Since then, "behavioral economics" has been an important, though controversial, concept in reinforcement theory and has had considerable impact in the field.

Of special interest in this field has been the law of supply and demand. Lea (1978) has shown an analogy from the demand curve of economics to the function that relates the number of reinforcers received with the strength of the operant behavior. Specifically, the law of supply and demand suggests that as the supply of a commodity, in this case food, goes down, the price, or responses per reinforcer, will go up (Hursh, 1984).

The concepts of classical economics can be applied most easily to simple ratio schedules (Felton & Lyon, 1966). Felton and Lyon (1966) studied food deprived pigeons working on a fixed ratio (FR) schedule such that a set number of responses would result in the delivery of a reinforcer. They found that responding would increase up to a ratio of 50, and then ratio strain would occur (Felton & Lyon, 1966). However, total consumption decreased as price increased.

Dougan (1992) shows that behavioral economics can be applied to interval schedules as well. There are two types of supply in classical economics, elastic and inelastic, and reinforcers can be classified in this way when describing behavioral experiments (Hursh, 1980). Specifically, ratio schedules can be seen as having elastic supply since the number of reinforcers varies based on response rates. In these experiments, cost (responses per reinforcer) is considered the independent variable while quantity (number of earned reinforcers) is the dependent variable. For interval schedules, the independent and dependent variables are switched in order to fit with economic analogs. Specifically, the quantity (or number of reinforcers available) is the independent variable and price (responses per reinforcer) is the dependent variable. Thus, interval schedules can be seen as having inelastic supply since the number of reinforcers in a session is constrained within a time interval (Dougan, 1992).

Competition in the market place is believed to be the underlying cause for the increase in cost for a commodity. For example, when the supply of something is limited, as are some fruits during a drought, the cost for that item will rapidly increase because many people want it but only a limited number of the item are available. Therefore, an individual willing to pay a higher price for a commodity will achieve access to it. The result is an increase in the market price. Thus, competition is responsible for driving prices up, especially inelastic commodities (Dougan, 1992).

Interestingly, previous research has shown that behavior on simple VI schedules follows the predictions of the law of supply and demand, but in the absence of any competition (Dougan, 1992). Dougan used pigeons responding alone on VI schedules and showed that the behavioral cost, measured by responses per reinforcer, increased as supply decreased, as would be predicted by economic theory. However, research by Johns (unpublished thesis) found that the presence of a second rat in the chamber did not have an effect on how rapidly the "price" increased. In her experiment, the second animal did not have access to a bar and did not receive any food reinforcers while in the chamber, and data were collected only on the rat actually working in the chamber. Competition was indirect in that only one rat was able to bar press and receive reinforcers, while the other was simply present, separated by a Plexiglas barrier.

The present study builds on these findings by arranging direct competition between rats. Competition is considered direct because both rats have access to a bar and the reinforcers, but only one rat actually receives the food pellet for each trial. It is designed to simulate an auction by investigating the effects of direct competition on how rapidly response rates, or price, increase. Rats responded on separate bars in the same chamber (with a barrier separating them), actively competing for each reinforcer. The rat that "bid" more (had a higher rate of responding) within a given time interval received the reinforcer. It is hypothesized that direct competition will cause the rate of responding to increase rapidly under conditions of direct competition, as predicted by classical economics.

Method

Subjects

Twelve female Long-Evans hooded rats served as subjects. All animals were obtained from the animal colony at Illinois Wesleyan University, and were experimentally naive and six months old at the start of the experiment. They were individually housed and maintained at 80% of their ad libitum weight with water freely available at all times in the home cage.

Apparatus

A BRS-LVE model RTC-028 operant conditioning unit for rats was used. The apparatus was 30 cm long, 26.5 cm high, and 24 cm wide. The ceiling and two side walls were made of Plexiglas, and the front and back walls were made of stainless steel. The front wall contained two retractable bars, each 5 cm from the floor and 3 cm from the nearest side wall. When retracted, the bars were flush with the wall, and projected 2.5 cm into the chamber when extended. Five centimeters above each bar was a bank of three cue lights (green, white, and red), with each individual light being 2 cm apart (center to center). The front wall also contained two food cups, located 10 centimeters from the nearest wall, 2 cm from the floor, and extending 1.5 cm into the chamber. The floor consisted of metal bars. This chamber varies from traditional operant chambers because of two very important modifications: Two feeders (as opposed to the traditional one) were located in the chamber, and a barrier separated the chamber into two equal halves, with a bar and a feeder on each half. The barrier was made of wire and wood such that the animals were able to see and smell one another, but were not able to get to the other side. It extended from the front wall to the back wall, and from the top of the unit to the bottom. The entire apparatus was contained within a sound-attenuating chamber, with a 5-W house light illuminating the chamber from the beginning to the end of the session. Reinforcement consisted of one 45mg Noyes improved formula A rodent pellets. Schedule and reinforcement control, as well as data collection, were conducted by an IBM compatible computer running MED-PC software and using a MED-Associates interface. The computer and interface were located in an adjacent room.

Procedure

The animals were reduced to 80% of their ad libitum weight, and hand shaped by successive approximations to press a bar for food reinforcement. Once all participants were reliably pressing the bar, the experiment proper began.

The animals were exposed to four different modified fixed interval schedules, FI 30 s, FI 60 s, FI 120 s, or FI 240 s. For each schedule, there were two conditions, the presence or the absence of another rat. The animals were randomly assigned to pairs, with the same pairings maintained throughout. Each pair received all four schedules in a counterbalanced order. Each pair of animals was exposed to a schedule for twelve consecutive days before another schedule began. Within each schedule, the days on which another rat was present were pseudo-randomly assigned, with the stipulation that a condition could not be in effect for more than two days. Each animal was tested six days alone and six days with another rat present. The "alone" days served as controls.

When the session began, both bars were extended, the house light was illuminated, and a red cue light above each bar was lit. After the scheduled time interval had elapsed, both bars were retracted into the wall and the reinforcer was delivered. There was then a 10 s pause to allow for the "winning" animal to consume the reinforcer. The cycle then repeated until the end of the session, approximately 30 minutes later. Supplementary feedings were given in their home cage approximately one hour after the conclusion of the session.

During the experimental days, the rats were actively competing for each reinforcer, such that the rat that made the higher number of responses in the specified time interval received the reinforcer. For each trial, both rats started over again with zero responses so that each reinforcer depended only on the responses made during that particular interval. On trials in which neither rat responded, no reinforcer was delivered. Control days were exactly like experimental days with the exception that the animals were run alone, without another rat competing for reinforcers. Thus, on no-competition days, the animal could conceivably receive every available reinforcer.

Results

Responses per session were divided by reinforcers earned to find the average cost per reinforcer for each animal. The average cost per schedule and condition was calculated for each animal, and then the mean across all animals was figured. Only the last four sessions of each condition were used when calculating the means. Also, approximately 5.5% of the sessions ended with zero reinforcers delivered, and cost was therefore incalculable. When one of the "zero reinforcer" days occurred in the last four days, an earlier session was used instead. This problem occurred most commonly on the FI 240 s schedule, usually under the competition condition.

Figure 1 shows the mean behavioral cost for all subjects plotted as a function of available reinforcers for both conditions. A two-way (competition by schedule) within subjects Analysis of Variance (ANOVA), with the two factors being competition and schedule, was used to analyze the data. A significant main effect was found for both schedule ($F[3,33] = 4.25$, $p < .05$) and competition ($F[1,11] = 9.89$, $p < .01$). However, no significant interaction was found ($F[3,33] = .37$, ns). In other words, the mean cost was significantly higher at low reinforcement rates for both the competition and no-competition conditions. Also, the mean cost was significantly higher on competition days across all schedules.

Discussion

The present study examined the effects of direct competition on the economic behavior of rats in a simulated auction. The results support previous research by Dougan (1992) in that the animals followed the law of supply and demand by paying more per reinforcer at low reinforcement rates than at high reinforcement rates. In addition, the results support economic theory by showing a significant increase in cost on those days when the animals were competing, compared to days on which no competitor was present.

The present data support the predictions of behavioral economic theory in general, and specifically predictions made by the law of supply and demand. The results showing a significant effect of competition can be used to support the assumptions of economic theory by demonstrating that competition does cause an increase in price.

One limitation of the present study was that, due to the nature of the experiment, reinforcement was often delayed. For example, an animal could press the bar many times during the first half of the interval. Because reinforcement was automatically delivered after the bar was retracted, this could result in a significant delay between response and reinforcer, which stand in contrast to the usual procedure in which the reinforcement is delivered immediately after the response. According to Thorndike's Law of Effect, responses immediately followed by a reinforcer will be strengthened (Thorndike, 1911), and it is well known that delayed reinforcers exert less control over behavior (Reynolds, 1975). Since in the present experiment reinforcement was delayed, there is the possibility that other behaviors were being reinforced, and not necessarily the target response.

An additional problem occurred because a substantial number of sessions ended without reinforcement delivery. This makes the cost calculation impossible because the number of reinforcers is in the denominator of the calculation. It is unclear what effect the exclusion of these sessions had on the results. However, future studies should insure that such sessions are unlikely or impossible.

The present study may have some analogous implications for business and economics. For example, Ehrenberg and Smith (1994) describe promotion tournaments in which a company hires several middle managers, all knowing that only one of them will be promoted to CEO of the company. Therefore, giving the CEO special privileges (i.e. high salary, power, etc.) motivates all managers to work harder to achieve the one available CEO slot. This may be comparable to the animals in the chamber competing for the one available reinforcer. Since the animals will work harder per reinforcer when they are in competition with another rat, it could follow that the managers will work harder when they are in competition with others for the promotion and the special privileges. Of course, we cannot conclude that identical processes are involved. However, an analogous situation apparently produces similar effects in both humans and rats.

Future research in this area should examine the parameters surrounding the presently observed behavior. Research could focus on the ecological processes underlying the economic behavior being witnessed. In addition, research could investigate the effects of having the animals compete with a different animal everyday, thus making it more like a "real" auction. Other studies could focus on the conditions in which this behavior occurs or is ideal, or examine the effects that different prices for different animals may have on this behavior.

References

Allison, J. (1983). Behavioral economics. New York: Praeger.

Allison, J. (1989). The nature of reinforcement. In S.B. Klein & R.R. Mowrer (Eds.), Contemporary learning theories: Instrumental conditioning theory and the impact of biological constraints on learning (pp 13-39). Hillsdale, NJ: Erlbaum.

Dougan, J.D. (1992). Inelastic supply: An economic approach to simple interval schedules. Journal of the Experimental Analysis of Behavior, 58, 415-429.

Ehrenberg, Ronald G., & Smith, Robert S. (1994). Modern labor economics: Theory and public policy. New York: HarperCollins College Publishers.

Felton, M. & Lyon, D.O. (1966). The post-reinforcement pause. Journal of the Experimental Analysis of Behavior, 9, 131-134.

Hursh, S.R. (1984). Behavioral economics. Journal of the Experimental Analysis of Behavior, 42, 435-452.

Johns, J.D. (1994). The effects of indirect competition on economic behavior. Unpublished undergraduate thesis, Illinois Wesleyan University, Bloomington.

Lea, S.E.G. (1978). The psychology and economics of demand. Psychological Bulletin, 85, 441-466.

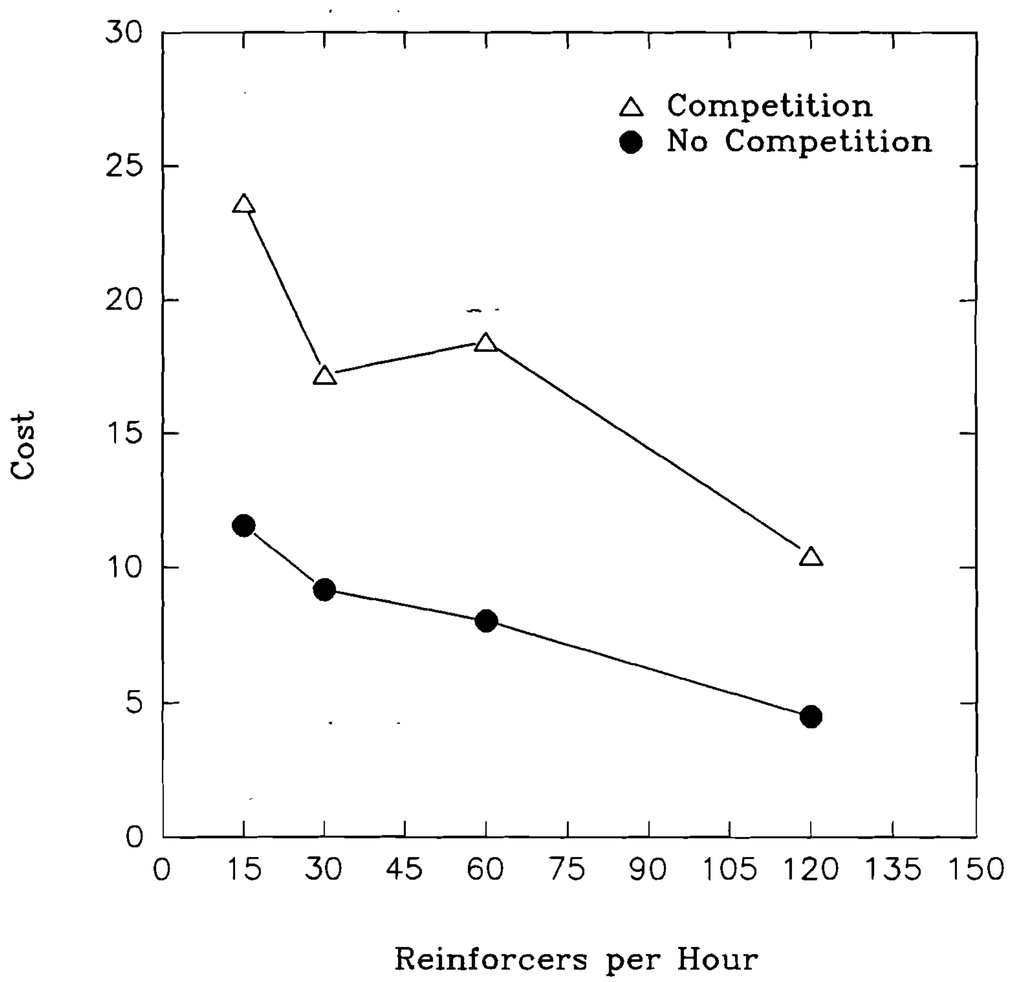
Reynolds, G.S. (1975). A primer of operant conditioning. Glenview, IL: Scott, Foresman and Company.

Skinner, B.F. (1938). The behavior of organisms. New York: Appleton-Century.

Thorndike, E.L. (1911). Animal Intelligence. New York: Macmillan.

Figure Caption

Figure 1. Mean behavioral cost (responses per reinforcer) plotted as a function of available reinforcer quantity, for both competition and no-competition conditions.


Competition
No Competition
Cost
Reinforcers per Hour
0
5
10
15
20
25
30
0
15
30
45
60
75
90
105
120
135
150