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Applying the Matching Law in a Sheltered Workshop

Kristin Elizabeth Skousgard
Western Michigan University

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APPLYING THE MATCHING LAW IN A SHELTERED WORKSHOP

by

Kristin Elizabeth Skousgard

**A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Psychology**

**Western Michigan University
Kalamazoo, Michigan
December 1990**

APPLYING THE MATCHING LAW IN A SHELTERED WORKSHOP

Kristin Elizabeth Skousgard, M.A.

Western Michigan University, 1990

This study assessed the validity of the matching law in an applied setting. It manipulated extraneous reinforcement and measured the rate of rocking in a 24-year-old developmentally disabled man. The resulting data were compared to that predicted by the matching law.

The results were important in three ways: (1) extraneous reinforcement systematically affected rocking in an applied setting in the manner predicted by the matching law, (2) a clinically undesirable behavior decreased in frequency, and (3) this decrease occurred in the absence of direct intervention on the target behavior. Thus, to a slight degree, scientific, practical and humanitarian goals were supported by these results.

ACKNOWLEDGEMENTS

Many thanks and enduring admiration go to Dr. Jack Michael and Dr. Sigrid Glenn for their guidance, encouragement and patience without which this manuscript would not have been possible.

Thank you to Dr. Jack McDowell and Dr. Walton Sharp for their generous gifts of very helpful procedural and technical assistance.

Last, but not least, much gratitude goes to my parents for their love, support and sacrifice throughout the course of this study.

Kristin Elizabeth Skousgard

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Skousgard, Kristin Elizabeth, M.A.

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CHAPTER I

INTRODUCTION

Background in Matching Law and Matching Theory

Matching Law

A long standing tenet of behavior analysis is that behavior is maintained by its consequences. A demonstration by Herrnstein (1961) revealed a quantitative relationship between the proportion of responding on a given response alternative and the proportion of reinforcement available on that alternative in a concurrent paradigm. Herrnstein dubbed this proportionality of responding matching and the theory which describes it, matching theory. His seminal experiment established the prototype design for laboratory matching experiments on "choice" behavior. Two keys, with a VI schedule of reinforcement programmed for each key, were continuously available in the experimental chamber. The organism (in Herrnstein's research, a pigeon) continuously responded on one key or the other, and the relative rate of responding on the two keys was found to be determined by the frequency of reinforcement available for each key. This differential responding is often referred to as "choice" behavior. In other words, rate of responding on each of the two keys was proportional to rate of reinforcement on each of the two keys. The equation for this function is called the matching equation and is used when two or more

responses (R's) and two or more reinforcer's (r's) are measured.

McDowell (1988) reports it as follows:

$$\frac{R1}{R1 + R2} = \frac{r1}{r1 + r2} \quad (1)$$

where R1 = response rate on first key
 R2 = response rate on second key
 r1 = reinforcement rate for R1
 r2 = reinforcement rate for R2

Change-over Delay

Experiments with non-human animals have repeatedly confirmed Herrnstein's results (e.g. deVilliers, 1977). In concurrent schedules this proportional relationship is obtained only when a change-over delay (COD) is arranged to follow each change from one key (schedule) to another. Bradshaw, Szabadi and Bevan (1976) present the one exception.

A COD is a minimum delay in the availability of reinforcement after the organism switches keys. The necessity of using such a procedure to achieve matching was delineated by Catania (1963). Catania compared response rates both with and without a COD. He concluded that this delay prevents adventitiously shaped control by one schedule over the other and therefore averts any superstitious bias in responding. The COD is now a standard procedure in

concurrent paradigm studies.

Matching Theory

Herrnstein (1970) reasoned on the basis of matching theory that the "choice" in a concurrent paradigm could be conceptualized as that between a single alternative and all other possible alternatives combined and considered as a conceptual unit. Furthermore, the reinforcement maintaining responses can be conceptualized as that which maintains the single alternative and the aggregate of all reinforcement maintaining all other responding. The following hyperbolic equation, derived from Herrnstein's original equation, (McDowell, 1988) quantifies this single alternative hypothesis:

$$R = \frac{kr}{r + re}$$

where R = response rate on a single key

r = reinforcement rate for R

k = total possible responses

re = extraneous reinforcement (all reinforcement other than that contingent on R)

This equation is particularly useful in assessing the potential of matching theory in applied settings because only one target behavior needs to be observed and measured and either reinforcement contingent on that behavior (r) or extraneous reinforcement (re) can be measured.

Research With Humans

Human Analog Research

Although laboratory research on non-human animals has repeatedly confirmed the matching law, research on use of the quantitative theory in work with human beings has been rather rare. Some research explores in the laboratory, with human beings, questions which may be relevant to humans but which have only been studied using non-human animals. These extrapolations of method and principle are sometimes referred to as human analog studies. They have extended the findings of matching theory into the realm of human behavior. Human responding, like that of laboratory animals, seems to be distributed among concurrent VI VI choices according to the proportion of reinforcement available on those choices.

Schroeder and Holland (1969) conditioned human macrosaccadic eye movements using a standard concurrent VI VI procedure with a change-over delay. Theirs was the first human analog experiment to test the matching theory. Indeed a hyperbolic relationship was obtained between eye movements to each alternative and reinforcement available for that alternative.

The first study to test the matching theory with humans in a more naturalistic environment was done by Conger and Killeen (1974). They measured verbal behavior and manipulated verbal reinforcement in a situation that is similar to situations often extant in the natural environment. Researchers cued two confederates to provide verbal

reinforcement for a subject's verbal responses and delivered it on one of two concurrent VI schedules. One confederate delivered 70% of the total reinforcement while the other confederate delivered 30% of the total. The results showed that the subject's proportion of talking to each confederate was a function of the proportion of total verbal reinforcement delivered by each confederate.

In a 1975 study by Baum on human vigilance, subjects' proportion of time spent looking at two different locations matched the proportion of successful "detections" of unpredictable light signals presented on two concurrent schedules, one occurring at each location. The amount of time spent looking at each alternative was measured by time spent holding down alternative keys which deactivated the light signals correlated with the location of the light signals.

Bradshaw et al. (1976) delivered monetary reinforcement contingent on button pressing on five different concurrent VIVI schedules. The data from this analog study showed that rate of responding on each key was hyperbolically related to rate of reinforcement on that key, as predicted by the hyperbolic form of the basic matching equation. No changeover delay was systematically programmed into this study. That a hyperbolic curve was found without this delay procedure found necessary by other experimenters is of note. Bradshaw et al. propose no explanation for this other than to say that this delay is apparently not needed in this type of experiment.

Applied Research

Two researchers have gone into natural or applied settings to look at the relationship of relative response rate to concurrently available reinforcers. Measuring but not manipulating variables and responses, they found that the relationships between responding and reinforcement were those predicted by matching theory.

Most recently, Martens and Houk (1989), interested in examining the usefulness of the matching law in a classroom setting, measured the naturally occurring on-task and disruptive behavior of a mentally retarded adolescent female. They found that the two classes of behavior were roughly proportional to the amount of social reinforcement contingent on each. Matching was assessed by analyzing and plotting amount of time allocated to target behaviors and frequency of reinforcement (primarily verbal praise or reprimands and physical proximity of the teacher) contingent on each class of target behavior.

McDowell (1981) further contributed to establishing the usefulness of the matching theory to the understanding and treatment of behavior in the natural environment. He moved from the strict analog experimental design of Bradshaw et al. (1986) into the natural environment of the home of a self-injurious 11 year-old-boy. As reported in this 1981 article, Carr and McDowell (1980) observed the rate of self-abusive scratching that occurred and the rate of verbal reprimands (reinforcement) contingent on that scratching. A quantitative analysis of the relationship between scratching and

reprimands using Herrnstein's single-alternative equation generated a typical hyperbolic function.

Practical Implications

McDowell (1982) went on to suggest four ways in which matching theory might lead to practical interventions in applied settings--two ways to increase a given response and two ways to decrease a given response. The first clinical intervention that might increase the rate of operant responding is to decrease the rate of reinforcement concurrently available for an alternative response. The second is to decrease the rate of non-contingent reinforcement available in the subject's environment. The first clinical intervention that might decrease the rate of a given response is to increase the rate of reinforcement concurrently available for an alternative response. The second is to increase the rate of extraneous reinforcement.

Epling and Pierce (1983) suggested that, clinically speaking, merely identifying and changing response/consequence relationships may lead to ineffective treatment or unwanted treatment side-effects. Furthermore, exclusive reliance on the principles of contingency and contiguity to design treatment could mean an incomplete understanding of the variables controlling a target behavior. The effect of a consequence contingent on a target behavior may depend on the frequency of the larger pool of reinforcers that are not contingent on that behavior. In this case the clinician needs to consider the matching theory notion that

behavioral consequences must be examined in the context of overall levels of reinforcement.

Myerson and Hale (1984) also reiterate some reasons the matching theory may be important practically. They note that McDowell (1981) suggested that the reinforcement maintaining a behavior may be difficult to manipulate, while extinction may generate unwanted emotional responses. They note also that Hutchinson (1977) suggested that punishment may also pose ethical problems.

Purpose of the Research

This study extended the basic research on the matching law in that it involved the actual manipulation of reinforcement to assess the validity of the matching law in an applied setting. As such, it extended the experimental analysis of matching theory from studies which measure but do not manipulate any variables into the realm of applied experimentation.

Another purpose of this study was to explore the usefulness of one of the therapeutic interventions suggested by the matching law. Often in applied settings the methodology of behavior change involves both the presentation and withdrawal of reinforcement. Sometimes it is not practically feasible to gain control over the reinforcement contingent on a target behavior. Social reinforcement, for example, may come from too many sources including peers, staff, visitors and outside professionals entering the client's environment. Rocking may be controlled by proprioceptive reinforcing stimuli which cannot be

manipulated independent of the behavior. A practical intervention which manipulates extraneous reinforcement as opposed to reinforcement contingent on a target behavior could change behavior without ever directly intervening on the target behavior itself.

In addition to these potential scientific and practical gains there are definite humanitarian goals to be achieved. Behavior change techniques utilizing the withdrawal of reinforcement or the application of punishment often engender unwanted emotional reactions and escape/avoidance behavior. A behavior change technique that side-steps undesirable escape or avoidance behavior, and emotional or behavioral side-effects common to reinforcement withdrawal or punishment procedures, would be of significant humanitarian value.

Furthermore, reinforcement withdrawal or punishment may lend themselves to abuse in institutional and other settings where their implementation may not be procedurally correct or rigorously monitored. Behavior management techniques, designed to accompany or replace punishment procedures, may be poorly taught to staff in such settings. Punishment and the withdrawal of reinforcement, although they often engender emotional reactions, also often produce an immediate change in behavior and are thus readily maintained in the repertoire of direct-contact staff.

The combination of these unprogrammed drawbacks could mean that punishment, poorly conceived or implemented and sometimes bordering on or constituting client abuse, becomes a primary undocumented and ad hoc technique for the management of behavior on a daily basis. A

new behavior change technique that involves the presentation of reinforcers on a non-contingent, variable interval schedule could be easy to implement by daily care staff and therefore likely to be implemented both regularly and well.

CHAPTER II

METHOD

Subject

A 24-year-old developmentally disabled man (HJ) participated as subject in the experiment. His most recent psychological assessment showed him performing at an Adaptive Behavior Level of II and showed him having a Slosson IQ of 36. His medical regimen remained the same throughout the study. According to its prescription he took 30 mg's of Mellaril four times per day, two mg's Haldol each evening, and two mg's of Cogentin each morning.

Subject Consent

The subject was shown a consent form and it was explained to him that he would be working as usual and that sometimes while he was at his table he would get M & M's. Since he is autistic and severely retarded this was explained to him in short sentences and small words that he was likely to know. His permission was indicated by a nod of his head and a smile. One witness viewed this request for permission to use him in this study.

The subject's legal guardian was contacted in person before the beginning of the experiment. The rationale, methodology, and possible outcomes (including potential gains for the subject) were

discussed. The guardian's questions were answered and a signed consent form (see Appendix C) granting permission for the subject's participation in the study was obtained.

Setting

HJ's normal schedule included participation in a sheltered workshop where the study was conducted. HJ sat at a table with four other workers, working on a task that consisted of selecting the two halves of a plastic "easter egg" from different containers, placing a small toy inside one half the egg, and snapping the two parts together. He generally played his radio while working. If HJ left the table for a break or to go to the bathroom the experiment was halted while he was gone.

Personnel

The experimenter was the individual who delivered extraneous reinforcement. The data collector was the person who recorded instances of the dependent variable and of reinforcement deliveries. Both experimenter and data collector sat on small, foldable camp stools. The experimenter sat next to the subject and the data collector sat approximately eight feet behind the subject. The counters could not be heard and the two data collectors could be seen by the client only if he turned fully around.

Apparatus

Audio tapes that signalled the experimenter that reinforcement was set up were prepared in the following manner. First, the VI schedules were prepared. An arithmetic progression was generated to derive the time intervals used in the interval schedules and this list of numbers was randomized. The list of numbers generated constituted the intervals of a VI schedule. Intervals were generated for four schedules: VI-1', VI-5', VI-8', VI-11'.

Clicks from a small board game clicker were recorded on a standard cassette machine according to each pre-determined schedule of intervals. A 90-minute tape was used and the intervals were re-cycled as they were recorded so as to continuously present the variable-interval schedule. The tape provided 90 minutes of uninterrupted presentation of clicks. The experimenter listened to the clicks, played through a "Sony Walkman" machine, with standard lightweight earphones. These clicks were not audible to others.

Dependent Variable

The dependent variable was the rate of rocking while HJ sat at his work table. Data were obtained by counting rocking cycles (with forward and backward movement counting as one cycle) on a counter that recorded up to 999. Because a movement forward might be followed by a return to resting position in the course of ordinary activity, rocking was considered to commence only when movement entered a second cycle immediately upon completion of a first. If

rocking stopped (even briefly) and re-commenced the first cycle was again discounted. Rocking varied from large rocks to small rocks. Because HJ was seated in a chair at a table, rocking was limited to the distance between the table top and the chair back.

Independent Variable

One-half an M & M candy was presented on four VI schedules of extraneous reinforcement (re). The candy was delivered when the subject was observed at his work table doing anything other than rocking. As demonstrated important by the preponderance of matching theory data, a changeover delay was instituted in this experiment. When the click sounded, the experimenter immediately delivered an M & M if the subject was not rocking. If the subject was rocking when the click occurred, the experimenter paused one to two seconds after the rocking ceased to deliver the reinforcer. This delay in reinforcement was implemented to insure that the reinforcer, when delivered, did not inadvertently reinforce the change from rocking to an alternative behavior.

Data Collection

Data were collected and analyzed in 10-minute segments. Early in the study (on the VI eight-minute schedule), data were collected for one half hour at a time (three consecutive 10-minute segments). Because 10 days passed before modest stability across 10-minute segments was obtained, between six and nine consecutive segments were

run daily during the remainder of the study. The data used in the analysis were the last two hours (12 segments) of data collected on each schedule. This allowed the behavior of the subject to stabilize on each schedule.

Reliability

Reliability measures on the dependent variable were taken by a second observer during 23 of 48 10-minute segments. Two people measured reliability on six different occasions for a period of 30 to 60 minutes on each occasion. At the end of each reliability session the two data collectors compared their total number of observations. The smaller number of these totals for each session was divided by the larger of these totals. In this way, a measure of reliability was obtained for each period during which reliability measures were taken. Reliability ranged from 91% to 99%. The overall reliability was 96%.

Although the primary data collector took data on the independent variable as well as on the dependent variable, the second observer did not collect data on the independent variable. The data on the number of M & M's delivered was checked against the number scheduled, however, and the number delivered was always within one of the number scheduled. A discrepancy of that magnitude may have been due to the variable length of the intervals or to a missed delivery. In either case, the effect would have been negligible on the rate of reinforcement used in the equation.

CHAPTER III

RESULTS

The data used in the analysis of matching were the last two hours (12, 10-minute segments) of data collected on each schedule. This allowed the behavior of the subject to stabilize on that schedule. Table 1 contains a summary of the data obtained on each of the four schedules.

Table 1
Data Summary

Responses per minute	Extraneous reinforcement per hour
.7	60
2.5	12
13.5	8
23.1	5

Two statistical procedures were utilized to obtain two constants critical to the single-alternative equation. The parameter, r , was estimated using the SPSS computer program for multiple regression analysis which yielded a slope of 1.9. This is the hypothetical slope of the line or the estimate of r generated by the statistical program when the obtained data are entered into the computer. The

constant, r , specifies the rate of change in the slope of the derived curve line that would be generated if the obtained data precisely fit the predictions of matching theory. The constant, k , was obtained using the following procedure. The reciprocal of R , $1/R$, was plotted as a function of the obtained r , as per McDowell (personal communication, June, 1990). The line-of-best-fit (a straight line) was drawn and where the line intercepted the ordinate was the estimate of k . Using the BMDP-PAR statistical package, these constants were fitted into Herrnstein's equation and the hyperbolic function that would best fit the data was obtained. Figure 1 shows the smooth curve that is the plot of this best fit hyperbola. It represents where the data would be positioned on the graph if 100% of the variance was accounted for by the equation. The squares represent obtained rates of responding on the four schedules of extraneous reinforcement. The equation accounted for 67% of the variance.

All of the data collected during the experiment are shown in Figure 1. This figure shows the number of rocking responses per 10-minute interval in each condition and over all the sessions. Each data point represents an interval. Daily sessions consisted of three to 12 intervals each.

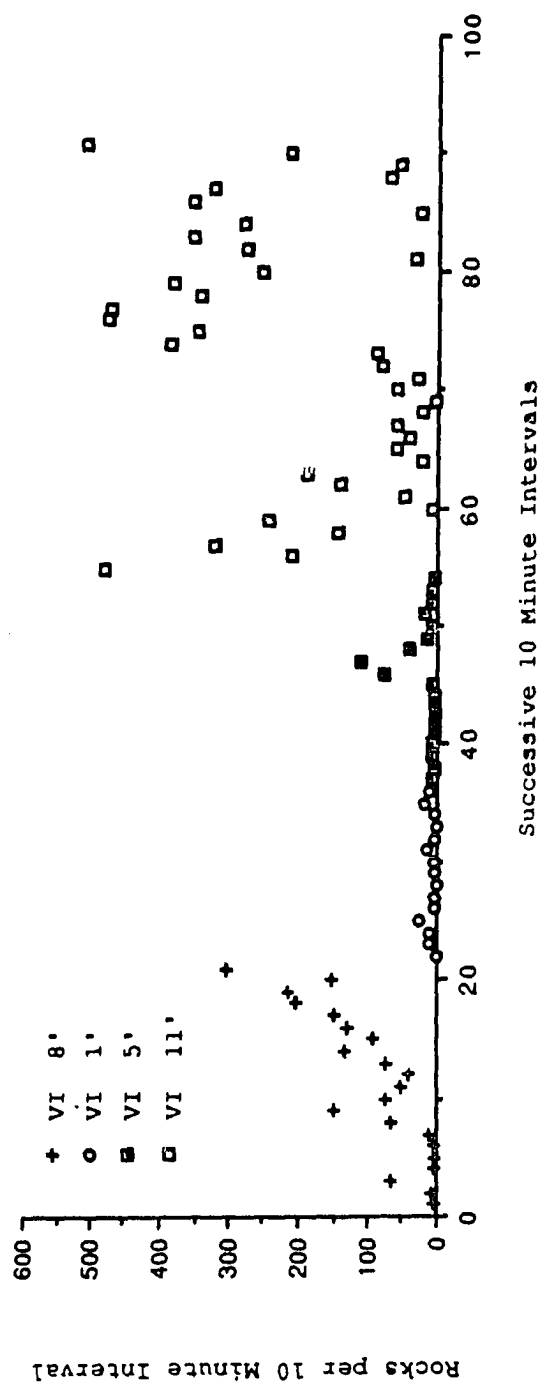


Figure 1. Rocking Responses per 10 Minute Intervals

CHAPTER IV

DISCUSSION

Rate of rocking, the target response, did vary systematically with the rate of extraneous reinforcement. The greater the rate of extraneous reinforcement, the lower the rate of rocking. When plotted, the data from this experiment took the basic hyperbolic form predicted by the matching equation. These results indicate that matching can be found in an applied setting when a common reinforcer is manipulated and a common behavior is targeted for measurement. An unwanted target behavior decreased in frequency, indicating some clinical usefulness of the procedure, or derivations thereof. Finally, the target behavior was affected without being intervened upon directly. Thus, the scientific, practical and humanitarian goals of this research were furthered.

One data point, however, is plotted away from the hyperbolic curve predicted by the matching equation. This point represents the data generated under the VI-5' schedule. There is no obvious reason for this deviation. It seems possible that the simple physical presence of the experimenter came to exert stimulus control over the subject's rocking behavior. The schedules were presented in the order VI-8', VI-1', VI-5' and VI-11'. Why stimulus control would have differentially affected the schedule presented third and not the

schedule presented second is unclear.

There are other variables that have appeared to affect the subject's behavior over the course of time since the study was completed. It is possible that one or more of these came into play unobserved by the experimenter or data collector. Once or twice a month the subject has hence been observed to enter the workshop in the morning grumbling, avoiding even minimum social contact if possible and generally angry. One plausible hypothesis is that something aversive occurred at his group home before the subject entered the work setting. The notes for one VI-5' session indicate some grumbling, grimacing and signs of emotional reaction during the session. An aversive occurrence the morning that schedule VI-5' was implemented may have affected the results. The rate of rocking may have risen when the intrinsic value of the reinforcer following that behavior increased. Some days HJ was observed to work more quickly and more steadily at his task. It should be noted that he was also paid twice monthly for what he had produced. If the reinforcers contingent on this task were particularly salient during the VI-5' phase, rocking could have decreased as a function of increased on-task behavior.

Despite these possible uncontrolled factors, extraneous reinforcement did systematically affect the target behavior. Further research is needed to experimentally determine the level at which extraneous reinforcement is useful in applied situations. There may be a level beyond which increased extraneous reinforcement is

ineffective in further decreasing a target behavior. For optimum treatment cost effectiveness, extraneous reinforcement would neither drop below or rise above this level.

APPENDICES

Appendix A

Human Subjects Review Approval: W.M.U.

WESTERN MICHIGAN UNIVERSITY

Date: March 25, 1990

To: Kristin Skousgard

From: Mary Anne Bunda, Chair *Mary Anne Bunda*

This letter will serve as confirmation that your research protocol, "Applying the Matching Law in a Sheltered Workshop", has been approved as expedited by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: J. Michael, Psychology

HSIRB Project Number 90-01-05

Approval Termination March 25, 1991

Appendix B

Human Subjects Review Approval: Bethphage

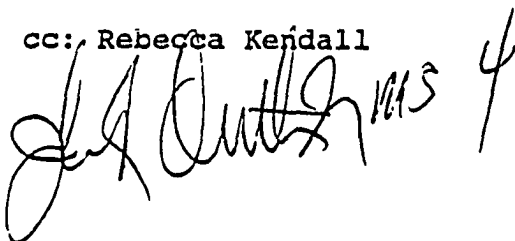
John Outler
Bethphage Community Services, Inc.
16990 Dallas Parkway, Suite 110
Dallas, TX 75248

To: Kristin Skousgard
From: John Outler
Date: 2 - 8 - 90
Re: Research Protocol: "Applying the Matching Law in
a Sheltered Workshop"

I am granting approval for implementation for the
research proposal entitled, "Applying the Matching Law in
a Sheltered Workshop", contingent on compliance with
recommendations made by the Research Review Committee.

Please forward a full report of findings as well as a
summary of findings to my office upon completion of the
project

cc: Rebecca Kendall



Appendix C
Client Consent Form

Informed Consent for Participation In A Research Study 28
Bethphage Industries Workshop

In the proposed study, I will select a target behavior that is inappropriate and that we wish to decrease in frequency. I will then give the subject an edible reinforcer or reward (something that the client likes to eat) on a prearranged schedule anytime that the client is not doing the inappropriate behavior. What I expect is that the inappropriate behavior will go down in frequency even though I am not doing anything to it. That is, I am not punishing it or removing anything that rewards the inappropriate behavior. The study may have the positive outcome of indicating a new intervention strategy that includes the positive application of reinforcement (or reward) and does not include changing the reward received for an inappropriate behavior. The inappropriate behavior is assumed to be maintained by some reward that occurs naturally in the environment for doing it. Changing that reward sometimes causes undesirable behavioral and emotional side-effects such as rage or crying when the reward is removed or altered. In addition the reward maintaining an inappropriate behavior is sometimes difficult to manipulate. Such a new intervention would not only help a specific client in this sheltered workshop but could help many developmentally disabled clients in the community as a whole.

The sessions will take place for 1/2 hour each day for a 4 week period. They will occur in the everyday workshop setting, will use edible rewards and will in no way interrupt the daily routine of the workshop. There are no risks for the participants in the study and in each case there is a potential gain to be had.

All information will remain confidential. Only the researcher, the workshop director and one supervisory administrator of Bethphage Industries will see the recording forms or data collection techniques. The two Bethphage personnel wish to see the data to determine if the technique has been successful and is therefore applicable to the client population at large.

The experimenter can be reached at home (817-781-9121) should you have any questions.

The subject may withdraw from the study without penalty at any time and without affecting the services the subject receives at the workshop. Non participation in the study will not affect the subject's relationship with the workshop or the services.

_____ is hereby given permission to participate the described research.

Guardian's signature

Date

Investigator's signature

Date

Client's signature

Date

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