2013

Headbanging by Pigeons III. A Systematic Replication and Extension of an Animal Model of Psychopathology

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Recommended Citation

Casler, Darin Allen, "Headbanging by Pigeons III. A Systematic Replication and Extension of an Animal Model of Psychopathology" (2013). *All NMU Master's Theses*. 364.
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HEADBANGING BY PIGEONS III. A SYSTEMATIC REPLICATION AND EXTENSION OF AN ANIMAL MODEL OF PSYCHOPATHOLOGY

By

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THESIS

Submitted to
Northern Michigan University
In partial fulfillment of the requirements
For the degree of

MASTER OF SCIENCE

Graduate Studies Office

2013

SIGNATURE APPROVAL FORM

Title of Thesis: HEADBANGING BY PIGEONS: III A SYSTEMATIC REPLICATION AND EXTENSION OF AN ANIMAL MODEL OF PSYCHOPATHOLOGY

This thesis by _____Darin Casler_____________ is recommended for approval by the student's Thesis Committee and Department Head in the Department of ____Psychology___and by the Assistant Provost of Graduate Education and Research.

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ABSTRACT

HEADBANGING BY PIGEONS III A SYSTEMATIC REPLICATION AND EXTENSION OF AN ANIMAL MODEL OF PSYCHOPATHOLOGY

By

Darin Allen Casler

Headbanging is a self-injurious behavior commonly associated with many forms of developmental and personality disorders, as well as a variety of mental illnesses. Any suggestion that such disturbing behavior may be influenced by its environmental (particularly social) effects in the past has been met routinely with vigorous counter-arguments; clinical observations traditionally have denied any social benefits that might maintain such self-injury. Nevertheless, a number of successful interventions have been devised on the basis of considering self-injurious behavior as instrumental in producing important reinforcing consequences for individuals engaging in it. Accordingly, Layng, Andronis, & Goldiamond (1997) demonstrated that such behavior in pigeons indeed could be established, maintained, and otherwise modified as operant behavior, not very different from keypecking, lever-pressing, treadle-pressing, or other mundane behaviors typically regarded as "normal." The present study systematically replicates those initial findings, extends them to include a different history of behavioral contingencies, and strengthens the heuristic value of this animal model for the study of (potentially) self-injurious behavior.

AKNOWLEDGEMENTS

I would like to thank Linaye Whitehead, Emily Bartholomy, Ashley Mattice, Dorothy Anderson, and Margaret Ylitalo for being a vigilant lab crew. Also, I would like to thank my Thesis committee members Adam Prus, Joseph Porter, and Paul Andronis for helping me with direction and guidance. I would also like to thank Professor Andronis for not only allowing me to use his lab space but also to pick his brain for a constant wealth of information. Without the help of Professor Andronis and others in the department it would have been almost impossible to finish in two years.

This thesis follows the format prescribed by the *APA Style Manual* and the Department of Psychology.

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Introduction

When analyzing the behavior of humans or other animals, it is crucial to examine what are the consequences of that behavior. Do those consequences serve as positive reinforceers, that is, does the organism receive something of value for this behavior, such as tangible and potent resources, like food, water, or warmth, or such social effects as attention or affection. Alternatively, do the consequences function as negative reinforcers, that is, does the organism escape a potentially harmful, demanding, or frustrating situation. Finally, are the consequences of its behavior merely stimulatory, that is does the organism experience solely sensory effects from its actions. In all these cases, but particularly those occurring in the natural ecology of the organism, it is crucial to consider how one organism's behavior may mediate or alter the consequences of another organism's behavior (Skinner, 1957).

Headbanging and other Self-Injurious Behaviors (SIB) have been seen in children with autism, as well as other developmental disorders. It is defined as a chronic dysfunction that often results in physical, social, and educational risks to the injurer (Oxford Dictionaries, 2013). Children with Autism self-injure for many different reasons, but the prevailing theories have centered on physiological disorders. In the present study on headbanging by pigeons, the focus of the experiments is on environmental conditions that may produce and maintain such SIB. Headbanging is defined clinically said to be a violent shaking of the head, often accompanied by rocking back and forth of the body (Oxford Dictionaries, 2013). Headbanging by pigeons was first demonstrated as an animal model of psychopathology to determine if headbanging could be brought under control of normal reinforcement contingencies through carefully arranged experimental conditions, using a tangible primary reinforcer (food) to establish and maintain the behavior (Layng, Andronis, Goldiamond, 1999). Such an analysis does not simply place the behavior into an S→R response model. , Rather it examines the behavior as a form of verbal action on private and social situations, in which instances it must account for more complexity than does the traditional S→R model, and alternatively focuses more importantly on behavioral outcomes (Layng, 1995). The present study examines the role of conditioned reinforcement in the acquisition and maintenance of headbanging, a common and disturbing behavior that accompanies many psychiatric disorders. . Conditioned or secondary reinforcement can come about from a neutral event acquiring reinforcing value because of its relation to a primary reinforcer; thus the neutral event can act as a reinforcer once established (Williams, 1994).

This experiment is the third in a series analyzing a model of pathological behavior that can be reinforced under normal contingencies. The first study in this series (Layng, Andronis, Goldiamond, 1999), demonstrated that headbanging could be established, maintained, and extinguished under normal positive reinforcement contingencies, and also demonstrated that, once established, with reinforcement and subsequent extinction of an alternative behavior, headbanging spontaneously recovered in force, a phenomenon often observed in clinical settings. The second study in the series (Hahn, 2010) was a systematic replication of the first study, and extended the findings to include a demonstration that once headbanging had been established and maintained with food reinforcement, it could then be maintained through conditioned reinforcement as well. The present study replicates the maintenance of headbanging through conditioned reinforcement, but also demonstrates that this behavior can be established in the first place by conditional reinforcement.

Human behaviors and patterns that are seen as problematic or socially disruptive are considered as indicative of psychopathology and mental illness (Layng, Andronis, Goldiamond, 1999). SIB is seen as a problem behavior and can be evoked through naturally occurring consequences (Dorey, Rosales-Ruiz, Smith, Lovelace, 2009). There are many clinical applications in the field of applied behavior analysis that pinpoint environmental and social conditions underlying the occurrence of SIB. Experimental studies of SIB manipulate the conditions that may be leading to or are indirectly linked to pathological behaviors. An experimental design that allows for the manipulation or control of SIB enables investigators to compare those behaviors produced in the laboratory to similar pathological behaviors within natural human environments.

There were two reasons for focusing on headbanging as the behavioral response of choice in this study. First, the response is topographically similar to that of a clinical setting (Layng, Andronis, Goldiamond, 1999). Second, there is no such maladaptive behavior that can be seen in the natural biological endowment of pigeons: pigeons do not normally bang their head against environmental surfaces; they simply do not emit such behaviors under naturally occurring circumstances (Staddon, Simmelhag 1971).

The Diagnostic and Statistical Manual of the American Psychiatric Association, Fourth Edition (DSM-IV) classifies head-banging as a superficial or moderate SIB (Stein, Grant, Franklin, Keuthen, Lochner, Singer, Woods, 2010). “These types of behaviors are characterized as repetitive, low lethality actions that alter or damage body tissue without suicidal intent (Favazza and Rosenthal, 1993)”. Many behaviors arise in nature that belong to the category of SIB, such as stripping feathers from the body, pulling out hair, or biting one’s own flesh. The present study does not contend that head-banging is a naturally occurring behavior by pigeons, but instead attempts to demonstrate a functional parallel with an equally unnatural human behavior, and that this “lower-order motor action that is characterized by repetition of movement” can be attributed to more subtle environmental factors (Lewis, Tanimuraa, Leea, Bodfishd, 2007).

In a study reporting SIB in a school setting, there was a prevalence rate around twenty-five percent for students with autism (Murphy, Hall, Oliver, Kissi-Debra 1999). Four percent of the general public, and twenty-one percent of clinical examinations have reported SIB within a sample population of neurotypical individuals (Briere and Gil, 1998). Studies on SIB in children with autism have put the prevalence rate as high as seventy-one percent for children with this diagnosis (Bodfish, Symons, Parker, Lewis). Comparing behaviors of neurotypical children to children with autism, we see vast differences in social communication and social interaction (Volkmar, Carter, Volkmar, Sparrow, Wang, Lord, Dawson, Fombonne, Loveland, Mesibov, Schopler, 1998). Autism has been seen as a disorder that result in SIB because of a genetic disposition towards such behavior.

Treatment for SIB

Treatment for SIB can be divided into two categories. The first involves treatment of SIB is through behavioral therapy. The second category includes treatment of SIB through a pharmacological approach. This type of treatment changes how the brain functions in order to change the individual's behavior. The concern of the present study is with its implications for the former approach to treatment.

The study of conditioned reinforcement of SIB has a practical application. In the case of the present study, the experimental conditions established are functionally similar to some circumstances encountered by children with autism, as well as those in clinics for children with various other physiological disorders. In the clinical setting, if the child bangs its head when a nurse or other staff member is present, then the staff member will often immediately attend to the child. The consequence of that child's behavior may not be due to an inherent defect, but may be maintained instead by getting the nurse's attention. With the nurse present, the child is afforded the opportunity for attention, water, food, and many other reinforcers. Therefore, once this behavior has been reinforced, even in a different setting, the child is likelier to attempt to further emit SIB when members of the clinical staff are momentarily unavailable. This behavior will assure at least attention from staff, as well as possible other reinforcers. A laboratory model that demonstrates shaping and maintenance of SIB by conditioned or secondary reinforcement can influence implementation of behavioral treatment approaches to lowering SIB rates and establishing more socially acceptable behavioral repertoires in affected children.

Behavioral Treatment

Self-injurious behavior can stem from many different causes, and not just one that is physiologically inherent -- it can also arise from variables in the social setting. Before considering treatments for SIB, clinicians must perform a functional analysis of the patient's behavior. Each case must be assessed individually, because lumping a patient into the category of SIB would be looking too broadly (Edelson, 2008). Having a careful functional analysis of not only the patients' behavior, but of the social setting in which they were raised and are in which they are now living gives a clear view of what may prompt or maintain the SIB. Behaviors such as head-banging, arm scratching, and self-biting may have different motivations. In headbanging, there may be a positive or negative reinforcement contingency behind the behavior, while in scratching there may be mainly self-stimulatory effects. There can be euphoric effects created by the release of opioid neural transmitters during SIB. This could lead to persistence of behavior because the child is therefore reinforced by physiological causes not seen behaviorally. Functional analysis of the step-by-step process of what is perceived as SIB allows the clinican to make a well-targeted, effective, and efficient behavioral treatment plan for the behaviors (Edelson, Taubman and Lovaas, 1983)

With SIB, investigators must examine what reinforcement contingencies may be acting on SIB. They must carefully consider whether there is merely an automatic reinforcement of SIB. Automatic reinforcement occurs without direct intervention from another person to produce a desired effect. This type of reinforcement may also occur when a neutral stimulus gets paired with a potent reinforcer; thus, any response that produces a stimulus similar to the neutral stimulus will then be automatically reinforced (Sundberg, Michael, Partington, Sundberg, 1996).

Under some circumstances in laboratory, clinical, and natural environmental settings, response-independent schedules of reinforcement may be in effect. This type of reinforcement contingency may be referred to technically as noncontingent reinforcement, or in more familiar language with descriptors like “unconditional positive regard.” This type of reinforcement contingency is often used to decrease certain unwanted target behaviors, in this case a decrease of SIB. Nevertheless, the behavior targeted for decrease might be reinforced directly by extrinsic reinforcers (Ahearn, Clark, Gardenier, Chung, Dube, 2003). With behavioral therapy conducted without regard to the specific functional class to which SIB belongs, clinicians may observe an initial decrease in the behavior, but it may increase over time and be just as persistent as treatment ends.

After conducting a functional analysis of a person engaging in SIB, different behavioral treatments will address the particular maintaining variables revealed by the analysis. Behavior that can be automatically reinforced may seem like a moot issue to humans that show neurotypical behavior, but with people who have autism, this reinforcement can be pervasive and strong. Aside from headbanging, there are other behaviors that comprise SIB in clinical cases. Pica is a behavior defined as ingestion of materials that possess no nutritional value. Such pica can be decreased when other alternatives to this particularly mild SIB are available. One study showed that patients displaying pica would ingest other nutritional materials if readily available (Piazza, Roane, Keeney, Boney, Abt, 2002). The study also showed that if the nutritional alternative was paired with a raised requirement for engaging in pica, then the latter behavior was greatly diminished. Stereotypical SIB, or injuries common with headbanging and biting (e.g., abrasions, bruises, skin lesions, hair loss, infection, etc.) can be persistent in some developmental disorders (Matthews, Wallis, 2002). Accordingly, treatment can be difficult, and its outcomes unclear, and the behavior can sometimes remain pervasive even after therapy. The therapy may appear to be working initially, but must continue to demonstrate any significant effects. In one study conducted with four children diagnosed with mental retardation or autism, the children were given the opportunity to engage in alternative behaviors leading to positive reinforcers, or punishment (electro-shock) of SIB. This study showed that punishment greatly decreased the likelihood of SIB, while reinforcement of other behaviors had little to no effect on SIB (Corte, Wolf, Locke, 1971). The authors of this study cautioned that if a person was punished for any action, regardless of whether they had a physiological disorder or were neurotypical, then the behavior would likely decrease in probability – this effect was not confined to SIB alone; the researchers further noted that there were many social situations in which the SIB can arise. In order to decrease the behavior we would then need to punish the behavior in all these situations. This would be almost impossible, not only from perspective of the punisher, but it would also likely do more damage to the patient than good in the long run.

Reinforcement of alternative behaviors may seem like a more humane way to decrease SIB, but children with autism are said to lack the ability to self-regulate. It is difficult for clinicians to identify the children’s intrinsic reinforcers, and to arrange the home environment to engender opportunities for the child to produce these, thus the behavior may not come under control of environmental variables once the therapy is no longer under the guidance of a clinician. This lack of regulation is attributed to be the cause of the behavior's persistence, thus punishment is often preferred as a treatment method because of quick results in decreasing injurious behaviors (Matson, LoVullo, 2008).

In an enriched environment, a person has several options for his or her actions. A child could play with a ball instead of engaging in SIB, or could do something of more interesting or having greater value than SIB. Accordingly, some forms of therapy focus on providing alternative sources of reinforcement other than SIB, and tries to rearrange the environment in which the child emits such behavior. This type of therapy also typically targets preventing the behavior before it has a chance to begin, an approach that has resulted in a decrease in targeted aberrant behaviors. The results of enriched environmental behavioral therapy demonstrate that arranging conditions that alter stimulus preference can mitigate the effects of unknown maintaining variables acting upon the behavior (Vollmer, Marcus, Leblanc, 1994).

Along with enrichment, an approach called Functional Communication Training (FCT) has proven to be an effective method of decreasing SIB. In FCT studies, children have been taught successfully in social communicative behavior more acceptable from a developmental standpoint than SIB. Children with autism normally lack the skills required to create a normal and adequate social environment to sustain socially mediated extrinsic motivation. With Functional Communication

Training, social situations are systematically analyzed in order to correctly identify appropriate communicative behaviors that would displace SIB. Children that are helped by peers through their daily routines show better social interaction and decreased SIB (McGee, Almeida, Sulzer-Azaroff, Feldman, 1992). Once these routines are established, the peers' participation is then slowly faded out, and the behaviors become more likely to occur in the child's everyday life. The behaviors may have to be peer-reviewed throughout the children's time in grade school, and even into later years, for the newly established repertoires to continue and be reinforced.

In order to establish acceptable target behaviors, some therapists attempt first to eliminate problem behaviors. Though this is a start in the right direction, the disturbing behaviors must still be replaced with socially useful repertoires (Goldiamond, 1974). With respect to children with autism, the lack of verbal acuity is a serious behavioral deficit that greatly complicates treatment. A study using Functional Communication Training showed that children's disruptive behavior typically occurred in more than one social context. Therapists must know the particular situations in which the disturbing behaviors occur before they can implement an effective training program. Such situations in this study included children's lack of attention, and difficulty of tasks required of them. Once the researchers had identified the relevant situations, they taught the children to utter phrases that would call for peer attention or help (Carr, Durand, 1985). This type of simple communication along with a functional analysis allowed the children to communicate their intentions and frustrations simply and directly. This lowered the children’s SIB and increased their social interactions now that the reinforcers were set in place and could be easily accessed by the children. When Functional Communication Training is used properly, it is like other types of therapy in that it arranges social situations with effective reinforcement contingencies. Also the training is preventative and allows the children’s behavior to come under control of both extrinsic and intrinsic positive reinforcers.

Many behavioral therapies involved in treating SIB have implemented *a priori* preventative measures, except those that us electric shock as punishment, by definition an *a posteriori* procedure. Other disorders characterized by behavior topographically similar to headbanging include Lesch-Nyhan Syndrome. With this syndrome, clinicians have used approaches to therapy that involve restraining a patient and even removing patients teeth in order to stop their SIB, typically biting themselves (Olson, Houlihan, 2000). Patients with Lesch-Nyhan syndrome have been restrained in order to protect not only themselves but also others. Functional analysis of SIB by children with Lesch-Nyhan syndrome reveals that restraint or other physical alterations were best used as distracters from SIB. Accordingly, these sorts of SIB inhibitors do not seem therapeutic in their effects. In a study of forty Lesch-Nyhan patients, there was a remarkable number of children who asked to be put into restraints. The children could verbalize that the restraints would stop them from self-injuring. The SIB was seen to be associated with more stressful situations (Anderson, Ernst 1994). Restraint upon request functioned as a method for the children to deescalate to a less stressful situation, and they were able to point out instigating situations. While restraints and physical alteration to stop SIB may be helpful in some circumstances, such methods are very labor intensive and are more reactive than proactive in nature.

Another behavioral approach to SIB is the method of stimulus fading. This procedure gradually fades out potentially stressful or SIB instigating situations. In a study done with phobias, researchers using stimulus fading were able get a child to gradually relinquish his phobic state for food reinforcers (Shabani, Fisher, 2006). With such fading techniques, the clinician identify those situations in which SIB occurs, and identify whether they involve either positive or negative reinforcement contingencies, or punishment contingencies. In another study on fading, there was evidence that a reduction in SIB stemmed from the acquisition of control over behavior by verbal instructions. With this analysis of the problem behavior, the investigators implemented a design in which they would not offer helpful instructions until the patients ceased their SIB (Pace, Iwata, Cowdery, Andree, McIntyre, 1993). They slowly allowed the children to acquire responses corresponding to verbal instructions. This allowed the children to become acclimated to both the situation and to the instructions being implemented.

Along with stimulus fading, researchers have implemented extinction procedures in order to further reduce SIB. In contrast to negative reinforcement, extinction has been used to limit SIB. Autistic children self-injure to escape punishment, high demands, and other aversive contingency arrangements. Accordingly, if SIB maintained by negative reinforcement (typically being allowed to escape an aversive situation) is extinguished, then the children be required to continue in those situations in which they typically self-injure. To mitigate the aversive aspects of extinction, it is usually paired with stimulus fading; this blended technique requires the children to stay in the situation that is frustrating them, but the fading allows for that situation to be handled easier (Zarcone, Iwata, Smith, Mazaleski, Lerman, 1994). Extinction as a method paired with another type of behavioral treatment can be a productive measure to lower SIB. Extinction by itself can cause adverse effects though. When examining the effects of extinction on behavior problems, the same effect as avoidance reinforcement can cause the behavior to continue. This suggests that for SIB maintained by positive or negative reinforcement, extinction we may require a dual approach for each reinforcement type (Iwata, Pace, Kalsher, Cowdery, Cataldo, 1990).

Animal Models

Animal models are a way to implement experimental designs that would otherwise be almost impossible to conduct with human subjects. Animals can exhibit behavior with the same frequency and topography of certain human behaviors. For example, pecking is a mundane everyday activity for pigeons, much as clicking left or right on a keypad is for humans. Through systematic manipulation of that everyday behavior in the laboratory, researchers may be able to gain insight with an animal model into those variables that control human behavior in certain social or interpersonal situations. Experiments pertaining to psychopathology with rats have shown that rats with physiological depletions of serotonin have been more susceptible to SIB when such depletions are imposed under conditions of social isolation (Ellison, 1977). These animal models allow physiological and behavioral comparisons between animals and humans with respect to variables controlling similar SIBs.

Animal studies allow the experimenter better to control for extraneous variables. In a study involving the effects of nicotine administration on visual perception and stress reactions, the experimenters used multiple baselines and various experimental interventions to reveal systematic changes in visual perception and stress following nicotine administration (Raiff, Dallery, 2009). Such a study using human subjects would likely have problems with ethical concerns over subjects' prolonged exposure to potentially harmful substances, and substantial variability in its results arising from unidentified extraneous factors in the subjects' histories and natural environments. Whereas animal studies allow longer periods of study and greater reliability of the data, arising from experimental control over those variables thought to exert the most control over the behavior of interest.

Experimental animal models can allow investigators to test and re-test information gained from human studies, and allow careful and systematic control over the environment and other behaviorally relevant variables. Schaefer (1970) systematically replicated typical human SIB in monkeys through particular environmental arrangements.

In another animal study, King (2000) showed increased rates of aggression by rats that had been injected with a drug that causes destruction of dopaminergic structures in the brain. Such studies with animals allow physiological alterations that provide insights into neurological pathways and their functions in the brain. Since most of the methods of studying drug discrimination include dissecting the rats' brains at the end of behavioral testing, this would be unachievable with human subjects. Animals possess many of the same structures and neural pathways as do humans, allowing research on animals to be correlated to our clinical knowledge of human physiology. Looking not only at ethics, animal models are less expensive and better calculated alternatives to human models.

There are drawbacks to any model used to simulate natural phenomena, and although studies done with animals can achieve exquisite experimental control, sometimes too much control affects naturalistic behaviors. Rhesus monkeys have been shown to display SIB due to stressors implicated with moving from one area of the laboratory environment to another (Davenport, Lutz, Tiefenbacher, Novaka, & Meyer, 2008). Nevertheless, experimenters would likely encounter insurmountable obstacles to replicating such findings with human preparations, or studies in the natural human social environment. There are very few if any situations where a natural social environment could be completely controlled, or changed from one setting to another. It is evident in the study by Davenport *et al* (2008) that complete control over the environment can have adverse effects on the subjects(i.e., reliably inducing SIB), but a similar study with human subjects, even if ethically permissible, would be unlikely to achieve comparable environmental control, and thus would fail to provide a clear and perspicuous analysis of the relevant variables. Thus, animal models of SIB have their benefits as well as drawbacks, but with respect to the present experiment, a laboratory model of SIB is necessary for not only ethical reasons but for its ability to achieve adequate environmental control and multiple manipulations on stimulus consequences.

Rationale

The present study sought to determine whether a form of SIB can be brought under control of positive reinforcement contingencies similar to those that control other normal behaviors. There are three experiments reported; the first used a conditioned reinforcer to shape SIB. This would strengthen the basic model because the current literature on SIB shows no instances of establishing SIB through conditioned reinforcement. The second experiment examined the ability of a conditioned reinforcement to maintain SIB reliably over time. The third experiment expanded on the second, examining the effects of increasing the response requirement for producing the conditioned reinforcer on maintenance of SIB.

Methods

Subjects

Three White Carneaux pigeons (*Columba livia*), approximately eleven years old, served as subjects. These birds participated previously in studies involving choice registered by keypecks, but were naïve to the variables and relations involved in the present study. The birds were maintained at (85%, ±5%) of their weights when fed ***ad libitum***. Between sessions, they had constant access to water and grit in their home cages. The birds were also given supplementary food after experimental sessions if their weights dropped below the (85%) criterion.

Apparatus

Two identical Lehigh Valley operant chambers (model 1519C) were used. The size of the enclosed space in each chamber was 10.5”x12”x13’’. Both were equipped with Lehigh Valley grain dispensers (model 1347) and three Lehigh Valley pecking keys (model 1348), completely covered with a translucent plastic shield to diffuse the light from the keys. The feeder opening in each chamber was 1.875”x 2.375” (see Figure 1).

Figure 1. Interior view of experimental chamber, showing houselight, keylights, and feeder opening.

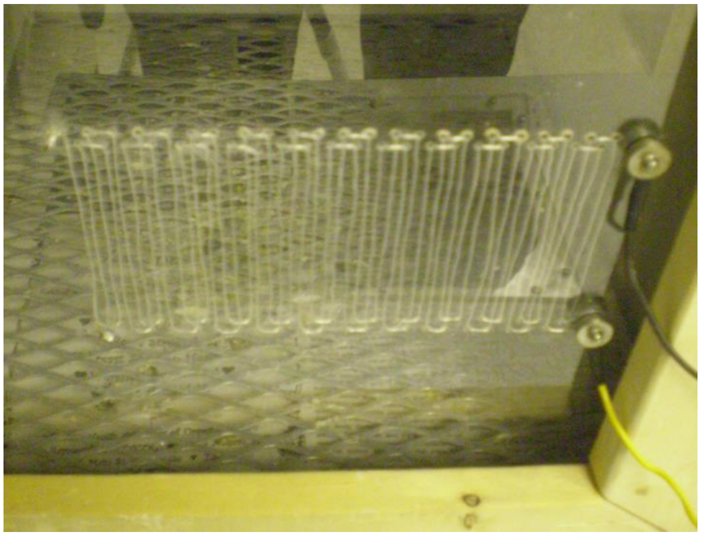


Figure 2. Wire grid on chamber door for registering headbangs. Black wire provided grid with 28 VDC ground current, and yellow wire passed circuit closures from headbangs to computer as -28 VDC input.

In the front of each chamber, attached to the clear Plexiglas window, was a 14.5cm x 8cm wire grid that enabled the pigeons' headbangs to complete a circuit that sent an electronic input signal to the computer that a head-bang had occurred (see Figure2). Both inputs and outputs (the lights and feeders of the chambers) were controlled simultaneously by the Med-PC computer programs (see Appendix 1 for MED-PC programs used in these experiments).

Each chamber contained a ventilation fan, and a white 28 volt bayonet bulb (house-light). The house-light remained on throughout each session except when food was being dispensed. The keylights were not turned on at the beginning of the session and remained off until a headbang had initiated the lights according to the procedures being implemented. A white noise generator was turned on throughout the sessions in order to mask any background noise. All sessions were monitored in a room adjacent to the experimental room by a closed circuit television. Some of the sessions were recorded by video-camera.

Weight data for the birds were recorded in the housing room on a daily basis, even on days when the birds were not being run in experiments. Data were recorded and experimental procedures were controlled by a computer that was located in the experimental room. The input data from the operant chambers were stored in a format generated by the program, Med-PC for Windows; all experimental programs used to control the experiments and to collect the data are included in Appendix 1.

General Procedure

Each pigeon was fitted with a small Velcro pad placed approximately .5cm above the base of the bird's beak. An aluminum foil helmet was made by placing two sides of Velcro tape together to create an adhesive bond thus the helmet had two sticky sides on the top and the bottom of the object. The bottom of the helmet was then attached to the pigeon's head with the aid of Elmer's Glue™ (see Figure 3). The top of the helmet was covered with a small piece of aluminum foil affixed also with Elmer's Glue. If the helmets fell off or the aluminum strips wore away, they could be reattached to the pigeons' heads without damage to feathers or skin.

Figure 3. Velcro helmet with aluminum foil covering affixed to pigeon's forehead with Elmer's Glue™.

When a session began, the pigeon would head-bang and thus make contact with the grid on the chamber door and send an input signal to the computer. All headbangs and food deliveries were controlled by a microcomputer. Daily cumulative records of head-bangs and food deliveries were created using Med-PC SoftCR. The appropriate Med-PC-IV programs could be changed throughout the experiment in order to generate the correct food reinforcement contingencies and for each experimental session. Sessions were run seven days a week and lasted from 30-60 minutes depending on which phase of the experiment the session was being implemented. The following table shows the various experimental conditions, and the numbers of sessions each bird was exposed to those conditions.

Table 1. Numbers of sessions each subject spent under each condition of the experiment.

	Experiment 1		***Experiment 2***			***Exp. 3***
Conditions	**“Shaping”**	**Hdbg1**	**Hdbg2**			**Hdbg2** w/FR3 on hdbgs
		VT food delivery schedule means				
		14 sec	**12 sec**	**10 sec**	**8 sec**	
Program	Hdbg1		Hdbg2	Hdbg3	Hdbg3f	Hdbg3i
Subjects	**Numbers of sessions under each condition**					
PP35	22	15	36	37	122	8
PP36	22	15	36	37	101	8
PP38	22	15	36	37	111	8

Experiment 1

The pigeons were first trained under a variable time (VT) schedule of food deliveries during thirty minute sessions. Throughout these sessions, both the houselights and white keylights were turned on, and food was dispensed at varying time intervals regardless of what the bird was doing at those times or during the preceding interim intervals.

Once the birds had completed training under the VT schedule of food delivery, a Multiple VT:Extinction (VT:EXT) schedule of food delivery was established. With this schedule, the birds learned to look for food to be delivered during periods when the keylights were turned on, whereas no food was delivered during alternating periods when the keylights were turned off. The pigeons were then trained by successive approximations to bang their heads against the wire grid; at the outset of each of these sessions, the keylights remained off until the targeted behavior had occurred, with each instance of the behavior producing a brief period with the keylights turned on and the VT schedule in effect for the duration. The sessions lasted thirty minutes apiece. The procedures implemented in Experiment one are summarized in the following diagram:

Shaping:

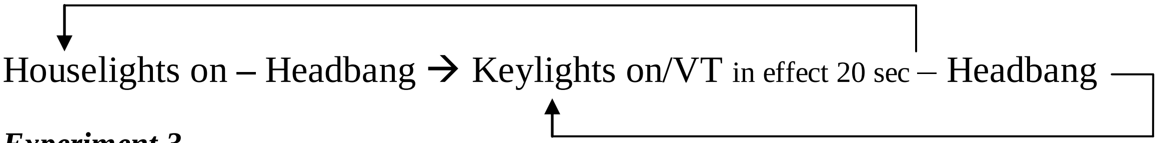
Maintenance:

Once the birds were trained clearly to bang their heads to turn on the keylights and the accompanying VT schedule of food delivery, they then advanced to Experiment 2.

Experiment 2

The sessions would begin in a keylights-off phase with only house-the light turned on to begin the session. The pigeons could bang their heads once to turn on the keylights; this would begin the lights-on phase. Once a keylights-on phase had begun, the pigeons would have 20 seconds of the keylights being on and the VT schedule in effect without having to emit another head-bang to avoid the lights-off phase. Under the VT schedule, the pigeons could receive food deliveries at intervals from six to fourteen seconds within the keylights-on phase. On average, the pigeons could thus receive a food delivery every 10 seconds during the keylights-on phase. When a keylights-on phase ended, the birds would then have to bang their heads again to turn the keylights back on and restore the VT schedule. If the pigeons banged their heads within the lights-on phase, they would reset that phase for an additional twenty seconds. The only way for birds to increase the duration of keylights-on phases and thus create a steady flow of food deliveries would be to headbang during the keylights-on phase. These conditions were maintained for approximately two hundred successive sessions for each bird. The procedures imposed in Experiment 2 are summarized in the following diagram:

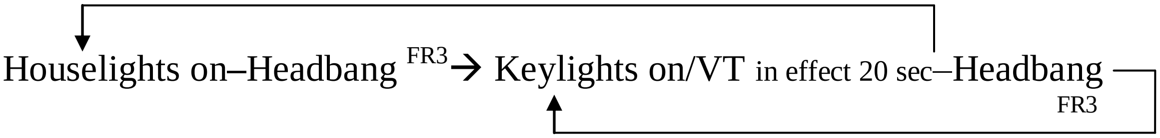
Hdbg2:



Experiment 3

The same conditions as those established in Experiment 2 remained in effect. Now, however, a fixed ratio (FR) requirement was imposed on headbangs, such that three headbangs were now required for each contingent change in conditions produced by headbangs. The first two of the three headbangs were registered, but produced no stimulus changes; the third headbang was required to turn the keylights on, reset the Phase 2 clock, and set a new FR3 requirement for headbangs. The procedure imposed in the final experiment are summarized in the following diagram.

Hdbg2 w/FR3 requirement on Hdbgs:



Results

Experiment 1

The pigeons were trained using the shaping procedure described in the Methods section with a VT 14 second schedule. The birds would receive food at intervals between 8 seconds and 20 seconds depending on what was randomly generated by the VT timer program. This produced steady but sometimes low rates of headbanging. It should be noted that because of the VT timer, the bird would sometimes randomly draw larger mean times for food reinforcement, and the ensuing low rate of food presentations would have maintained relatively low rates of responding.

As shown in Figure 4 (below), during Experiment One, under shaping and establishment, the pigeons were shaped to bang their heads, and did so at a steady rate of about 1 headbang per minute. The rates rose modestly but steadily for all birds, and dipped for 35 and 38 until the headbangs began to be steadily reinforced. The rates are slightly higher for PP36 than for the other two, but all emitted a steady rate of headbanging.

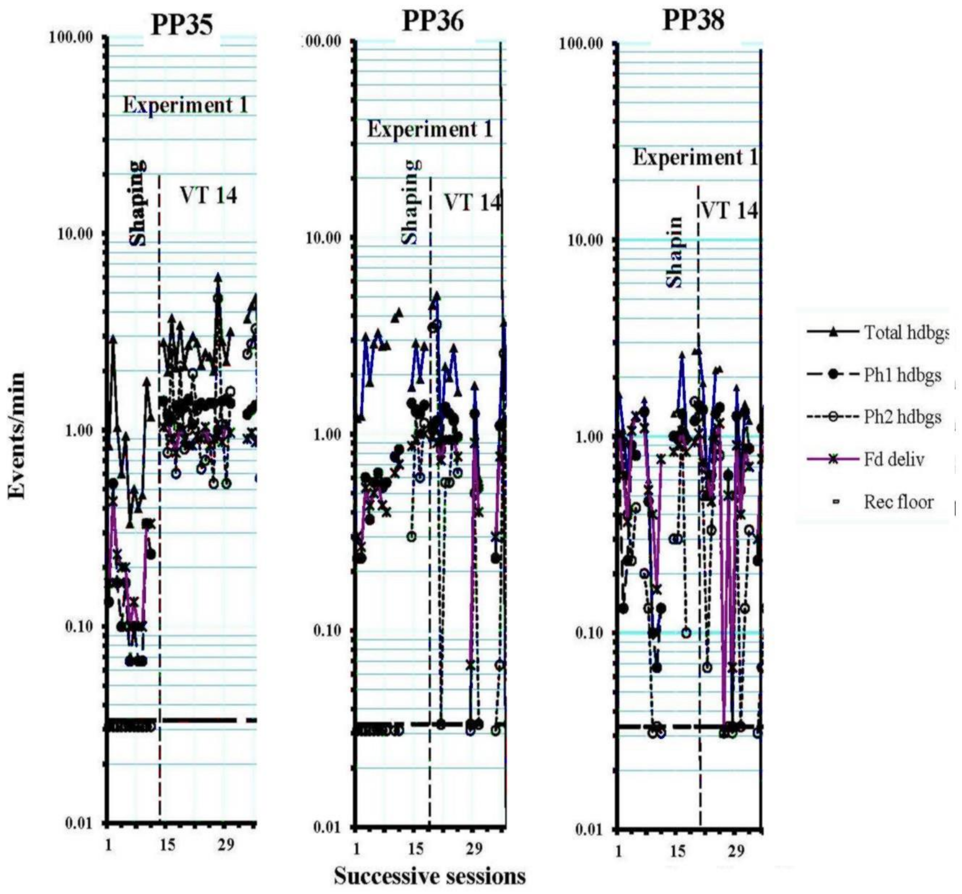


Figure 4. Standard celeration chart for PP35, PP36, and PP38 from Experiment 1. The data include total headbangs per session, represented by (---▲---), Phase 1 headbangs, represented by (–•–), Phase 2 headbangs, represented by (--ᵒ--), and food deliveries represented by (—×—). A change in the experimental condition is marked by dashed and vertical lines. The solid horizontal line indicates the record floor, which is the point where one observed event per session would be indicated.

All three of the birds came under control of the association of the light-on phase with food presentations; their headbangs increased as the sessions continued. In the shaping procedure, once the birds' behavior was no longer being reinforced manually, and the lights-on phase was solely contingent on actual headbanging, PP35, PP36, and PP38's response rates increased, indicating that the neutral stimulus of lights-on associated with intermittent food presentations had become a conditioned reinforcer maintaining the headbanging behavior.

Experiment 2

This experiment demonstrated that SIB could be maintained by conditioned reinforcement over an extended period. Once again, a VT schedule of food presentations was in effect during a lights-on phase. The lights-on phase now lasted twenty seconds after a headbang, and would end after the twenty seconds period had elapsed. Once a lights-on phase was initiated, the bird could either wait for food presentations or could bang its head again and extend the lights-on phase for another twenty seconds. Any headbang that occurred during a lights-on phase was called a phase 2 headbang. Figure 5 (see below) 5shows rates of total headbangs, Phase 1 and Phase 2 headbangs, and rates food presentations throughout different VT conditions.

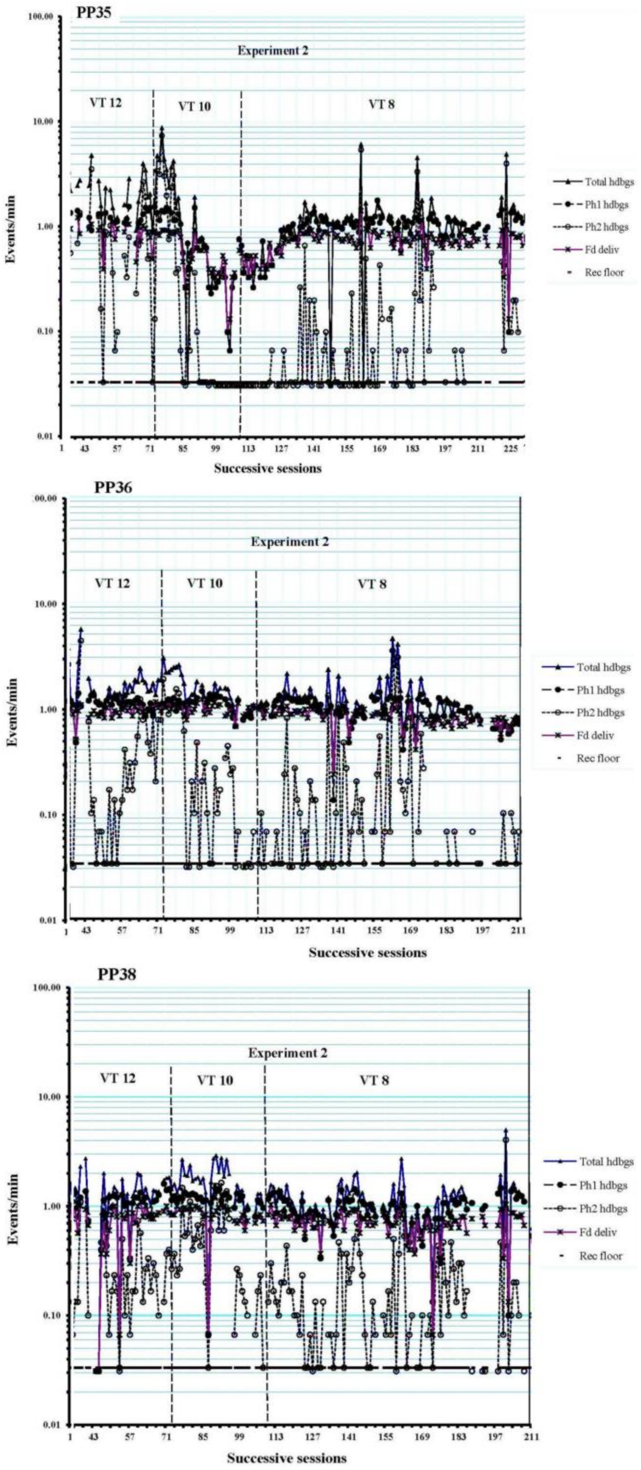


Figure 5. Standard celeration chart for PP35, PP36, and PP38 from Experiment 2. The data include total headbangs per session, represented by (---▲---), Phase 1 headbangs, represented by (–•–), Phase 2 headbangs, represented by (--○-), and food deliveries represented by (—×—). A change in the experimental condition is marked by dashed and vertical lines. The solid horizontal line indicates the record floor, which is the point where one observed event per session would be indicated.

The VT schedules of 14 seconds and 12 seconds in HDBG1 and HDBG2 had only slight effects on total headbangs, but there was small drop off from other VT schedules. Subject PP35 however had a large decrease in response rates over some sessions. This might be attributed experimental error. The pigeon's headgear would sometimes slip off during test sessions and needed to be replaced; on several occasions, PP35's helmet needed to be re-glued between sessions as well. Also the wires on the operant chambers sometimes became coated with dust from the pigeons' feathers. The investigators had to wipe down the cages daily in order to ensure clean contact surfaces required for consistent registration of headbangs. Other than this extraneous source of variability, there were no indications that the pigeon had not come under control of the conditioned reinforcement contingency. Throughout Experiment Two, there were relatively steady rates of Phase One headbangs, as well as total headbangs, by all three birds across all phases except for a brief time for PP35 under VT mean 12, 10, and 8. Once again, this temporary deviation may be attributed to headgear or equipment malfunctions which, when remedied, resulted in a steady return to consistent rates of headbanging.

Experiment Two demonstrated long-term maintenance of headbanging with a conditioned reinforcer, through total headbangs and Phase 1 headbangs by all three pigeons (see Figure 5) under VT means 12, 10, and 8. Under these conditions, there was not a clear association of headbangs during the lights-on phase (Phase 2) and prolongation of the lights-on phase. Experiment Two did not result in steady Phase 2 headbangs by any of the pigeons under any of the conditions. PP36 and PP35 emitted Phase 2 headbangs at rates close to zero. PP38 emitted slightly higher rates but Phase

2 headbangs lacked long-term consistency, indicating there was little control by the association of headbanging during lights-on phase with prolongation of that phase.

There was little difference in response rates between a VT 14 second and VT 8 second according to total headbangs and Phase 1 headbangs. There was too much variability to determine whether a change in reinforcement rate had any effect on Phase 2 headbangs. A lowered VT mean led to consistent results for total headbangs and phase 1 headbangs within the condition, but not across conditions as the VT means were lowered. About the same steady rates occurred at a VT mean of 14 seconds, but was a very slight deceleration under these conditions, probably resulting from the passage of numerous Phase Two intervals without food presentation (given the random times programmed, some VT intervals exceeded the Phase Two duration).

Experiment 3

This experiment attempted to increase Phase Two headbangs by means of increasing the FR schedule for headbangs from FR1 to FR3. Under FR1, the bird had to bang his head only once to initiate the lights-on phase: under FR3, the pigeon now had to bang his head three times to initiate the lights-on phase. This procedure was established to determine what effects the FR3 would have on total headbangs, and on Phase One, and Phase Two headbangs. As expected, there was a marked increase in total and Phase One headbangs for all three birds (see Figure 6, below). There were some issues with the headgear of PP328, believed to be for initially unstable and low rates of headbanging during the lights-off phase.

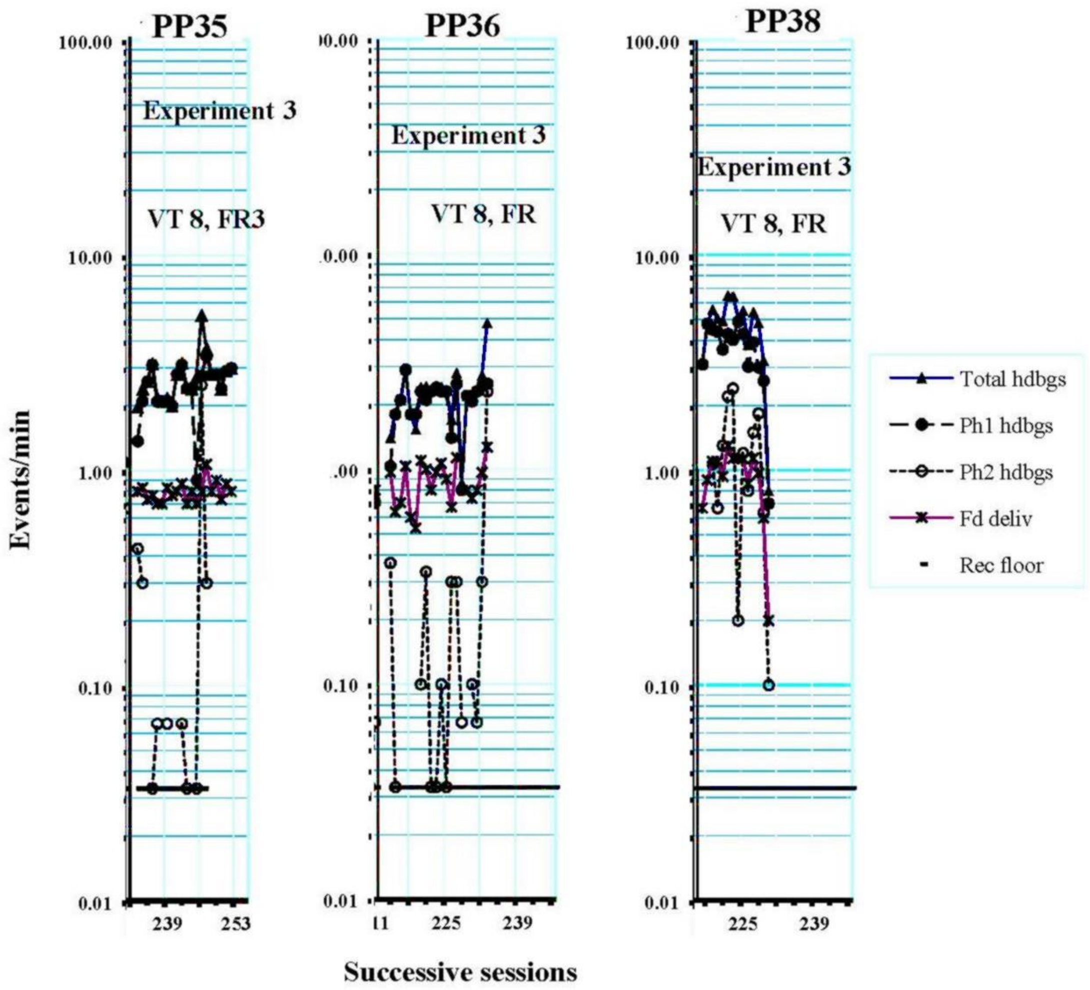


Figure 6. Standard celeration chart for PP35, PP36, and PP38 from Experiment 3. The data include total headbangs per session, represented by (—▲—), Phase 1 headbangs, represented by (–•–), Phase 2 headbangs, represented by (--○-), and food deliveries represented by (—×—). A change in the experimental condition is marked by dashed and vertical lines. The solid horizontal line indicates the record floor, which is the point where one observed event per session would be indicated.

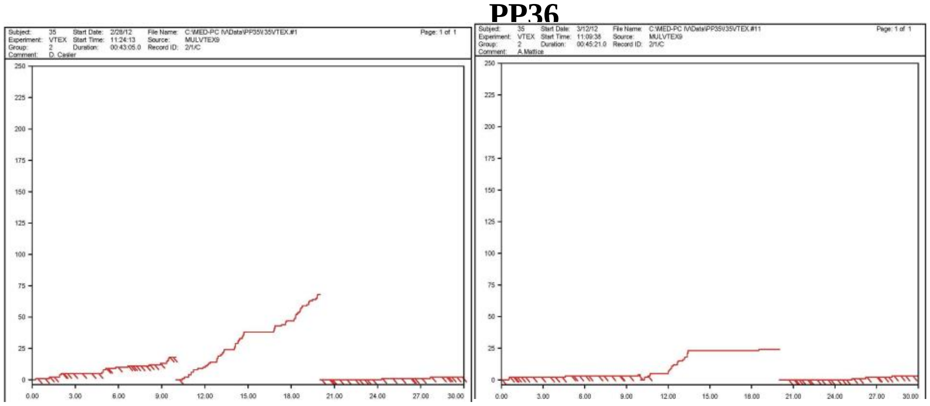
Once this was remedied, PP38 emitted the same increased rates of Phase One headbanging as the other subjects, and also emitted more Phase Two headbangs. There has been an increase in Phase Two headbangs by all three birds. Once again, there are marked differences between Phase 1 and total headbangs, and Phase 2 headbangs.

Figure 7. Characteristic cumulative records from the final phase of training. Data from all three subjects are shown in corresponding rows; headbangs are recorded on the cumulating line, while VT food deliveries are shown as brief downward deflections of the pen. The first record in each row is from an early session under the Multiple Variable Time: Extinction schedule (MULT VT:EXT); the second record in each row is from the final session under this condition.

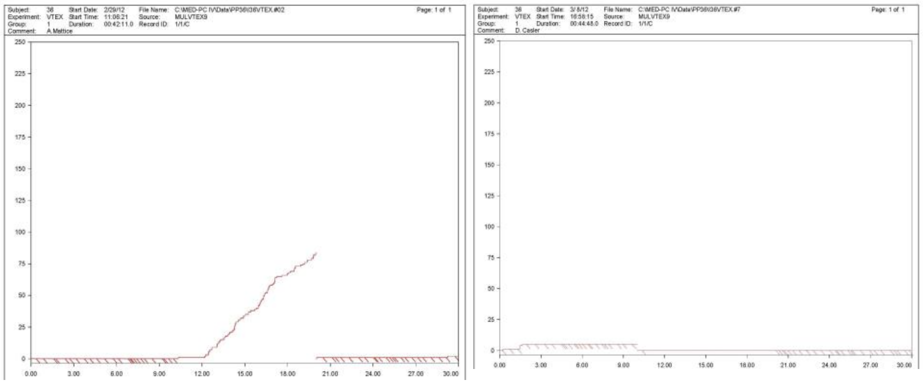
.

PP35

PP36



PP36



PP38

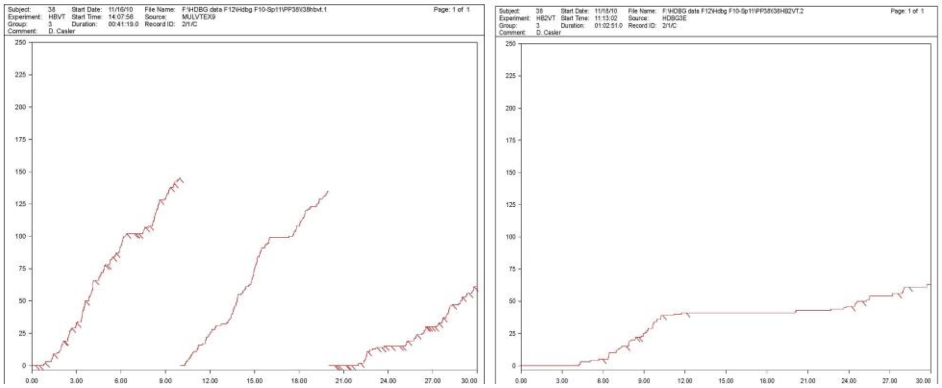
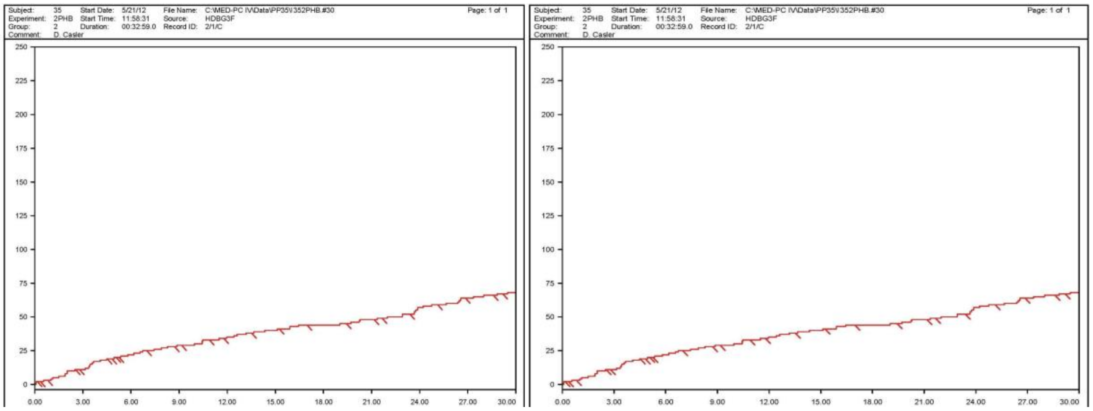


Figure 8. Characteristic cumulative records from the final phase of Experiment 1. Data from all three subjects are shown in corresponding rows; headbangs are recorded on the cumulating line, while VT food deliveries are shown as brief downward deflections of the pen. The first record in each row is from an early session under the Phase 1 procedure; the second record in each row is from the final session under this condition.

.

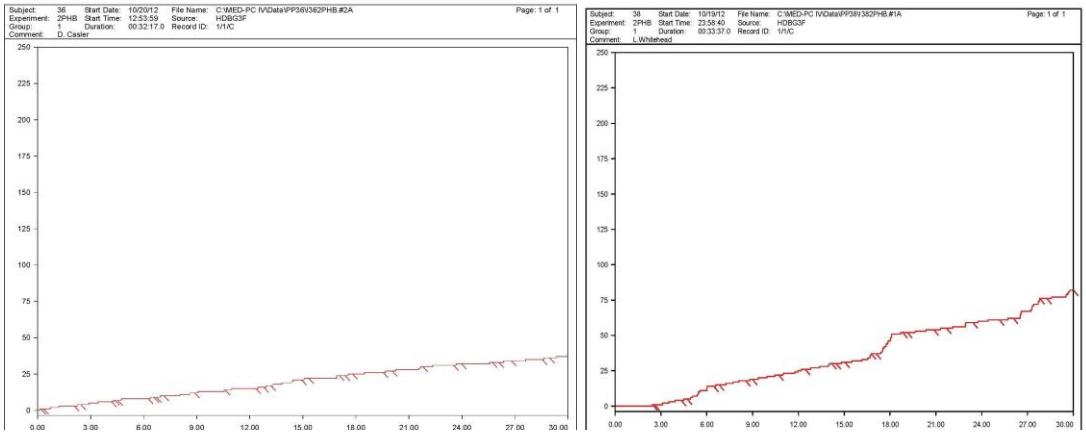
PP35



Subject: 35 Start Date: 5/21/12 File Name: C:\MED-PC IV\Data\PP35\352PHB.#30 Page: 1 of 1
Experiment: 2PHB Start Time: 11:58:31 Source: HDBG3F
Group: 2 Duration: 00:32:59.0 Record ID: 2/1/C
Comment: D. Casler

Subject: 35 Start Date: 5/21/12 File Name: C:\MED-PC IV\Data\PP35\352PHB.#30 Page: 1 of 1
Experiment: 2PHB Start Time: 11:58:31 Source: HDBG3F
Group: 2 Duration: 00:32:59.0 Record ID: 2/1/C
Comment: D. Casler

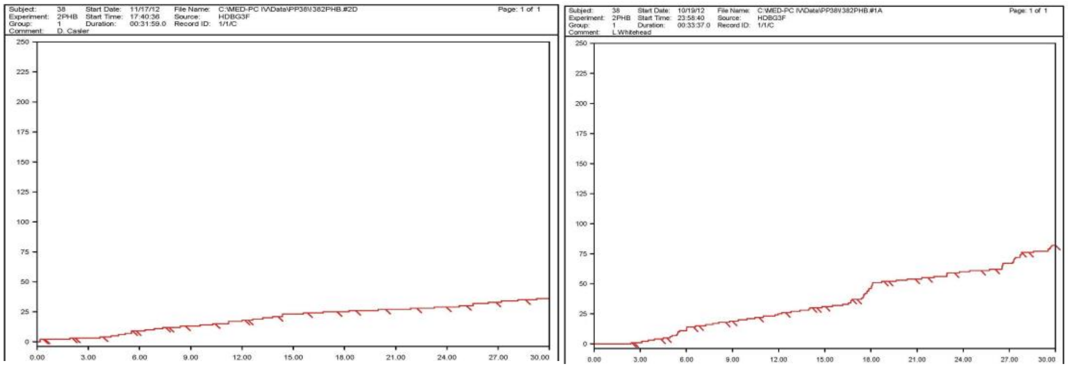
PP36



Subject: 36 Start Date: 10/20/12 File Name: C:\MED-PC IV\Data\PP36\362PHB.#2A Page: 1 of 1
Experiment: 2PHB Start Time: 12:53:59 Source: HDBG3F
Group: 1 Duration: 00:32:17.0 Record ID: 1/1/C
Comment: D. Casler

Subject: 38 Start Date: 10/19/12 File Name: C:\MED-PC IV\Data\PP38\382PHB.#1A Page: 1 of 1
Experiment: 2PHB Start Time: 23:58:40 Source: HDBG3F
Group: 1 Duration: 00:33:37.0 Record ID: 1/1/C
Comment: L.Whitehead

PP38



Subject: 38 Start Date: 11/17/12 File Name: C:\MED-PC IV\Data\PP38\382PHB.#2D Page: 1 of 1
Experiment: 2PHB Start Time: 17:40:36 Source: HDBG3F
Group: 1 Duration: 00:31:59.0 Record ID: 1/1/C
Comment: D. Casler

Subject: 38 Start Date: 10/19/12 File Name: C:\MED-PC IV\Data\PP38\382PHB.#1A Page: 1 of 1
Experiment: 2PHB Start Time: 23:58:40 Source: HDBG3F
Group: 1 Duration: 00:33:37.0 Record ID: 1/1/C
Comment: L.Whitehead

Discussion

The current study demonstrated that headbanging, a behavior not typically occurring in pigeons, could be brought under control of experimental contingencies involving only conditioned reinforcement. The three experiments together demonstrated that conditioned reinforcement can establish and maintain SIB.

In Experiment One, headbanging was shaped using only conditioned reinforcement. This experiment showed that SIB does not have to be directly associated with a primary reinforcer to be selected by environmental contingencies and maintained at steady rates. This is important to human cases because it reveals how such behavior can be selected and maintained by more subtle contingency variables. The effects of conditions arranged in this study suggest that behavioral interventions, if not carefully implemented can produce aversive effects. In a study on vocalization in autism, an unintended reverse effect was accomplished when positive reinforcement and extinction contingencies, designed to strengthen a conditioned reinforcer, made a positive situation aversive to the subject (Drash, High, Tudor, 1999).

The results here can alert clinicians to the possibility that a disturbing pattern of behavior (like SIB) may be maintained by conditioned reinforcement. This could be very helpful in trying to understand why children with autism appear to engage in certain SIBs without any discernible reinforcement, and often relapse and perform old behaviors when environmental conditions change and alter newly learned patterns of behavior. If a treatment is implemented and there is a relapse, then it may not be due to improper treatment but it may be due to improper analysis of all potentiating variables (Lerman, Iwata, Smith, Zarcone, Vollmer, 1994).

Understanding through a Functional Analysis what is increasing or maintaining SIB can lead to particular behavioral treatments (Pelios, Morren, Tesch, Axelrod, 1999). Clinicians could use stimulus fading to slowly fade out negative reinforcement maintaining SIB and, instead, establish a more acceptable form of behavior. Environmental factors that potentiate conditioned reinforcement contingencies may now be included among the variables acting upon the organism to select and maintain disturbing patterns like SIB.

Experiment Two examined the long-term maintenance of headbanging by conditioned reinforcement. As shown in Figures 4, 5, and 6, headbanging clearly was maintained at different values of VT schedules of food deliveryat relatively steady rates of about one headbang a minute throughout more than two hundred sessions, and there was little systematic variation in the rate of headbanging with small changes in the VT schedules. Under these conditions, not many Phase 2 headbangs occurred, and only intermittently. This could be attributable to the procedural arrangement itself, which provided the birds no cues that the Phase Two timer was reset by headbangs during that phase. The experimenters could have implemented a brief tone or light flash after a Phase Two headbang occurred and reset the Phase Two timer, making the prolongation of the lights-on period more salient. Even though this association was never made explicitly discriminable in the current study, the data still indicate that Phase 1 headbangs occurred under control of lights-on and opportunities for food acquisition.

In clinical settings, there may indeed be cases wherein conditioned reinforcers are be relevant to maintenance of disturbing patterns of behavior by children with autism. If a child has had access to certain reinforcers only when a nurse has been present, then the child may engage in SIB to maintain the presence of the nurse and concomitant access to a widened array of reinforcement contingencies. If the stimulus in this instance (a nurse), historically has been correlated with increased opportunities for a range of positive reinforcement contingencies, then the association between this stimulus and reinforcement will potentiate the nurse as a conditioned reinforcer. In the present study, Phase 2 headbangs correspond to the already present nurse in the clinical example. If the nurse is associated by circumstances with attention or other reinforcers, then when the nurse is about to leave or is no longer providing opportunities for the child to engage in other reinforced behavior, the disturbing behavior may escalate, thus ensuring more prolonged opportunity for other positive reinforcement.

Experiment Three did result in an instant increase in headbangs under the FR3 schedule imposed, including an increase in Phase 2 headbangs. This confirmed that the pigeons would emit the required behavior at higher rates to receive the benefit accompanying the presentation of the conditioned reinforcer. One implication of this experiment for patterns of human SIB is that long term maintenance of SIB under increased response requirements may demand higher cost/benefit procedures in order to curtail the behavior.

As noted before, the present study is the first demonstration that a conditioned reinforcer may be critical in shaping pathological patterns of behavior. The behavior involved here was not meant to have an exact one-to-one topographic correspondence to SIB in humans, but functionally, the behavior was never reinforced directly by food delivery (a primary reinforcer), and this does explicitly mirror conditions under which humans engage in SIB. This model may also be used to understand SIB by other animal species. Many animal models rely on stress and aversive stimuli in order to produce SIB. The present study showed that SIB, a disturbing or abnormal pattern of behavior, could come under control of positive reinforcement contingencies similar to those that maintain normal everyday behavior.

There remain numerous unanswered questions in this series of experiments. Perhaps the most pressing and interesting issue is identification of the conditions necessary to maintain headbangs during Phase 2. In the present study, this was addressed by imposing an FR3 requirement for headbanging to produce the conditioned reinforcer and initiate period of VT food deliveries. Another planned approach involves implementation of a new procedure which would slightly dim the lights shortly before the end of Phase Two. That is, the keylights would dim slightly after 15 seconds of being on during the lights-on phase. This dimming of the keylights would thus function as a mild warning signal that the lights-on phase will end soon, and also make the effect of Phase Two headbangs (extending the lights-on period by resetting the twenty seconds clock) a discriminable event. It is predicted that under these conditions, the birds will begin emitting Phase Two headbangs during the dimming periods, which themselves can then be faded out to result in unabated high rates of headbanging throughout entire sessions.

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Appendix A: Program used to run Experiments.

```
\VT PROGRAM FOR MED-PC

\RECORDS OPERANT LEVEL OF HEADBANGING

\30 MIN SESSION, FILENAME, VT1.MPC

\DATE LAST REVISED: 2.xi.09

\ The current version of the program imposes a VT schedule, and records the operant
level of \headbanging, under red houselights. The total session duration currently is
set at 30 minutes.

\INPUTS

^HDBG = 3

\OUTPUTS

^REDLIGHTS = 2

^FEEDER = 3

^HOUSELIGHT = 4

DISKVARS = A,B,C,D,E,F,G,H,J,K,L,P,Q,R,S

DISKFORMAT = 10.2

DISKOPTIONS = FULLHEADERS

\DEFINED VARIABLES

\C() = Array for irt's on HDBG grid

\I = Subscript for array C

\A = TOTAL HEADBANGING RESPONSES

\ TIMERS FOR SCHEDULES AND SESSION

\N = SESSION CLOCK

\T = Used to increment counts at 0.1" intervals for irt's

\U = VT SCHEDULE VALUE

\Z-PULSES USED IN THIS PROCEDURE

\Z1 = Signal for marking HDBG Rf on cumulative record

PRINTORIENTATION=PORTRAIT
```

```
PRINTCOLUMNS = 6

PRINTOPTIONS = FULLHEADERS, NOFORMFEEDS

PRINT VARS = A,B,C,D,E,F,G,H,J,K,L,P,Q,R,S

\ARRAY FOR CUMULATIVE RECORD DATA

DIM C = 9500

\LISTS FOR GENERATING VT SCHEDULES

LIST U = 1,3,5,7,9,11,13,15,17,19,21,23,24,27,29,31,33,35,37,39,41,43,45,47,49,51,53,55,57,59 \mean = 30sec
```

Appendix B: Program used to run Experiments.

```
\MULTIPLE VT/EXT PROGRAM FOR MED-PC
\FILENAME, MULVTEX8.MPC
\DATE LAST REVISED:8.ii.10
\ The current version of the program is set up for a Multiple VT 20-sec:EXT
\ schedule, with the keylights alternating on and off every 10 minutes when the
\ schedules are reversed. The total session duration currently is set at 40
\ minutes, with 10 min phase changes.
\INPUTS
^HDBG = 3
\OUTPUTS
^KEYLIGHT1 = 1
^KEYLIGHT2 = 2
^FEEDER = 3
^HOUSELIGHT = 4
DISKVARS = A,B,C,D,E,F,G,H,J,K,L,P,Q,R,S
DISKFORMAT = 10.2
DISKOPTIONS = FULLHEADERS
\DEFINED VARIABLES
\C() = Array for HDBG irt's
\I = Subscript for array C
\A = TOTAL HDBG RESPONSES
\B = TOTAL HDBG REINFORCERS
```

```
\CONDITIONAL COUNTERS FOR HDBG

\H = REINFORCERS UNDER VT:HOUSELIGHT & KEYLIGHTS

\J = HDBG RESPONSES UNDER EXT

\TIMERS FOR SCHEDULES AND SESSION

\M = PHASE FLAGS

\N = SESSION CLOCK

\T = Used to increment counts at 0.1" intervals for irt's

\U = VT SCHEDULE VALUE

\V = EXT SCHEDULE VALUE

\Z-PULSES USED IN THIS PROCEDURE

\Z1 = Signal for marking Rf on cumulative record

Last revised: 8.ii.10 1
```

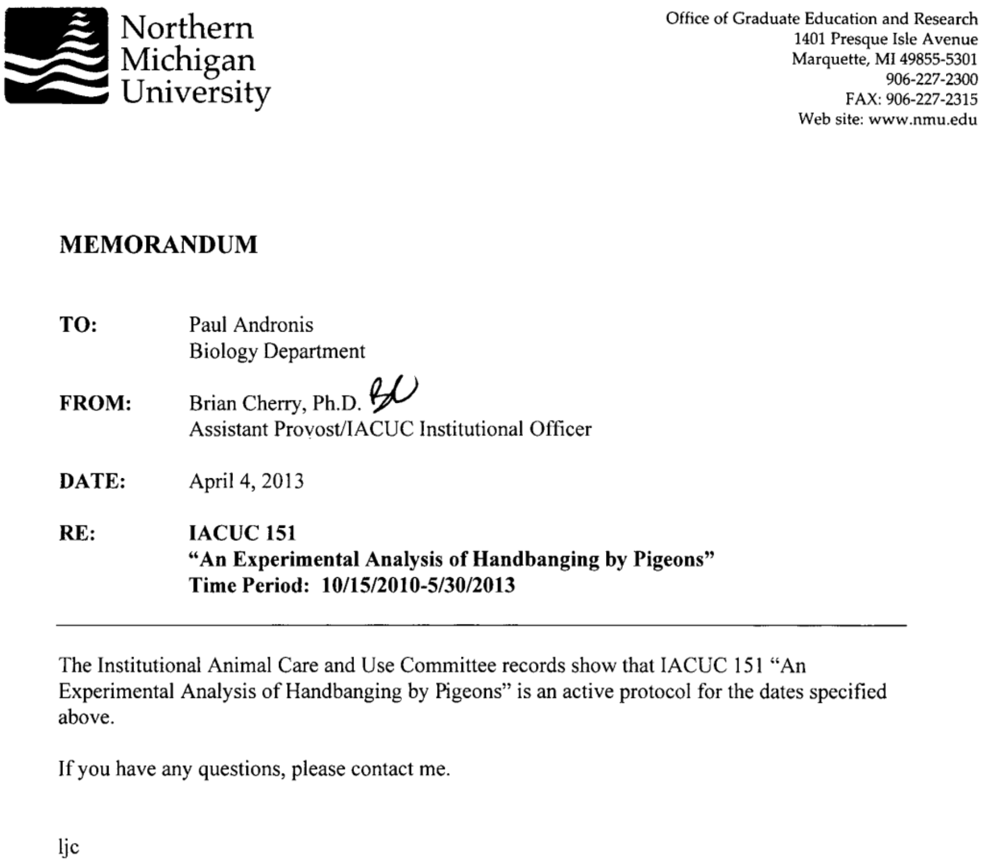
Appendix C: Program used to run Experiments.

```
\HDBG3a.MPC
\DATE LAST REVISED:24.iii.10
\ The current version of the program is set up for shaping and maintaining headbanging in a two-phase
\ procedure. During Phase 1, under a white houselight, a headbang causes transition to Phase 2 for fifteen
\ seconds (15 secs); in Phase 2, white keylights are turned on, accompanied by a VT-10 sec schedule of
\ food reinforcement under which no further responses are necessary. Headbangs during Phase 2 are
\ counted separately and should also reset the 15 sec timer defining Phase 2. The total session duration
\ currently is set at 60 minutes.
\INPUTS
^HDBG = 3
\OUTPUTS
^KEYLIGHT1 = 1
^KEYLIGHT2 = 2
^FEEDER = 3
^HOUSELIGHT = 4
DISKVARS = A,B,C,D,E,F,G,H,J,K,L,P,Q,R,S
DISKFORMAT = 10.2
```

```
DISKOPTIONS = FULLHEADERS

\DEFINED VARIABLES

\C() = Array for irt's on LKEY and RKEY

\I = Subscript for array C

\A = TOTAL HEADBANGING RESPONSES

\B = HEADBANGING during Phase 1

\D = HEADBANGING during Phase 2

\F = Food deliveries

\G = P1->P2 transitions caused by USER

\TIMERS FOR SCHEDULES AND SESSION

\N = SESSION CLOCK

\T = Used to increment counts at 0.1" intervals for irt's

\U = Schedule value for VT clock

\Z- & K-PULSES USED IN THIS PROCEDURE

\Z1 = Signal for starting VT clock

\Z2 = Signal for marking HDBG Rf on cumulative record

\K1 = USER INPUT to cause transition from Phase 1 to Phase 2

PRINTORIENTATION=PORTRAIT

PRINTCOLUMNS = 6

PRINTOPTIONS = FULLHEADERS, NOFORMFEEDS

PRINT VARS = A,B,C,D,E,F,G,H,J,K,L,P,Q,R,S

\ARRAY FOR CUMULATIVE RECORD DATA

DIM C = 9500
```

```
\LIST FOR GENERATING VT SCHEDULE

LIST U = 3,4,5,6,7,14,15,17,19 \mean = 10
```

Appendix D: IACUC Approval Form



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MEMORANDUM

TO: Paul Andronis
Biology Department

FROM: Brian Cherry, Ph.D.
Assistant Provost/IACUC Institutional Officer

DATE: April 4, 2013

RE: **IACUC 151**
"An Experimental Analysis of Handbanging by Pigeons"
Time Period: 10/15/2010-5/30/2013

The Institutional Animal Care and Use Committee records show that IACUC 151 "An Experimental Analysis of Handbanging by Pigeons" is an active protocol for the dates specified above.

If you have any questions, please contact me.

ljc